DOCTORAL DISSERTATION

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Academic Entrepreneurship in Hungary
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BEFA: abbreviation of the Hungarian title of Investment Fund (Befektetési Alap, since 1992 Befektetésösztönzési Alap)

CEO: Chief Executive Officer

CMEA: Council for Mutual Economic Assistance

CNRS: abbreviation of the French title of National Centre for Scientific Research (Centre National de la Recherche Scientifique)

CSO: Chief Scientific Officer

CTDF: Centralized Technical Development Fund (in Hungarian: KMÜFA – Központi Műszaki Fejlesztési Alap)

DCI: Development Capacity Index

DNA: Deoxyribonucleic acid

DOD: Department of Defense (in the USA)

EPO: European Patent Office

GFC: abbreviation of the Hungarian title of Economic Development Programme (Gazdaságfejlesztési Célelőirányzat)

GMK: abbreviation of the Hungarian title of small working groups (gazdasági munkaközösség)

GOP: abbreviation of the Hungarian title of Economic Development Operational Programme (Gazdaságfejlesztési Operatív Program)

GVOP: abbreviation of the Hungarian title of Economic Competitiveness Operational Programme (Gazdasági Versenyképesség Operatív Program)

HEW: Department of Health, Education and Welfare (in the USA)

ICT: Information and communication technology

IKTA: abbreviation of the Hungarian title of Information and Communication Technology Programme (Infokommunikációs Technológiák és Alkalmazások Program)

ILO: Industrial Liaison Office

IP: Intellectual property

IPA: Institutional Patent Agreement

IPMO: Intellectual Property Management Office

IPO: Initial public offering

IPR: Intellectual property right

IT: Information technology

ITDH: Hungarian Investment and Trade Development Agency

KEFA: abbreviation of the Hungarian title of Trade Development Fund (Kereskedelemfejlesztési Alap)

MIT: Massachusetts Institute of Technology

NEM: New Economic Mechanism

NIH: National Institute of Health

NKFP: abbreviation of the Hungarian title of National Research and Development Programme (Nemzeti Kutatási és Fejlesztési Program)

NSF: National Science Foundation

NSRF: National Scientific Research Fund

NTFB: New technology-based firms

OECD: Organisation for Economic Co-operation and Development

OMFB: abbreviation of the Hungarian title of National Committee for Technological Development or National Technical Development Committee

PRO: Public research organisation

R&D: Research and development

rDNA: Recombinant DNA

SAB: Scientific Advisory Boards

SME: Small and medium sized enterprises

TÁMOP: abbreviation of the Hungarian title of Social Renewal Operational Programme (Társadalmi Megújulás Operatív Program)

TLO: Technology Licensing Office

TTO: Technology Transfer Office

USO: University spin-off

VC: Venture Capital

WARF: Wisconsin Alumni Research Foundation

1. Introduction

In the 20th and 21st centuries, universities are increasingly seen as crucial actors in the economic and social development of their region (Varga, 1998; Etzkowitz and Leydesdorff, 2000; Goldstein, 2009; Youtie and Shapira, 2008). In the globalized world, to be latecomer in scientific discoveries and in turning them into products that increase the welfare of the society equals to defeat. In the age of knowledge-based economies, universities as knowledge generator and disseminator institutions, providers of knowledge infrastructure are inevitable actors in establishing the competitive advantage of a country or a region (Luger and Goldstein, 1997).

Nevertheless the transformation of universities from the middle ages' educational organisations to modern teaching and research organisations that are often considered as regional economic boosters (Florax, 1992) has been a long, gradual and sometimes even controversial process. The simultaneous conduct of teaching and research activities of faculty members are already common in most of the contemporary universities. The integration of the latest research results into education creates better job opportunities to the newly graduated, while talented students may also take part in research, extending this way the scientific frontier. However, this has not always been the case, since it was not before the 19th century that the first academic revolution extended the original teaching mission of universities with the research function (Etzkowitz, 1983). Also the term revolution suggests the controversial character of the process (Gulbrandsen-Slipersaeter, 2007); some were heavily against it arguing that research activities would divert faculty members from the more important teaching duties (Etzkowitz, 2003a). Though in some geographic areas the first academic revolution has not finished yet, in the most developed university systems another has already been started (Etzkowitz, 1998).

Changes of the world economy in the 20th century, such as the increasing importance of knowledge and changes in the methods and processes of scientific research induced a second revolution in academia that extended the already embedded teaching and research functions with the third mission: regional economic development (Etzkowitz, 1983 and 1998; Etzkowitz and Leydesdorff, 2000; Goldstein, 2009). Encouraged by the enormous scientific results achieved during the Second World War, and triggered by the fear of lagging behind in economic competition with Germany and Japan, the US government turned to universities for help (Franzoni and Lissoni, 2009).

National legislations were altered in a way as they now support entrepreneurial activities of universities. The most well-known among these is the Public Law 96-517 (the Patent and Trademark Amendment Law of 1980) or as commonly referred to the Bayh-Dole Act. The regulation, named after the senators who submitted it, granted the intellectual property rights (IPR) of research results from federally funded projects to universities. The aim was to accelerate and ensure commercial application of scientific results (Grimaldi et al., 2011). Before the Bayh-Dole Act, the IPR of federally funded research results belonged to the federal government and universities had to negotiate on a case-by-case basis which was a time demanding process (Aldridge and Audretsch, 2011).

The expectation that universities should contribute to the development of their surrounding area has not been peculiar in the US for a long time. In 1862, the Morrill Act established the model of land-grant universities by granting federally owned land to universities to support agricultural and mechanical arts through their extension activities (Etzkowitz, 1998; Etzkowitz et al., 2000; Goldstein, 2007; Mowery et al., 2004). Additionally, consultancy services and external teaching activities of faculty members have long been in effect for assisting the advancement of local communities.

However, as Gulbrandsen and Slipersaeter (2007) argued, the new types of entrepreneurial activities brought by the second academic revolution, namely patenting, licensing and spin-off, are different from the more traditional ones. These are usually more controversial regarding their effect on open science, and they may require the establishment of support structures, like for example technology transfer offices. Even against the potential setbacks, many universities responded quickly to exploit the opportunity opened; they set up technology transfer offices, built science parks and established venture capital funds. The leadership in influencing regional development shifted from business to university (Etzkowitz, 1998).

Besides legislative changes, such as the Bayh-Dole Act, also other factors played an important role in the recent shift that resulted in a dramatic increase of patenting, licensing and spin-off involvement of universities (Aldridge and Audretsch, 2011; Mowery et al., 2004). One of the industries experiencing the highest level of academic entrepreneurial activity was biotechnology (Franzoni and Lissoni, 2009). The share of US academic patents in technology areas that have biomedical relevance increased from less than 25% in 1980 to some 39% in 2001 (Vincent-Lancrin, 2006).

Not only in America, but also in Europe (and in other parts of the World), universities were seen as engines of economic development (Goldstein, 2009) and many countries passed IPR legislations similar to Bayh-Dole Act (Baldini, 2008). However, what seems to be a natural evolutionary process of universities in the US, it was rather a top-down political initiative in the EU trying to emulate the success of the former (Soete, 2002). However, there are strict limits of the imitation of developmental models (Boschma, 2004). Even the success stories of Silicon Valley and Route 128 are not to generalize and unlikely to be repeatable in most of the US federal states (Bania et al., 1993), not even to mention the European opportunities.

This difference in the regional economic development potential of the Anglo-Saxon and continental European universities can be traced back to their different historical evolutionary paths. The continental European system is characterized by a strong dominance of governmental laboratories and other public research organizations (PROs) that puts universities in a relatively disadvantageous position in research competition (Etzkowitz et al., 2000; Vincent-Lancrin, 2006). Further peculiarity is the strongly centralized research funding system that in general does not favour long run and large scale science projects (Bonaccorsi, 2007), consequently impedes the generation of inventions with potential commercial application.

There is a risk that even promising inventions remain unutilized owing to the traditionally low financial autonomy of European universities that inhibits the accumulation of competences and knowledge that are needed to effectively manage their IPR portfolio (Franzoni and Lissoni, 2009). Since the employment and reward structures of the continental European systems ensure only very limited, if any, space for financial incentives of entrepreneurial activities (Bonaccorsi, 2007), the voluntary participation of scientists in entrepreneurial activities cannot be taken for granted. The risk of entrepreneurship aversion is increased by the low level of cross-institutional, namely university-industry mobility that hinders the establishment of industrial and business networks that would be beneficial for the entrepreneurial spirit.

Whatever the context might be, the most important actor of the entrepreneurial turn seems to be the academic entrepreneur himself. Every technology transfer process begins with the disclosure that is unlikely to happen if the faculty believes that the costs of co-operating with the TTO outweigh its benefits (Owen-Smith and Powell, 2001). Even after licensing, due to the usually very embryonic stage of the invention, further development requires the collaboration of the inventor (Thursby and Thursby, 2003a) who embodies all the related tacit knowledge.

Also Gulbrandsen and Slipersaeter (2007) claim that one of the distinctive features of the new academic entrepreneurial activities, that represent the so-called science-directed commercialization of university research, is the key role of individual faculty. Etzkowitz (1998) highlighted that the evolution of entrepreneurial universities was made possible by a normative shift in the academia. This brought an era where university scientists changed their belief about the exclusivity of the ivory tower spirit. He insists that the normative turn resulted in the appearance and extension of a group of scientists who were interested in pursuing knowledge not exclusively for its scientific truth, but also to turn inventions into commercially applicable products.

Due to the key role that scientists play in the technology transfer process, the exploration of their motivations can significantly contribute to the passage of successful policies aiming to promote academic entrepreneurship. The most plausible motivation seems to be personal financial gain (Etzkowitz, 1998; Helm and Mauroner, 2007; Martinelli et al., 2008), but also necessity, e.g. absence of potential/interested developer companies or insufficient career opportunities at the university, can motivate faculty members to start a company (Etzkowitz, 1983; Meyer, 2006). However, many authors argue that the primary motivation of university faculty members with entrepreneurial activities was rather the advancement of their academic career (Etzkowitz, 2003a; Franzoni and Lissoni, 2009; Owen-Smith and Powell, 2001) and enhancement of their reputation among peers (Martinelli et al., 2008).

Empirical evidences suggest that there is not a single type of academic entrepreneur but there is a variety of academic entrepreneurs that are different in their motivations and levels of involvement. Meyer (2003) made a distinction between entrepreneurial academics and academic entrepreneurs, arguing that the basic difference is that entrepreneurial academics establish companies that are not necessarily growth-oriented, and they rather focus primarily on their research interest also in the company work.

Shinn and Lamy (2006) differentiated academic entrepreneurs based on the – sequential or permanent – dominance of science- or business related motivations, while Etzkowitz (1998) used the level of involvement as a categorization criterion, arguing that the seamless web type of academic entrepreneur not only makes invention disclosure and takes part in the licensing process, but also helps to set the strategic direction of the company and maybe takes a seat in the board as well. Probably this intensive and deep involvement enables the exploitation of the broadest synergies between academic and business life.

Even against this outstanding importance of academic entrepreneurs, relatively few research works focused on academic entrepreneurship at the individual level (Aldridge and Audretsch, 2011). Some studies analysed the personal characteristics, social and human capital of the faculty (Azagra-Caro, 2007; D'Este and Patel, 2007; DiGregorio and Shane, 2003), but the scarcity of empirical evidence related to the motivation of spin-off founders was striking when we started our work. In this dissertation we aim to investigate this latter issue, the motivation of academic entrepreneurs, the intention that lead them to establish a company.

Further novelty of this research is the Hungarian context in which it is undertaken. The Hungarian university system roots in the German tradition, but it inherited some features of the even more centralized Soviet system. All of the potential institutional setbacks of the continental European system mentioned above are present in Hungary. The government sector carries out more basic research than the higher education sector (Vincent-Lancrin, 2006), there is a centralized funding system, the financial autonomy of the universities is very limited, and faculty members are civil servants, who were not allowed to establish a company before the political system change.

To the best of my knowledge there are only a very limited number of studies dedicated to Hungarian academic entrepreneurship, most of them are related to Katalin Balázs (1996)[1], who found that establishment of firms in Hungary after the transition was usually necessitated by financial constraints. Therefore, it is a highly relevant question

[1] Further studies, like Balázs (1995), Balázs et al. (1995a and 1995b) deal with the Central and Eastern European academic entrepreneurship, including Hungary as well.

to investigate whether academic entrepreneurs led by academic incentives have already appeared since then or whether necessity entrepreneurs still dominate the Hungarian academic entrepreneurial domain.

To eliminate potential biases caused by different fields of operation, we decided to investigate biotechnology spin-off founders. The primary reason for this was my personal motivation. My interest in this branch was awoken in 2008, when I spent a semester at the University of North Carolina at Chapel Hill. The Research Triangle located in the Piedmont region of North Carolina is a prominent example of innovative regional economic development (Youtie and Shapira, 2008) and an outstanding performer in US biotechnology. My experiences gained during making interviews at the technology transfer offices of large research universities in the area, such as Duke, North Carolina State University and University of North Carolina at Chapel Hill, respectively visiting North Carolina Biotechnology Centre have proven to be decisive in shaping my interest.

A further reason was the extremely intense academic entrepreneurial activity observed in this branch. Many authors suggest that there was a co-evolution of biotechnology and academic entrepreneurship (Mowery et al., 2004). The traditional division of basic and applied research is diminishing in biotechnology and research is typically carried out in the Pasteur's quadrant (Stokes, 1997), thus they not only extend the knowledge base, but also have a practical, commercial application prospect as well. Etzkowitz and colleagues (2000) call it a dual cognitive mode, where fundamental knowledge extension and commercialization are both important. These features combined with scientific breakthroughs, like discovery of the recombinant DNA, are likely to contribute to the sharp increase of both academic and traditional entrepreneurial activities experienced in biotechnology.

Considering also the pharmaceuticals and related biotechnology traditions of Hungary, if we fail to identify Hungarian spin-off founders in this sector, than – with the exception of the IT sector – we are very unlikely to be able to find them elsewhere too.

Thus the general investigation area of this dissertation is the individual level, the scientist who takes part in spin-off founding. In particular, what we are interested in is whether the academic entrepreneur triggered by scientific career motivations is present in Hungary or different boosters respond for spinning off activities, and if yes, which types of academic entrepreneurs can be differentiated. The related investigation of the overall framework conditions, in particular at the institutional and university levels, is an inevitable element of a comprehensive analysis.

Our hypotheses at the start of the empirical investigation can be summarized as follows.

H1: Against the relatively unfavourable conditions classical academic entrepreneurs as described by Etzkowitz (1983) can exist in the current university system of Hungary.

H2: The Hungarian university context during the transitional and post-transitional periods offered an unsupportive environment for academic entrepreneurs, thus most of the spin-offs before the Millennium are "backyard farms" and their founders are rather entrepreneurial academics as described by Meyer (2003) than classical academic entrepreneurs.

H3: The university technology transfer offices established after the legislative changes around 2003 and 2005 induced a rapid rise in academic entrepreneurship in Hungary.

The dissertation is structured as follows. The second chapter deals with the entrepreneurial evolution of universities. First it introduces the gradual and continuous extension of academic missions from teaching through research to regional economic development. This latter includes public service activities that have been longer present in the academic domain, like consultancy or external teaching, while academic entrepreneurial forms like patenting, licensing and spin-off – although are not entirely new – only recently experienced a drastic increase in their depth and breadth. After the activities the related types of organisations become in the focus of investigation. Departing from the mediaeval universities, we get through the classical and engaged universities to the entrepreneurial universities. The introduction of the latter provides an insight into the internal and external drivers of the entrepreneurial turn and also offers different definitional approaches of the entrepreneurial university. The entrepreneurial turn of universities coincided with the unfolding of the biotechnology industry, thus the rise of this and the role of universities and academic entrepreneurs in that is also included in the second chapter. Though the importance of biotechnology is a shared characteristic, the American and continental European entrepreneurial turns are realized in fundamentally different institutional contexts that influence the extension of the academic entrepreneur phenomenon.

The third chapter is devoted to the engine of the whole process; to the academic entrepreneur. It discusses in detail one of the most important elements of his entrepreneurial turn, the motivation underlying his decision to start an own company. Besides different types of motivations also further individual characteristics are discussed that seem to be common in the most successful academic entrepreneurs. Additionally, elements of the organisational environment, such as university policies, technology transfer offices, and that of the broader external environment, such as the regional milieu or venture capital funds are discussed to see all the potential factors that can have an effect on the realization of the motivations.

After providing information on the historical evolution of the Hungarian university system Chapter 4 presents the results of the empirical study that we carried out among academic entrepreneurs in the Hungarian biotechnology sector. The introduction of the Hungarian research system allows a better understanding of the limited potential of academic entrepreneurship owing to the historical neglect of universities as research entities and the consequent lack of related experience on the institutional and partly on the individual level as well. This chapter also introduces the biotechnology sector that has a long history as a strategic branch in Hungary and builds the era of the empirical analysis. Based on the interview data a categorisation of the Hungarian academic entrepreneurs is provided that also refers to the effect of potential influencing factors identified in Chapter 3.

Finally, summary and conclusion close the dissertation and envisage some prospective future research avenues.

2. Universities for the benefit of the society

2.1. Introduction

This chapter introduces the gradual extension of university missions and the related institutional evolution of entrepreneurial universities. Universities have long been involved in multiple activities that benefit the regional economy, but the set of outputs through which research universities enhance economic development became much broader over time (Varga, 2009). Universities now may be understood as multiproduct organizations including a large variety of outputs (Luger and Goldstein, 1997). From the creation of knowledge through building human capital and conducting research, they are also involved in the transfer of know-how and technological application of knowledge to create and commercialize new products. Additional ways of their involvement in the regional economy are capital investment, leadership in addressing social problems, coproduction of knowledge-based infrastructure and the creation of a favourable milieu (Goldstein, 2009; Luger and Goldstein, 1997).

After shortly describing the teaching and research tasks, the chapter provides a detailed analysis of the regional economic development contribution of universities. After describing some indirect and direct forms, we analyse in detail the entrepreneurial activities of universities. We make a distinction between the public service related missions, like consultancy or external teaching and academic entrepreneurship that encompasses patenting, licensing and spin-off activities. As it will be described, the separation is reasoned by the different direction of influence in university-business interactions and the impact of these tasks on the university organisation and scientific norms (Gulbrandsen and Slipersaeter, 2007; Goldstein, 2010). After the introduction of the change in the missions this chapter describes the different university settings that hosted various mix of these missions starting from the middle ages' universities through the ivory towers and engaged universities and finally arriving to the entrepreneurial universities. Since these latter are in the focus of our investigation, external and internal forces that led to the entrepreneurial turn of universities will be discussed, just like the different definitional approaches applied in the literature to describe the merit of this organisation. Additionally, a short discussion of the relationship of the entrepreneurial university to the preceding and partly co-existing university types will be offered. Owing to its special role in the entrepreneurial turn, the evolution of biotechnology and its peculiarities must be introduced in a bit more detail. The pace and stage of academic revolutions seem to differ between continents, namely the regional development mission in the USA and some Anglo-Saxon countries is more pronounced than in the rest of the world. Consequently, institutional differences of the Anglo-Saxon and the continental European systems as potential explanatory factors of this phenomenon deserve a closer attention at the end of the chapter.

2.2. Missions

> "The U.S. university system has compiled an admirable record of teaching, research, public service, and contributions to the U.S. and global economies during this century. A key challenge for the next century is maintaining a balance among these missions."
> Mowery et al. (2001; p. 118)

2.2.1. The core missions – teaching and research

Although it is recently relatively neglected in the literature on universities (Goldstein, 2009), skilled labour force is one of the most fundamental elements of the competitiveness and development of any regions (Luger and Goldstein, 1997). Teaching has been the oldest form of contribution of universities to the wealth of the society, and this was their primary role from the industrial perspective as well (Etzkowitz, 1998). Goldstein (2002) argues that the creation of human capital is still one of the major contributions of universities to regional economic development.

Geuna (1999) claims that the teaching function was originally related to the preparation of students (scholares) for education, ecclesiastical, government and professional careers. There was a continuity of curriculum starting with the seven liberal arts divided into apprentice (grammar, logic and rhetoric) and bachelor (arithmetic, geometry, astronomy and music). The next stage included the three advanced professional courses that were followed by postgraduate faculties (theology, law and medicine). (Geuna, 1999)

Over time teaching environments and methods went through significant changes. The originally elite education faced with a dramatic increase in the number of students after the Second World War that led to massification of teaching (Geuna, 1999). The traditional classroom was complemented and partly shifted by distant education (Goldstein, 2009).

The first academic revolution in the 19th century added research to the core missions of universities (Etzkowitz and Leydesdorff, 2000). We can distinct between basic and applied types of research. Basic research primarily aims at the extension of the area of fundamental understanding, whereas applied research is usually directed towards practical applicability, e.g. individual, group or societal need (Stokes, 1997). Basic research usually ends in public good type of knowledge (Goldstein, 2009), characterized by non-rivalry, non-excludability, very low marginal cost of duplicating (Geuna, 2001) and generally wide geographic impact (Luger and Goldstein, 1997). Owing these peculiarities, governments are more likely to fund basic research than industry is (Luger and Goldstein, 1997; Goldstein, 2009).

The integration of research, the creation of knowledge and teaching, the dissemination of new knowledge is a vital element of the modern research universities. The responsibility of university professors was enhanced behind teaching, and they became "single-discipline professors focused on the advancement and transmission of a specific, well-defined portion of knowledge" (Geuna, 1999; p. 45).

2.2.2. Regional economic development

The second academic revolution added regional development as an explicit task to the already accepted core missions of teaching and research (Etzkowitz, 1998). This mission covers a variety of contributions (Goldstein and Glaser, 2012). Some of the regional economic development impacts seem to be a kind of co-product on the side of the core missions, like for example establishment of the *knowledge infrastructure* and creation of a favourable *milieu*[2] (for detailed case studies on this see Perry and Wiewel, 2005). The creation of knowledge infrastructure and a favourable milieu both are related to the teaching and research functions of universities, since they provide the necessary framework of those. But at the same time, the availability of knowledge in forms of books and researchers, and facilitation of knowledge flows within the scientific and business world can enhance the productivity of a particular region (Goldstein, 2009). Also some part of the *capital investment* activities of universities can be related to the core missions in forms of building of classrooms, laboratories, administrative offices, but they also serve the interest of the broader region with roads, power stations, recreational facilities (Goldstein, 2009). Directly business-related capital investments include the establishment of research and advanced technology parks (Luger and Goldstein, 1997).

[2] Although these activities also include some risks and possible negative effects, like more expensive housing, conflicts related to tax-exemption, for details see Goldstein (2009) and Luger and Goldstein (1997).

A further and more direct regional development targeting activity of universities is the participation in *regional leadership and governance*. By taking seats in local and regional boards and commissions addressing social, environmental and economic issues and the participation in policy and strategy creation universities contribute to increasing the quality of life (Luger and Goldstein, 1997). Universities play a double role in regional leadership: they provide technical expertise and moral authority at once (Goldstein, 2009). Their involvement has a symbolic importance for the city or region, but at the same time it serves the universities' institutional goals through greater control of their resource flow (Goldstein and Glaser, 2012).

All of the above mentioned activities contribute to regional economic development, since density of a high-quality knowledge infrastructure and a high quality of life can generate a local buzz and attract talented, creative people. The advantages of a strong and diversified creative class contributing to sustainable economic development are already described in the literature (see for example Florida, 2005).

However, the recent scientific literature puts more emphasis on *entrepreneurial activities* of universities enhancing regional economic development. These include activities that have long been present in the academic domain, like e.g. external teaching and consulting services provided by faculty members, the outreach or extension services of the institutions, contract research and industrial cooperation. These seem to be already accepted by faculty members and are embedded in the academic culture. On the other hand, patenting, licensing and spin-off activities, which attract larger attention of researchers and politicians as well, appear to be controversial in many aspects, so these are investigated separately below.

2.2.2.1. The first wave of commercialization: public service

Though different labels are used by researchers of the field, like user-directed commercialization (Gulbrandsen and Slipersaeter, 2007), commercialization (Jacob et al., 2003), transfer of existing know-how (Luger and Goldstein, 1997) or technical assistance (Goldstein, 2009), usually they refer to the same group of activities that have the common feature of being widely recognized and accepted as beneficial for the society.

This type of contribution can take various forms and includes outreach or extension activities of universities, and public service in forms of consultancy, expert advice and custom made further education services[3]. Goldstein (2009) argues that the output is often realized through small business assistance centres, industrial and agricultural extension centres, clinical programmes and economics and business research bureaus. He mentions the Manufacturing Extension Partnerships (MEPs) or the Small Business Development Centers (SBDC) as well-known good practices.

Consultation can be considered as the traditional form of connection between universities and private firms (Etzkowitz and Peters, 1991) that has already been at work in the 19th century German chemistry and is largely compatible with accepted academic standards (Etzkowitz, 1983). Its general acceptance is also reflected in the one-fifth rule that permitted external activities for faculty one day a week (Etzkowitz, 1983), though there is disagreement whether it applies for working (5 days) or calendar (7 days) week (Etzkowitz and Peters, 1991). Extension services of universities provided through faculty consultation can take place paid or pro bono as well (Luger and Goldstein, 1997).

External teaching has been long present in the academic domain (Bok, 2003). In frame of cooperative extension starting in the 19th century as the earliest form of 'institutionalized public service', university agents were sent to rural areas with the task to disseminate agricultural research results to agricultural producers (Goldstein, 2010). Owing it to its explicit economic development objective, these activities usually have steep spatial gradient (Luger and Goldstein, 1997). Later also industrial extension set off, where agents delivered the latest engineering results to manufacturing firms (Goldstein, 2010). Outreach contributions included important inventions, like the test for milk butterfat content by Professor Stephen Babcock (Goldstein, 2010), and success stories like the Manufacturing Extension Partnerships (Goldstein, 2009).

All of these activities relate to the more traditional concept of the third mission of universities (Goldstein, 2010). Luger and Goldstein (1997) argue that they aim problem solving or the improvement of a product or process through the application of existing know-how and unlike research and teaching they explicitly target regional development. They also highlight that this type of commercialization can often be combined with the core missions, teaching and research and is similar to those with the difference that the clients here are not students but private and public sector organizations.

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[3] Goldstein (2010) argues that social entrepreneurship in form of establishment of innovative organizations or programs addressing societal problems also overlaps with public service and they are often referred to as engagement.

Also Gulbrandsen and Slipersaeter (2007) argue that these activities have a synergic relationship with traditional missions of universities and have been long present at universities. They call it traditional mode of commercialization or user-directed commercialization to emphasize the central role of the clients such as industry and other users. Cohen and colleagues (2002) argue that these[4] are still among the most important channels through which university research impacts industrial R&D.

2.2.2.2. The second wave of commercialization: academic entrepreneurship

This wave of commercialization intensively draws the attention of scientist and policy makers since the second half of the 20th century. Similarly to the first wave of commercialization, these activities also got different labels in the recent scientific literature, like science-directed commercialization (Gulbrandsen and Slipersaeter, 2007), commodification (Jacob et al., 2003) or technological innovation (Goldstein, 2009). Usually they aim to produce inventions with commercial potential (Goldstein, 2009), so the application of knowledge targets the creation and commercialization of a new product or service, what often happens through corporate laboratories (Luger and Goldstein, 1997).

The most common activities that belong here are related to the involvement of universities in patenting, licensing and spin-off processes, but Grimaldi and her co-authors (2011) mention here also university-industry partnerships.

According to the widely accepted definition of the World Intellectual Property Right Organization, "a patent is an exclusive right granted for an invention, which is a product or a process that provides a new way of doing something, or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years" (WIPO). *Licensing* agreements enable universities to earn revenue from a company in return for using the invention of the university. This revenue can take the form of upfront fees at the time of issuing the agreement, and annual royalty payments contingent upon the commercial success of the invention (Feldman et al., 2002). The benefits of a license are mainly that it allows the inventor and the organization to capitalise on the technology and at the same time, it does not demand too much time of the scientist for business issues (Lockett et al., 2003).

[4] Together with publications, conferences, meetings, and informal information exchange (Cohen et al., 2002).

Patenting of university faculty dates back to the 19th century (Etzkowitz, 1983) but their proliferation in the academic domain only occurred in the second half of the 20th century, mainly starting from the 1970s onward[5]. The number of patents issued to US universities and colleges between 1979 and 1997 increased from 264 to 2,436 (Mowery et al., 2001 based on USPTO data). Universities also increased their efforts to license patents. As a result the related income of AUTM universities increased from USD 222 million in 1991 to USD 698 million in 1997 (Mowery et al., 2001 based on AUTM data of 1998). Between 1996 and 2007 the number of inventions disclosed increased form 67.1 per institution to 131.1, while new patent applications more than tripled from 23.2 to 77.6 (Thursby and Thursby, 2011 based on AUTM data). Some argue that this increase can be owed to the passage of the Bayh-Dole Act (on the details of this Act see Chapter 2.3.4.1), but others (Mowery et al, 2001; Mowery et al., 2004) emphasize that it simply reflects the acceleration of trends, mainly in biomedical areas, that had already been at work before 1980[6]. Geuna and Nesta (2006) reached similar conclusion in European context about the importance of biotechnology in increased patenting activity.

Henderson and colleagues (1998) claim that the rise in the number of university patents was guided by a decrease in their importance and generality both in case of universities with long history in patenting and in case of new entrants of the field. However, a subsequent analysis by Mowery and Ziedonis (2002) found no evidence of quality decline in case of incumbent universities, and mixed evidence for entrants. Furthermore, Mowery and colleagues (2002) argue that the importance of entrants' patents improved between 1980 and 1990, suggesting learning by new institutions, the sources of which remain unclear. Using a longer stream of patent citation data Sampat and colleagues (2003) did not find evidence for the quality decline mentioned by Henderson and her co-authors.

Spin-off activity also dates back to the 19th century. It has its roots in consulting firms, like e.g. Arthur D. Little Company or Raytheon Company and it meant an extension of individual consultancy when high demand required an increase in human capital (Etzkowitz and Peters, 1991). However, establishment of a firm involved in production was rather the exception than the rule before 1980 – mainly concentrating in leading institutions like MIT or Stanford (Etzkowitz and Peters, 1991). The generally low enthu-

[5] The reasons of this are related to the normative change in the academia, for details see Chapter 3.
[6] Chapter 2.3.5. deals in detail with the role of biotechnology in the entrepreneurial turn of universities.

siasm of universities towards spinning off a firm is related to its higher complicatedness compared to licensing (Wright et al., 2004).

Nevertheless, in many cases commercialization through licensing is not easily executable (Franzoni and Lissoni, 2009). Different characteristics of an invention, a patent or that of a technology regime can increase the likelihood of firm establishment. For example, broad scope of patent rights, technologically radical and important inventions tend to be commercialized through firm formation (Shane, 2001a). Technology regimes characterized by younger technical fields, by markets with segmentation tendency, by business lines with more effective patens and less important complementary assets in marketing and distribution are also likely to experience higher spin-off activity (Shane, 2001b).

Furthermore, success stories like Genentech, Cisco Systems or Netscape Communications, that all had the origin as academic spin-outs (Lerner, 2005) attracted the attention of university administrators as well. To reap the benefits of knowledge spillovers, university spin-offs tend to locate close the parent organisations (Audretsch et al., 2005), and their clustering can significantly contribute to regional economic development[7]. Etzkowitz and Dzisah (2008b, p. 654) note that "MIT-related companies employ about 1.1 million people and have annual world sales of US$232 billion. This 1997 output was at the time comparable to a gross domestic product of US$116 billion, which was a little less than the GDP of South Africa and more than the GDP of Thailand."

Although they reflect a definitely different scale, also some successful European high-technology regions can be identified, e.g. Oxfordshire in the UK where some 114 companies originated in the regions' universities and research laboratories employed some 9,000 people in 2002, generating a total turnover nearly 1 billion pound (Lawton Smith and Glasson, 2005).

The definition of spin-offs is nearly not standard. Wright and colleagues (2007; p. 4) for example defined its merit in accordance with the AUTM survey as "new ventures that are dependent upon licensing or assignment of an institution's IP for initiation", and they extended it with faculty start-ups without formal assignment of the university's IP, but which draws on the scientist's IP or knowledge. However, they did not include

[7] However, the spatial gradient of the regional economic development impact of universities is a subject of change based on industrial sectors, ownership status and size of firms and size of city (Varga, 2002).

companies of graduates established after graduation and firms created by outsiders, even if they draw on university owned IP. The OECD (2000) definition claims that a company should be labelled as spin-off if it meets one of the following criteria: it is established by the employee of a university or an other public research organisation; it acquired the underlying technology from a university or an other public research organisation through licensing agreement; it has a capital investment from a university or an other public research organisation; it is established by a university or an other public research organisation.

Gulbrandsen and Slipersaeter (2007) argue that professors were involved in not only in industrial collaboration, but also patenting, licensing and spin-off not later than since the end of the 19th century, but over time there has been a dramatic change in their role. Around the 1980s the term academic entrepreneurship started to spread in the scientific literature to signal the central, actually leading role that scientists took in the entrepreneurial processes. Also the term science-directed commercialization used by Gulbrandsen and Slipersaeter (2007) highlights the importance of *faculty member as the engine* of the whole technology transfer process[8].

In contrast to the activities described in the previous part of the chapter, patenting, licensing and spin-off are much more controversial compared to the user-directed commercialization methods and they are not accepted everywhere and by everyone. The main tensions and risks are related to the norms of open science or, as Goldstein (2009) called, to the treatment of knowledge as a public good or as a commodity.

The separation of user- and science-directed commercialization is not clear-cut and commercialization processes are usually not linear (Gulbrandsen and Slipersaeter, 2007). Additionally, both basic research and industry funded research can lead to inventions with further commercial potential in forms of patenting, licensing or spin-offs (Goldstein, 2009). The spread of the second wave of commercialization – as we labelled it – also does not mean that consultancy or other ‘more traditional’ extension services would be abandoned and fully replaced by patenting, licensing and spin-offs with the intensification of academic entrepreneurship. It rather points to the fact that there seems to be a restructuring or a shift in the activity portfolio of universities that appears to put

[8] On the importance of the scientist in the second academic revolution see Chapter 3.

academic entrepreneurship in the forefront with the unfolding of the entrepreneurial turn of universities which is the theme of the next part of the chapter.

2.3. Institutions – Evolution of the entrepreneurial university

> "Universities are *the* institutions with the resources to provide
> the stream of knowledge, know-how, and human capital […]
> as the fuel for innovation, entrepreneurship, and regional synergy."
> Luger and Goldstein (1997, p. 105)

As it has already been mentioned in the previous part of the chapter, the contribution of universities to regional economic development may take different forms and was always broadened over time. The authentic mission of universities was teaching that was complemented with the research function. This process took place in the 19th century in frame of the first academic revolution. The second academic revolution in the 20th century added regional economic development to the explicit missions of universities. Neither of the revolutions was without controversy (Gulbrandsen and Slipersaeter, 2007), but as Geuna (1999) highlights, universities always adjusted themselves to the changing environment by incremental institutional innovations throughout their 800 years history. This continuous series of adjustments led to the evolution of modern universities. Thus to understand their current state one should apply an historical approach. He also argues that four (and an additional) phases of the historical development of universities can be identified:

1. Birth of the university between the late 12th and early 16th century.
2. Period of decline from the second part of the 16th century until the end of the 18th century.
3. Recovery and German transformation from the 19th century until the Second World War.
4. Expansion and diversification from the end of the Second World War until the end of the 1970s.
5. Institutional reconfiguration.

The first phase is about the mediaeval university, whereas the second can be considered as a for-runner of the first academic revolution that resulted in the evolution of the 'classical' universities in the third phase. This latter period also includes the evolution of 'engaged universities' as Martin and Etzkowitz (2000) called, and the fourth phase is the era of the linear innovation model of Bush (1945) which can be considered as a for-runner of the entrepreneurial university that evolved in the second half of the 20th century during institutional reconfiguration. From our point of view phase 1, 3, 4 and 5 are about crucial importance.

The changes in the missions and environment of universities went hand in hand with the change of the universities themselves from teaching only organizations through modern research universities to entrepreneurial universities. This part of the chapter provides an insight into the historical evolution of universities by trying to connect the missions with the appropriate organizational forms. It starts with a short introduction of the middle-ages' university and the first academic revolution with the resulting 'classical university' model. Then it describes in detail the second academic revolution including all the internal and external factors that boosted the change and the entrepreneurial university model, devoting a separate sub-chapter to the role of the biotechnology in the entrepreneurial turn and its peculiarities. It also introduces the institutional differences between the Anglo-Saxon and continental European university systems that predict a somewhat different route for the European academic entrepreneurship.

2.3.1. Mediaeval universities

> "The evolution of the mediaeval university represented
> the birth of one of the most significant and maybe
> most timeless institutions of the European culture circle."
> Ferencz (2001; p. 33)

Geuna (1999) argues that universities are all European creations and the predecessor of the modern university, the 'studium generale' evolved in the Middle Ages between the 12th and 13th centuries. The most prominent representatives of this type have been Paris (theology and philosophy) and Bologna (law), but also the centre of mathematics and natural sciences, Oxford can be mentioned here (Ferencz, 2001). Earlier centres of higher learning like the philosophy school of Athens (4th century before Christ), the school of Beirut (flourished between the 3rd and 6th centuries) or the "university" of Byzantine (425–1453) cannot be comprehended as predecessors of the mediaeval universities, since they lacked the emphasized organizational/corporate features of the latter, and there is no institutional/organizational continuity between them either (Ferencz, 2001).

Geuna (1999; p. 40) stresses that the studium generale incorporated three important rights: (1) the jus ubique docendi which meant awarding of masters or doctoral degrees that were generally acknowledged in the Christendom, (2) papal or imperial protection from “local, religious and lay authority”, and (3) clergy studying entitlement ‘to receive the fruit of their benefices’.

Martin and Etzkowitz (2000) emphasize two important functions of mediaeval universities: providing teaching for public servants, priests, and offering scholarship in various disciplines (medical, classical etc.). They argue that later on a diversification of teaching took place according to its aim; either to develop full potential of the individual student or training people based on the societies’ needs. The relationship of universities with the key external actors; church, monarch or government and industry was fundamental in shaping the evolution of universities (Martin and Etzkowitz, 2000). Nevertheless, they “were all members of a ‘super-national’ intellectual unity devoted to the cultivation of knowledge, enjoying a certain degree of independence from the papacy, the empire and the municipal authority” (Geuna, 1999; p. 42).

However, the legal, political and theoretical independence that universities enjoyed against the temporal power disappeared by the 15th century and universities became political battlefields (Borbély, 2001).

2.3.2. ‘Classical’ universities – The ‘ivory towers’

> “[…] the development of the German university during the nineteenth century can be seen as a result of the interaction between a new social organisation of science, the Humboldtian model, and a new structure of science – that is, the spontaneous trend towards the subdivision of knowledge into scientific fields.”
>
> Geuna (1999; p. 46)

During the 17th and 18th centuries scientific research was carried out in scientific societies and academies whose members started to develop an international scientific community along the norms of open science (Geuna, 1999; Tóth, 2001), whereas research was not part of the professors' duties at universities (Jonsson, 2006), consequently university education and scientific research were practically independent (Békés, 2001). Békés (2001) argues that though university professors were required to be experts in their subject areas, personal scientific results were neither expected nor supported by the institutions; university professors conducted research only in their spare time if at all. However, as scientific societies and academies became unable to adjust to the specialization of knowledge that was required by the professionalization and emergence of new scientific fields, the world of research opened for universities that earlier played only a peripheral role in knowledge generation (Geuna, 1999).

Although the Humbolditan university is most frequently mentioned as the fundament of modern research universities, the traces of the 19th century changes date back until the 18th century. Universities of the Scottish Enlightment could be mentioned here (Rothblatt, 2006), since subject specialisation, one of the key features of the new universities, first appeared in Scotland and a century later this influenced the German and French university revolutions (Geuna, 1999). Additionally, the concept of the Gottingen research university, developed in the 18th century, strongly affected the German and Russian and Hungarian (both influenced by the German system) scientific research until the first third of the 19th century (Békés, 2001).

Békés (2001) highlights that scientific research became an explicit professional requirement for university professors in Gottingen that has been carried out with the cooperation of students as part of the curriculum and was supported by appropriate infrastructures (library, laboratories, etc.). Instead of being expert in all fields, professors focussed on specialized subjects (Geuna, 1999). This complex programme was fundamentally different from all previous and later research programmes and served as the basis of the Humboldtian reform ideas in the 19th century (Békés, 2001).

With these antecedents, the first academic revolution in the 19th century added research to the already existing teaching mission of universities (Etzkowitz and Leydesdorff, 2000; Frängsmyr, 2006). The transformation of the mediaeval university resulted in the classical universities that were characterized with the pure or immaculate ethos that meant teaching and research 'for its own sake' (Martin and Etzkowitz, 2000). However, at this point we also have to note that the permanent modernisation of the European universities – tracing back until the comprehensive (but precisely opposite) reform measures of Napoleon in France (1808) and Humboldt in Germany (1810) – lasted until the 1960s and the resulting university models strongly influenced the reform of other European university systems as well (Tóth, 2001). Tóth (2001) argues that – though choosing different routes to achieve it – the envisioned university of both reformers was a modern institution that develops and disseminates knowledge of direct or indirect societal benefit and also educates legal, political, engineering and military elite.

Geuna (1999) highlights that modern research universities are national institutions preparing for professional careers and creating knowledge for the benefit of the nation-state. They retained some elements of the mediaeval university and added scientific research by merging the methodologies and social organisation of academies and societies with the new disciplinary subdivision of knowledge that resulted in "[a] new social organisation' of science and a new classification of science developed" (Geuna, 1999; p. 46).

Against the shared features, there were some national differences among universities (Geuna, 1999). In the *Cardinal Newman university* in Britain independent professors pursued knowledge for its own sake and taught it to students, whereas in the German version, the *Humboldt model*[9] this was complemented with the unity of teaching and research (Martin and Etzkowitz, 2000), thus teaching and research had to be conducted within the same institution (Martin, 2003).

Also Goldstein (2010) highlights the importance of inseparability of learning and research, just as the academic freedom for professors[10], and the unity of science and scholarly inquiry in general. The universities could freely decide on the allocation of general governmental funding across disciplines, and scientists could freely choose their research topics that typically demanded 30–50% of their time (Martin, 2003). The German model, that also incorporated discipline-based division, had the greatest influence on the evolving new university species (Geuna, 1999).

The European classical university models were later on transferred to the USA and Japan, resulting in the *'Ivy League' university* and *imperial* (subsequently national) *uni-*

[9] Some authors (Geuna, 1999 Wittrock, 2006) note that the Humboldtian concept as a whole was realised mainly if not only in the Friedrich-Wilhelms-University of Berlin established in 1810.
[10] Though Martin and Etzkowitz (2000) argue that autonomy was more important for 'classical universities' in other countries. Also Goldstein (2010; p. 86) mentions that "German universities were otherwise highly undemocratic, hierarchical and authoritarian organizations".

versity, respectively (Martin and Etzkowitz, 2000; Martin, 2003). The first research university in the USA that has been built on the grounds of the Humboldtian concept was the Johns Hopkins Research University established in 1876 (Békés, 2001), later on followed by more private and wealthy universities (Goldstein, 2010).

2.3.3. 'Engaged' universities

Similarly to classical universities, also engaged university covers not one, but more university species, like technical and regional universities, which again may consist of several types of institutions[11].

Technical universities include various organizations, like institute of technology or polytechnic emerging in Europe, and later on transferred to the United States, Japan and elsewhere (Martin and Etzkowitz, 2000). Martin and Etzkowitz (2000) mention the French Ecole Polytechnique as one of the earliest examples of a technical university, which was assumed to train engineers and to serve the military needs of the country. Further examples are the German and Swiss 'high schools', British institutes of science and technology (like the Imperial College in London), the American MIT and Caltech, the Italian polytechnics in Milan and Turin, and the Japanese Tokyo Institute of Technology (Martin and Etzkowitz, 2000).

Regional universities include two main types of institutions; the European regional colleges and American land-grant universities. The former aims the development of a region in economic, industrial or cultural sense (Martin and Etzkowitz, 2000).

The other type of regional universities is the land-grant university that arose in the USA in the second half of the 19th century with the aim of meeting local or regional needs (Martin and Etzkowitz, 2000). To support agricultural development, the Morrill Act, passed in 1862, granted government owned land to universities (Etzkowitz et al., 2000). The Massachusetts Institute of Technology (MIT) was established in the same year as a land-grant university (Etzkowitz, 2003a). The exceptional treatment of agriculture was reasoned by its outstanding role as in the early 19th century this was the major industry in the US (Etzkowitz and Peters, 1991).

[11] Martin and Etzkowitz (2000) treated 'technical' and 'regional' (including 'land grant') universities separated, however, also they note that the land grant universities might be regarded as a special type of technical universities. In this chapter we group them together under the umbrella of 'engaged' universities, since regarding our investigation this seems to be more appropriate.

Goldstein (2010) argues that the contemporary form of land-grant universities is often referred to as the engaged university.

> *"Engagement is the partnership of university knowledge and resources with those of the public and private sectors to enrich scholarship, research, and creative activity; enhance curriculum, teaching, and learning; prepare educated, engaged citizens; strengthen democratic values and civic responsibility; address critical societal issues; and contribute to the public good."*

CIC Committee on Engagement in Goldstein (2010; p. 88)

The joint treatment of technical and regional university species under the umbrella of 'engagement' is reasoned by the fact that they all seem to meet the above definition. As also Martin and Etzkowitz (2000; p. 10) argue, "there is an element of ambiguity in such classification decisions", but all of these institutions seem to be to some extent involved in what we called the first wave of commercialization – the public service activities. Accordingly, they consider knowledge as public good (Goldstein, 2010). The technical university can be characterized by the instrumental or utilitarian ethos of university, which means that their role "is to create and disseminate useful knowledge and to train students with skills useful to the society" (Martin and Etzkowitz, 2000; p. 10) and in our view approximately the same holds for regional universities. Goldstein (2010; p. 87) argues related to land-grant universities that "[m]any now often refer to this model in its contemporary form as the *engaged university*."

As Martin and Etzkowitz (2000) highlight, the modern university species discussed in the previous sections did not dominate exclusively within a country, but there were usually at least two types co-existing, like for example the Humboldt and technical in Germany or the universities and grandes écoles in France. The US witnessed an even larger variety with the presence of the Ivy League universities, land-grants, 'liberal arts' colleges and institutes of technology. A special feature of this system was the presence of hybrid institutions, e.g. the Cornell that was positioned between the Ivy League and the land-grant (Martin and Etzkowitz, 2000).

Martin and Etzkowitz (2000) argue that there was a permanent competition between the pure or immaculate and the instrumental or utilitarian ethos regarding the university's purpose. They insist that during the early period of the 20th century the pure ethos started to dominate and this was accompanied by the prominence of the Mode 1 knowledge production. In Mode 1 knowledge production occurs along disciplines and with the division of the theoretical core (fundamental knowledge) and other (applied) knowledge areas (Gibbons et al., 1994). Mode 1 knowledge production usually takes place in universities and other academic institutes and has limited direct connection to societal needs, and the knowledge primarily produced within scientific disciplines is transferred at the end of the projects (Martin and Etzkowitz, 2000). "The basic research model of science was ascendant from the mid-19th century to the mid-20th century" (Etzkowitz, 2003a, p. 119).

The dominance of the pure ethos evolved "in the late nineteenth century to protect a relatively weak academic sphere from untoward outside influences" (Etzkowitz and Leydesdorff, 1998; p. 205) and in the 1920s it led to an effort to ban even the traditional consultancy activity, but these attempts were not successful (Etzkowitz and Peters, 1991). The pure ethos became even more evident in the period following the Second World War, primarily resulting from the war-time contribution of science that was best exemplified by the Manhattan Project and entitled scientists to apply for general support and low accountability.

Acknowledging the breakthroughs achieved, Franklin Delano Roosevelt, President of the United States commissioned Vannevar Bush to make suggestions how it was possible to turn military inventions into civil products increasing the wealth of people, without compromising the nation's security. Bush's report titled 'Science: The Endless Frontier' was published in 1945 and introduced a linear 'science-push' model of innovation, where there is a one-way flow from basic research through applied research, technological development and final innovation (Martin and Etzkowitz, 2000). As Stokes (1997) highlights, besides this dynamic version of postwar paradigm, a further important element of Bush's concepts was the static version of the postwar paradigm reflected in the rigid division of basic and applied research – in the belief that former could be best performed by universities (Martin, 2003). Actually, the linear model meant the culmination of the basic research concept that arose in the late 19th century (Etzkowitz and Leydesdorff, 1998). It argued for a division of labour between the actors of innovation; "universities performed basic research, government laboratories did applied, and industry innovated by moving products to the market" (Slaughter and Rhoades, 2005; p. 544). Bush (1945) called for the establishment of a federal agency responsible for funding of basic science in all areas and he was also an advocate of institutional funding instead of project funding (Mowery et al., 2004) and argued for the institutionalisation of the peer-review system in resource allocation (Martin, 2003).

Mowery and his colleagues (2004) argue that though at the end various agencies and not a single one was responsible for science funding, that actually happened on a project basis instead of the proposed institutional one, the federal R&D support of universities increased considerably in the post-war period, especially in basic research fields. Thus a new social contract emerged on the basis of the simple model that worked from 1945 until the late 1980s and provided sufficient autonomy to universities that was accompanied with low level of societal accountability (Martin and Etzkowitz, 2000).

2.3.4. Entrepreneurial universities

Nevertheless, societal needs were not entirely disregarded even between 1945 and 1980. Even though the research grants did not require short-term practical uses, "eventual utility was part of the post-war 'social contract' between scientists and government" (Etzkowitz et al., 2000; p. 318). Martin and Etzkowitz (2000) insist that though Mode 1 was prominent during 1945–1980, also much *Mode 2* took place due to the funds coming from mission-oriented agencies that also considered societal needs. "Mode 2 knowledge production is transdisciplinary. It is characterised by a constant flow back and forth between the fundamental and the applied, between the theoretical and the practical" (Gibbons et al., 1994; p. 19). Research is undertaken also in institutions other than universities as well, and sectoral differences between university and industry start to be blurred (Martin and Etzkowitz, 2000). A shift can be observed in the experimental design as well inasmuch it shows more and more elements developed in the industrial research context (Stokes, 1997). Martin and Etzkowitz (2000) argue that this model represents higher level of social accountability and consideration of societal needs (application possibilities) from an early stage.

The consideration of potential practical use of science is also underpinned by Mowery and his colleagues (2004; p. 184) who note that many universities and researchers in the USA were characterized by a "relatively utilitarian research orientation [...] throughout the twentieth century". Mowery and Sampat (2005) argue that US university research in the late 19th and 20th century focused on fundamental scientific questions and solving of practical problems in agriculture, public health and industry at the same time. This view is strengthened by Slaughter and Rhodes (1996; p. 307) who insist that "[i]n narrations about science and technology policy it was always difficult to include resource providers in the plot of the post-World War II basic science narrative because science was portrayed as autonomous and scientists as beholden only to truth (Slaughter 1993a). Nonetheless, academic researchers depended on the mission agencies, organizations with applied goals, for the vast majority of their research funds." University researchers actually contributed to innovations in medical devices, scientific instrumentation, and computer software (Mowery et al., 2001).

Around the end of the 1980s there seems to be a fundamental shift in the share of the pure and *utilitarian ethos* in favour of the latter, guided by a shift in *Mode* 1 and *2*, again in favour of the latter. The ascendance of the utilitarian ethos coincided with the second academic revolution that resulted in the rise of entrepreneurial universities. Though also the first academic revolution has not ended yet, the second one broadened the existing missions of universities with regional economic development as an explicit task (Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000; Etzkowitz et al., 2000; Göktepe-Hulten and Mahagaonkar, 2010). Henry Etzkowitz argued in his frequently cited paper 'Entrepreneurial Scientists and Entrepreneurial Universities in American Academic Science' (1983) that the evolution of entrepreneurial universities is a natural phenomenon that is boosted by internal and external factors as well.

2.3.4.1. External forces of the entrepreneurial turn[12]

Among the external factors one can mention the end of Cold War that "lessened the force to military justifications" (Etzkowitz and Leydesdorff, 1998; p. 206) and drastically reduced the need for some physical and engineering research fields (Martin and Etzkowitz, 2000). The shift is also reflected on the policy level, as Slaughter and Rhoades (1996; p. 303) highlight: "Over the past fifteen years, the policy issues—defense and health—that preoccupied the Washington, D.C.-focused science and technology policy community since World War II have changed substantially." Though the traditional cul-

[12] By entrepreneurial turn of universities Goldstein (2010; p. 84) meant "(1) the active involvement of universities—as institutions—in the development and commercialization of technology stemming from university-based research; and (2) changing the internal regulations, rewards and incentives, norms of behavior, and governance of universities to remove barriers to individual faculty, other researchers, and research centers/institutes engaging in behavior that leads to the commercialization of university-generated knowledge."

tural and military legitimations for support of science still hold[13] (Etzkowitz and Leydesdorff, 1998), during the 1980s a *competitiveness agenda* was evolving that overshadowed the military-industrial and medical-industrial complexes and provided new rationale for R&D policy (Slaughter and Rhoades, 1996).

This is partly connected to another external influence, the growing importance of *new technologies*. Martin and Etzkowitz (2000) emphasize the strong basic research dependence of information and communication technologies (ICT) and biotechnology[14] and highlight the increased pressure on universities to contribute to the nations' competitiveness in a *knowledge-based economy*. Knowledge-based economies substantially rely on the production and utilization of knowledge. The shortening of the time gap between the born of an invention and the mass production of the related good is crucial to maintain competitive advantage of a firm and increase the wealth of a nation. Luger and Goldstein (1997) argue that the ability of regions to survive in this competitive environment is dependent upon the universities as generators of knowledge and skilled labour.

Changes in regional economic conditions, globalization of input and product markets and the increase of knowledge intensity as a production input jointly contributed to the importance of higher education in regional and economic development (Goldstein, 2009; Goldstein and Renault, 2004). Besides competition, also *globalization*[15] means a challenge to science and technology that are considered as "strategic, competitive resources that nations have to use to maximum advantage" (Martin and Etzkowitz, 2000; p. 15).

The new challenges were guided by *constraints on public expenditure* that resulted in an increased need for accountability in science and technology as well (Martin and Etzkowitz, 2000), both of which lead to the weakening of universities' independence and status (Geuna, 1999). The sharp *increase in the costs* guided by the stagnation of income urged universities to seek for additional funding (Chiesa and Piccaluga, 2000; Etzkowitz, 1983). The willingness of university administrators to ensure this was further

[13] Though in the paper published in 1998 the military was assumed to hold only "to some extent" (Etzkowitz and Leydesdorff, 1998), "[t]he invasion of Iraq had broad bipartisan support, creating conditions for the Cold War coalition to reemerge as the War on Terrorism, greatly increasing the budgets of DOD and defense-related agencies such as Homeland Security" (Slaughter and Rhoades, 2005; p. 566).
[14] On the detailed role of biotechnology see the next section; Chapter 2.3.5.
[15] Also the globalization of higher education (Martin and Etzkowitz, 2000).

increased by the *falling enrolment* figures coupled with expensive, sophisticated equipment and rapidly rising salaries (Luger and Goldstein, 1997) that created a financial pressure.

The already mentioned competitiveness agenda boosted by the fear that the US lags behind in competitiveness compared to Germany and Japan and the recognition of the increasing role of universities in knowledge based societies induced *legislative changes* in the United States that gave a further impetus to the entrepreneurial turn[16]. The best known among these is The Patent and Trademark Amendments of 1980 (Public Law 96-517) or Bayh-Dole Act as it is commonly referred to. The Bayh-Dole Act was submitted by two Senators, the democratic Birch Bayh from Indiana and the republic Robert Dole from Kansas (Mowery et al., 2004). The Bayh-Dole Act enabled universities to retain property rights on inventions that result from federally funded research (Franzoni and Lissoni, 2009; Henderson et al., 1998; Shane, 2002) and created a "uniform federal patent policy for universities and small businesses" (Mowery et al., 2004; p. 92). At the same time it required the utilization of the IP created (Etzkowitz et al., 2000). The Act also declared the royalty-free nonexclusive licence right of the federal government and a so-called "march-in" right (Mowery et al., 2004). The latter enabled federal governments to utilize the invention themselves in case of insufficient licensing policy of the contractor or if public safety or health issues necessitated.

The Bayh-Dole Act aimed the acceleration of the innovation process[17], since before the 1960s universities had to negotiate with the federal government or the mission oriented funding agency on a case-by-case system (Aldridge and Audretsch, 2011; Mowery et al., 2004), which was "a long and cumbersome application process" (Slaughter and Rhoades, 1996; p. 318). This was somewhat mitigated around the mid-1960s, when Department of Defense (followed by Department of Health, Education and Welfare (HEW) in 1968 and National Science Foundation (NSF) in 1973) introduced the first Institutional Patent Agreement (IPA) that eliminated the case-by-case review system (Mowery et al., 2001), and in 1980 the Bayh-Dole Act replaced the IPA system (Mowery and Sampat, 2005). An expansion of the Bayh-Dole Act was The Trademark

[16] Some consider Bayh-Dole as one of the major generators of the entrepreneurial turn, while others argue that it was response on the already existing trends (Mowery et al., 2004) or both an outcome and a response (Grimaldi et al., 2011).

[17] The Stevenson-Wydler Technology Innovation Act of 1980 targeted similar purposes and regulation regarding national laboratories (Link et al., 2011).

Clarification Act of 1984 (Public Law 98-620) that removed some of the restrictions regarding the kind of inventions that can be owned by universities and regarding the rights under which they can assign their IPR to other parties (Franzoni and Lissoni, 2009; Henderson et al., 1998; Shane, 2002).

2.3.4.2. Internal forces of the entrepreneurial turn

As it has already been mentioned, not only external pressure, but also internal forces triggered the entrepreneurial turn of universities. Martin and Etzkowitz (2000) highlight the importance of *poor university infrastructure*, permanent pressure on faculty to do more teaching and research at the same time for a *relatively low salary*. Additionally, the emergence of *interdisciplinary research* areas (Martin and Etzkowitz, 2000) was about crucial importance, since it led to changes in the organization of science and consequently in institutional arrangements as well.

The model where an individual professor alone or with a small number of assistants makes research does not hold anymore. The complexity of technical issues created a ground for group research that was relatively rare in the period between the two world wars, but the Second World War accelerated its spread (Etzkowitz, 1983; Peters and Etzkowitz, 1990), since complex technical issues required division of labour among scientists with different background, and also complicated equipment underpinned its importance.

Etzkowitz (1983) argues that most of the military research during the Second World War was carried out on university locations in hierarchically organized research groups, '*quasi-firms*', as he labelled them (Etzkowitz, 1983 and 2003), with common administrative authority, where members came from different departments but they had to learn to cooperate with another and simultaneously meet the requirements set by different actors, e.g. government administrators, businessmen or military leaders. He also highlights that since the sources of these projects came through grants and contracts from the federal government they enabled both university administrators and scientists to acquire the necessary knowledge and skills that are needed to the full administration of a research project.

One famous example of such large research projects that enabled the realization of the advantages of group research was the Manhattan Project aiming the development of the atomic bomb[18], but also health care related projects showed that generous support of science coupled with effective organizational structures can result in rapid inventions.

After the Second World War, university administrators tried to ensure the sustainability of the established laboratories (Etzkowitz, 1983), and also Bush (1945) argued in his report for the maintenance of multidisciplinary research groups. Consequently, the group research proved to be durable after the Second World War, and other funding agencies, like the National Institute of Health (NIH) or the National Science Foundation (NSF)[19] took over the role of funding (Etzkowitz, 1983).

A further change in the university funding over time was the shift from basic to *applied research*, and from individual to *group research* e.g. in case of the NIH funds (Slaughter and Rhoades, 1996). This seems to be in accordance with the notion of Martin and Etzkowitz (2000) who argue that around the 1980s utilitarian ethos and Mode 2 research mode started to dominate at universities, as it has already been discussed above. This can be partly owed to the already mentioned emergence of new technologies and scientific fields, for which the linear 'science-push' model of Bush and the related Mode 1 knowledge production was inappropriate. The Bush model relied on the "dominance of physics, the power of the atomic bomb, and institutionalization of the Cold War" and was heavily relying on defense spending (Brooks, 1996 cited by Slaughter and Rhoades, 2005; p. 546). Brooks also argues that this simplistic approach disregarded reverse flows from market to production.

In Mode 2 research not only the number of researchers in a group, but also the *variety* in their scientific background is about interest. The rise of interdisciplinary research areas created tensions within the university by questioning the department's legitimacy as the best organizational unit to conduct research (Martin and Etzkowitz, 2000). Martin and Etzkowitz (2000) argue that departments were appropriate for teaching a discipline and for general research purposes, but they may inhibit radical scientific advances. They note that the intensive specialization of science often requires subfield-based groups.

However, this was not the only system-level change during the 1980s. The above described internal and external forces resulted in many fundamental institutional inventions within universities and outside universities, including also innovation systems.

[18] Further important inventions were the proximity fuse and the radar (Etzkowitz and Peters, 1991).
[19] Peer-review system enabled scientists to control NSF funds (Etzkowitz and Peters, 1991).

Etzkowitz and his colleagues (2000) highlighted the *changes in the innovation systems* as a consequence of the increasing importance of universities as knowledge generators and disseminators. They argue that industrial innovation was previously dominated by the industrial or governmental spheres, consequently also industrial policies focused upon their relationship and the improvement of their environment. In knowledge based economies *universities became a key player* in the innovation systems that are interweaving with the business and governmental sector in spiral pattern of linkages that is labelled Triple Helix. The Triple Helix model identified four important processes related to the changing role and generation of knowledge; the internal transformation of the helices, the influence of the institutional spheres upon another that results in transformation, the establishment of new overlay of trilateral linkages, networks and organizations, and the recursive effect of these networks (Etzkowitz, 2003b; Etzkowitz et al., 2000).

2.3.4.3. The entrepreneurial university – definitional issues

The above-mentioned processes jointly led to the development of the entrepreneurial university. There are several approaches and definitions that try to describe the entrepreneurial university. Yusof and Jain (2010) argue that papers on entrepreneurial university usually dealt with institutional level issues, e.g. institutional policy, policy on higher education and socio-economic development. They define the entrepreneurial university as "[…] a university that strategically adapts the entrepreneurial mindset throughout the organization and practices academic entrepreneurship which also encompasses technology transfer activities" (Yusof and Jain, 2010; p. 91).

Rothaermel and his co-authors (2007) describe the entrepreneurial university as a generator of technology advances and facilitator of technology transfer processes through intermediaries (technology transfer offices, incubators or science parks).

Gulbrandsen and Slipersaeter (2007) use the term for institutions that are not only general knowledge sources, hire student for collaborative or consultative project, but are sources of knowledge that is increasingly commodified, embedded in patents and spin-off firms.

Clark (1998) argues that by taking the risk and moving towards entrepreneurialism universities can mitigate the imbalance between the demand they face and the capabilities they possess above. The entrepreneurial transformation of universities requires interactive instrumentalism represented by a strengthened steering core, an expanded developmental periphery, a diversified funding base, a stimulated academic heartland and an integrated entrepreneurial culture (Clark, 1998).

Goldstein (2010; p. 88) highlights that "[…] although many versions of the idea of the entrepreneurial university have been put forth, the triple helix model is perhaps the most well-articulated and best historically grounded in the evolution of the university and the requirements of the knowledge-based economy". Etzkowitz and his co-authors (2000) describe the merit of the entrepreneurial university by highlighting the developmental mechanisms and evolving structures in the university related to the Triple Helix. They argue that internal transformation was guided by the revision of existing tasks in the light of the newly emerging functions. The trans-institutional impact meant stabilization in form of institutionalization of collaborative arrangements' formats for easier understanding and negotiation. Interface processes covered centralization and decentralization at once. Centralized interface capabilities, like e.g. technology transfer offices, usually play a larger role in the early phase of the entrepreneurial turn. As time elapses interface, capabilities become decentralized and spread throughout the university. The last process, the recursive effect is reflected by the appearance of trilateral organizations, like Joint Ventures or centres integrating actors from each helices. (Etzkowitz et al., 2000)

Based on several models Guerrero and Urbano (2012) developed a conceptual model to investigate the transformation of a university into an entrepreneurial university. They tested environmental and internal factors. The former included formal (entrepreneurial organizational and governance structure, support measures for entrepreneurship and entrepreneurship education) and informal (university community's attitudes towards entrepreneurship, entrepreneurial teaching methodologies, role models and reward system) elements. The internal factors investigated were resources (human capital, financial, physical and commercial resources) and capabilities (status and prestige, networks and alliances, localization). They found that entrepreneurial universities have three stages (initial, development and consolidation) that exhibit differences in the external and internal factors analysed.

Although there are slight differences in the above cited definitions, the literature generally interprets entrepreneurial universities "as a step in the natural evolution of a university system that emphasizes economic development in addition to the more traditional mandates of education and research" (Rothaermel et al.. 2007; p. 708). Martin and Etzkowitz (2000) also note that the shift from the dominance of the pure ethos to the utilitarian (and Mode 1 to Mode 2 knowledge production) around the 1980s reflects *a return to the social contract of the late 19th century* when many universities undertook the regional development mission.

2.3.4.4. From 'Endless frontier' to 'Endless transition'

It is important to highlight the fundamental effects of the entrepreneurial transformation on universities. Entrepreneurial activities of scientists occurred already in the 19th century (Etzkowitz, 1983). However, these "did not affect academic research sites", whereas the recent commercialization trends have "significant cognitive and organizational consequences" (Etzkowitz, 1998; p. 823). Also Goldstein (2010; p. 89) stresses that though there is a clear division between the ivory tower universities on the one hand and the engaged and entrepreneurial ones on the other in the degree of interactions between university actors and external organization, and in the institutionalization of this interaction in the universities' missions and activities there "is a more fundamental break between the engaged university and the entrepreneurial university in terms of the set of norms, governance, social relationships, and organizational arrangements within the university." Even though land-grant universities were responsible for the majority of large-scale war research projects and they became involved in patenting for the first among universities (Mowery et al., 2004), "[t]he triple helix model goes well beyond being a single and logical extension of the 'engaged university'" (Goldstein, 2010; p. 88).

These fundamental changes affected also the location of the university in subsystems of the society. Goldstein (2010) argues that the institutionalized links of universities with both the political and economic spheres simultaneously question its disinterestedness, consequently move it away or exclude it from the fiduciary subsystem. In his reasoning this goes hand in hand with the "loss of its autonomy and protection" (Goldstein, 2010; p. 90). Gulbrandsen and Slipersaeter (2007) go further and discuss that eventually the importance of universities in the knowledge production in general will decrease, however, Geuna (1999) insists that there is not a decline in importance, but rather an institutional change that universities are facing.

There is also a major difference in the institutionalized form of commitment of open science and in the treatment of knowledge as public or private good. Goldstein (2010) argues that according to the scientific ethos of Merton scientific findings logically should be regarded as a common property and consequently communicated in a full and open manner. He insists that though also engaged universities exercise their intellectual property rights, their IPR policies "foster the availability of knowledge and research [outputs] as a public good" (CIC Committee on Engagement, 2005; p. 5. cited by Goldstein, 2010; p. 89), whereas entrepreneurial universities regard *knowledge as commodity*. This view is supported by Buchbinder (1993) who claims that this commodification can be owed to the change in the privatization of the social context of knowledge production.

The third fundamental change emphasized by Goldstein (2010) can be observed in the core value of the institutions. In the engaged model the cognitive rationality is the only way of evaluation incorporated by the peer-review system[20]. In the entrepreneurial model the economic rationality plays at least as important role as the cognitive one, and the evaluation of the former made by external actors. Also scientists start to examine their inventions' technological and economic potential in a "*dual cognitive mode*" as Etzkowitz and his co-authors (2000) call it, where fundamental scientific advancement and commercialization both are important. The divergence of the second wave of commercialization from the first one is also underpinned by Gulbrandsen and Slipersaeter (2007) who emphasize the differences in the assessment criteria of the user- and science-directed commercialization.

Contrasting this reasoning with our classification of university missions and tasks and university species this suggest that even though Martin and Etzkowitz (2000) make the ethos of the entrepreneurial university equal to that of land-grant in terms of utilitarianism, there are differences in their approaches to regional development. The emphasis in case of land-grant universities seems to be on tasks that are related to public service activities, whereas the focus of entrepreneurial universities is on – what we labelled as

[20] However, recently also the peer-review system is subject of controversy, see for example Pitsoulis and Schnellenbach (2012).

the second wave of commercialization – *academic entrepreneurship*. This view is also strengthened by Gulbrandsen and Slipersaeter (2007) who argue that though the collaboration of university professors with industry, and also their patenting and spin-off activity were present already in the late 19th century, the term academic entrepreneurship has been used "[o]nly in the last two or three decades [...] when university scientists have taken a leadership role in ensuring successful commercialization of research-based knowledge and ideas" (Gulbrandsen and Slipersaeter, 2007; p. 117). In the "endless transition" model of innovation (Etzkowitz and Leydesdorff, 1998) *universities will become key players*[21] (Etzkowitz et al., 2000; Martin and Etzkowitz, 2000) that is also reflected by the shift of "the direction of influence in relationships between business and the university from business to the university" (Etzkowitz, 1998; p. 825).

There is no clear-cut division between user- and science-directed commercialization and both have been long present in the academic domain (Gulbrandsen and Slipersaeter, 2007). However, the entrepreneurial university evolving in frame of the second academic revolution that was led by the above described forces seems to put more emphasis on the latter and on the potential financial benefits resulting from patenting, licensing and spinning off, since as Shane (2004a; p. 131) argues they "[…] view *technology transfer as a commercial activity"*. Also Etzkowitz (1998; p. 828) notes that "the new entrepreneurialism is the old one plus the profit motive." The potential financial returns of commercialization seem to be much higher than ever before, partly related to the newly emerging field of biotechnology[22] that deserves a closer look in the next section of the chapter.

[21] Though Gibbons and his co-authors (1994) predicted that Mode 2 knowledge production will decrease universities' role in the knowledge production system.

[22] Further fast evolving sectors are information and communication technology, materials technology (Gulbrandsen and Slipersaeter, 2007), however, for the purpose of this dissertation the analysis of the biotechnological academic entrepreneurship trends is the most fruitful.

2.3.5. Biotechnology and the entrepreneurial turn

"[…] [A]t the time the biotechnology industry began,
nearly all molecular biologists were located in the universities."
Kenney (1986; p. 94)

The first use of the word 'biotechnology' was in 1919, long before the second academic revolution. Károly Ereky, a scientist of Hungarian origin used it in his book (Frigyesi and Nyeste, 2008). The Organization for Economic Co-operation and Development (OECD) defined biotechnology as follows:

"*The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services."* (OECD)

Though biotechnology is a very old discipline dating back to the use of yeast in food and beverage production, modern biotechnology that underlies the recent development of the industry is related to the time of the elucidation of the structure of the DNA by Watson and Crick in the 1950s (Hine and Kapeleris, 2006).

The evolution of biotechnology as an industrial sector dates around the 1970s and its scientific foundation was the invention of the recombinant DNA technique of university scientists Herbert Boyer and Stanley Cohen. A further crucial development was the invention of the cell-fusion technique by George Köhler and Cesar Milstein to create monoclonal antibodies. (Zucker et al., 1998; Owen-Smith et al., 2002)

As it has already been mentioned above, biotechnology is one of the newly emerging fields that significantly contributed to the intensification of the second wave of commercialization. Many authors emphasize the fast increase in the number of biotechnology patents and spin-offs (Henderson et al., 1998; Mowery et al., 2004). From the late 1970s and early 1980s a start-up founding wave was launched in the US (Hine and Kapeleris, 2006). Riccaboni and colleagues (2003) argue that science-based start-ups and the participating university researchers played a very important role in the development of commercial biotechnology.

Mowery and his co-authors (2004) highlight that the rapid rise in patenting at US universities was affected by the breakthrough basic research results achieved in *molecular biology*. They insist that the developments of the 1970s and 1980s were enabled by the R&D infrastructure established with the help of the federal support programmes of the 1960s. The extent of biotechnology patent shares is well exemplified by the data of three large US research universities: between 1981 and 1995 some 75% of the 877 inventions reported at Columbia University were biomedical, of which biotechnology accounted for 60% of the reports, 45% of the patents and almost 70% of licensed inventions (Mowery et al., 2001). Biotechnology led to intensification not only in patenting and licensing, but also in *firm establishment*. One of the exemplary cases was that of Genentech, co-founded by Herbert Boyer, Professor of the University of California at San Francisco in the mid-1970s and went public in 1980 – earning millions of dollars to Professor Boyer (Etzkowitz, 1983). Genentech became a model of firm formation in biotechnology (Etzkowitz and Peters, 1991).

The majority of the biotechnological inventions are in the *Pasteur's quadrant* of science. This type of research simultaneously pursuits practical and theoretical purposes, like Pasteur did in his time by carrying out fundamental research and choosing applied inquiry lines at the same time (Stokes, 1997). Pasteur's quadrant research and related merger of basic and applied research is one of the central features of entrepreneurial universities (Gulbrandsen and Slipersaeter, 2007). Powell and Owen-Smith (1998) go a step further and highlight that not only the boundaries of basic and applied research start to be blurred, but also the organizational and reward structures that divide science and business are increasingly merged.

Due to the complexity of the scientific field, usually there is not a single organization where all the knowledge and skills are available that are required by breakthrough technological inventions, thus the best organizational form seems to be the co-operation of universities, small start-ups and large pharmaceutical companies (Powell and Owen-Smith, 1998; Owen-Smith et al., 2002), which again underpins the importance of universities. Asheim and colleagues (2011; p. 896) note that biotechnology is characterized by an analytical knowledge base "[…] where scientific knowledge based on formal models and codification is highly important[23]." They also claim that university-industry interactions and networks play a crucial role in these knowledge bases, just as scientific discoveries. Owing to codification, often in forms of patents, individuals with research experience or university training are important actors.

[23] But it does not imply the irrelevance of tacit knowledge (Asheim et al., 2011).

Zucker and her co-authors (1998) emphasize the role of the *faculty* by arguing that the biotechnology industry and the underlying science co-evolved, and many companies were established based on the knowledge of scientists. Actually, Kenney (1986; p. 94) insists that "[a]ll of the earliest genetic engineering companies were founded by professors." The importance of spin-offs is also underpinned by Asheim and colleagues (2011; p. 897) who also claim that these firms are usually established "[…] on the basis of radically new knowledge and inventions". Since many founder scientists did not want to abandon their status at the university, however, also tacit knowledge and knowledge spill-overs play an important role in the new branch, the new companies were usually clustered around universities (Cooke, 2001; Lawton Smith and Bagchi-Sen, 2008)[24]. As the most important attractiveness of universities is not the infrastructure itself, but the faculty who are leading scientists in the field, the main task of universities is to enable entrepreneurial activity of their employees (Zucker et al., 1998 and 2002).

The fast development of biotechnology was also supported by *legislative changes* and court decisions. The Bayh-Dole Act opened the way to universities to participate in entrepreneurial processes, but regarding biotechnology at least as important was the Supreme Court decision in the Diamond vs. Chakrabarty case that enabled patenting of organisms, molecules, and research techniques emerging from biotechnology (Mowery and Ziedonis, 2002) and consequently increased patenting and licensing activity (Mowery and Sampat, 2005).

Although legislative changes clearly contributed to the fast development of biotechnology in the US, it is also important to see the *institutional settings* that are favourable to the *search regimes of new sciences* underlying biotechnology. The search regimes can be characterized based on three features: rate of growth, degree of diversity, and level and type of complementarity (Bonaccorsi, 2008). Bonaccorsi (2008) argues that new sciences, like e.g. life sciences based on molecular biology, emerged at the beginning of the 20th century, developed fully after the Second World War, and accelerated after the 1970s. He insists that many characteristics of these new sciences are different from the old ones, and search regimes of these can be "characterized by extremely high rate of growth, high degree of diversity and new forms of complementarity"

[24] However, Powell and Owen-Smith (1998) draw the attention that in the later stage of the development the networks of the scientists are not so strongly localized. Also Tödtling and Trippl (2007) argue that biotechnological innovations are the result of the interactions of connections about different types and geographical scope.

(Bonaccorsi, 2008; p. 309). This means that there are permanently new sub-fields emerging and growing very rapidly, that the new search programmes based on the established paradigms show divergence and that there is often a need for cross-disciplinary competence building or new institutional co-operations of different actors (Bonaccorsi, 2008).

These features of the new sciences often challenge institutional settings that offer largely different environment in the USA and in the continental part of Europe, so they deserve a more thorough analysis that is targeted by the next section of the chapter.

2.3.6. The role of institutional differences

As Rothaermel and his co-authors (2007) highlight based on a very extensive literature survey, most of the studies of university entrepreneurship focus on the United States and some selected European countries. They argue that it is still unclear whether the entrepreneurial activities show the same pattern or same dynamics in culturally and economically different countries. Also Geuna and Mowery (2007) claim that the different historical evolution of the modern university systems in the two continents may result in limited or no applicability of the research findings of the US.

Geuna (2001) argues that the sharp increase in the support of scientific research after the Second World War in European countries was – similarly to the US – based on the linear model of innovation and on the public good character of knowledge. He insists that the economic crises of the 1970s and the bureaucratization and massification of universities at the same time resulted in a more direct governmental intervention. In the 1980s there was a shift from the post-World War II to a contractual-oriented scientific funding that also required universities to contribute to economic development and enhance competitiveness (Geuna, 2001).

The role of universities in regional economic development increasingly got in the policy focus in Europe around the mid-1990s. The European Paradox presented in 1995 by the Green Paper on Innovation of the European Commission stresses that European science is fully comparable to US science, but the translation of the knowledge into marketable products is poor, resulting in a weak high-tech technological position of the old continent (Bonaccorsi, 2007; Dosi et al., 2006). At the same time, thriving entrepreneurial science in the United States and the success stories like Route 128 and Silicon

Valley (Etzkowitz and Dzisah, 2008a) attracted the attention of many policy makers and inspired them to try emulate it (Mowery and Sampat, 2005)[25], though none of the typical governmental initiatives launched in favour of this aim in Europe and Japan contributed to the success of the Boston area (Roberts, 1991).

The research university system is assumed to play a significant role in the rapid economic growth of the USA in the second half of the 20th century (Nelson, 2001). This central position is often connected to changes in IPR system, emulation efforts were usually centred around the Bayh-Dole and similar incentives. However, Shane (2004a) argues that thorough thinking should precede this, and also Baldini (2006) warns that IP modifications without a fertile general context are not sufficient. Actually a simple emulation is likely to result in limited success or even counterproductive results (Mowery et al., 2004), and the negative effects can show up with a significant time lag (Mowery and Sampat, 2005). The reason behind is sometimes the "[...] misreading of the limited evidence concerning the effects of Bayh-Dole, [...] and [on] a misunderstanding of the factors that have encouraged the long-standing and relatively close relationship between US universities and industrial innovation" (Mowery and Sampat, 2005; p. 124).

This selective learning is also underpinned by Franzoni and Lissoni (2009) who miss the European implementation of elements of the US system like strong basic research support, faculty mobility, university autonomy, and the system of principal investigators which seem to be decisive factors in academic entrepreneurship. Also Lissoni and his co-authors (2008; p. 87) highlight the role of institutional differences that include, besides the already mentioned autonomy, the control of universities "over their academic staff, and the legal norms on the assignment of intellectual property rights (IPR) over academic research results". Clark (1998) argues that European universities usually have a very low performance in steering themselves.

Mowery and his co-authors (2004) highlight the importance of the institutional context by arguing that the entrepreneurial turn at US universities was closely connected to the features of the American university system that are unique among OECD countries. They note that more important than the Bayh-Dole Act in the rise of patenting were features of the American universities like "its lack of strong central governmental controls

[25] However, many studies suggest that these examples are not to generalize (Bania et al., 2001; Florida and Kenney, 1990).

of policy, administration, or resources; its large scale; its dependence on local sources of political and financial support; and its strong interinstitutional competition for resources, faculty and prestige" (Mowery et al., 2004; p. 33). This view is supported by Lissoni and his co-authors (2008) who believe that also European patenting trends depend more on institutional differences than on IPR reform and also Geuna and Nesta (2006) owe the increasing patenting activity to the emergence of the biotechnology (and ICT) sector and not to IPR regulation. Barbosa and Faria (2011) actually question the role of stronger intellectual property rights as a tool to foster innovation.

Geuna and Mowery (2007) draw the attention to the historically different evolution of the modern research universities in the USA and Europe. Though they have some common roots, since many of the European university models discussed in the previous part of the chapter were transferred to the United States, the various local contexts and historical evolutionary paths resulted in mismatching systems. The differences can be best analysed in an Anglo-Saxon (including the USA, Canada, Australia, UK and the Scandinavian countries) vs. continental European comparison. Nevertheless, there are differences among the continental European countries as well, like e.g. between France and Germany, but the divergence of the UK and the Scandinavian systems from the previous ones is even more expressed. The understanding of the institutional differences is important not only because of the new sciences and their underlying search regimes per se, but in general to the entrepreneurial turn of universities, since many of these rely on the new sciences.

Mowery and Sampat (2005; p. 118) mention the importance of the *heterogeneity* of the US university system by including "religious and secular, public and private, large and small" institutions. They also highlight the dependence of the universities from state-level sources for financial and political support as well.

On the other hand, by investigating the relative poor performance of Europe in new search regimes, Bonaccorsi (2007; p. 311) highlighted the importance of institutional differences like "low credibility in competitive selection; limited mobility of human capital; the overwhelming role of central government in direct funding of public research and lack (or relative scarcity) of complementary sources of funding."

There is inter-relatedness between the different features mentioned above. The *autonomy* of universities should be interpreted in terms of their reliance on external key actors. The autonomy of US universities has a long history, since "the American university system has always lacked any centralized control", that is partly related to their responsiveness of the local societies' needs (Mowery et al., 2004; p. 10). The local control was exercised by the president and board of trustees including state representatives and local stakeholders (Lissoni et al., 2008), and any centralization efforts were unsuccessful (Franzoni and Lissoni, 2009). The strategic autonomy of universities in the continental European system, on the contrary, is very limited (Franzoni and Lissoni, 2009), even against the legislative reforms (Bonaccorsi and Daraio, 2007). The central state strongly influences financial decisions of the institutions whose management is usually not a professional top-managerial layer, but interest groups led by professors (Novotny, 2010a). This lack of autonomy jointly with that of administrative skills resulted in the low level of competencies and capabilities of European universities to manage their intellectual property (Franzoni and Lissoni, 2009), and led to the reluctance of universities to institutionally deal with patenting, instead they left all IPRs stemming from cooperative or contract research in the hand of the scientist or the funding firm (Lissoni et al., 2008).

Regarding the *IPR issues* one cannot neglect the differences within Europe as well. While in the US the Bayh-Dole Act created a clear IPR system in the 1980s (Henderson et al., 1998), the European IPR landscape was very mixed still around the end of the 20th century. The so called Professor's privilege or Hochschullehrerprivileg was originated in the German patent law system and adopted by many other countries that borrowed their university systems from Germany (Franzoni and Lissoni, 2009; Lissoni et al., 2008). The Professor's privilege meant the exemption of university scientists from assigning the rights over their inventions to their employers (Buenstorf, 2009; Franzoni and Lissoni, 2009) in contrast to those working in company or public laboratories (Lissoni et al., 2008). As part of the Bayh-Dole emulation efforts, many countries abolished the Professor's privilege around the millennium[26] (Franzoni and Lissoni, 2009; Lissoni et al., 2008; Mowery and Sampat, 2005) and today universities have the right to patent their employees' inventions (Geuna and Rossi, 2011).

[26] Germany abolished professor's privilege in 2002, Denmark in 2000, France in 2001 (Mowery and Sampat, 2005). An interesting exemption was Italy that introduced the professor's privilege in 2001 (Lissoni et al., 2008).

However, the imperfect approach is also present here, since these changes aimed to transfer the IPR from individual scientists to universities, whereas the Bayh-Dole argued against government ownership (Mowery and Sampat, 2005). This imperfection is even more disadvantageous if we consider that Kenney and Patton (2011) claim that inventor ownership encourages spin-off formation far better than university ownership. Additionally, even against the reforms, the European academic patenting IPR landscape is still very various and institutional ownership does not necessarily mean higher level of utilization or better quality patents (Geuna and Rossi, 2011). Furthermore, there are some informal technology transfer mechanisms that evolved in the past and may remain at work even after the IP reforms (Grimpe and Fier, 2010).

Not only the academic IP issues can affect academic entrepreneurship negatively, but also the general IPR system in Europe seems to be an impediment. In the fragmented European system patent applications can be filed directly to the European Patent Office (EPO), or to the National Patent Office, and afterwards to the EPO. Compared to the US the system has several cost burdens (translation costs, validation fees and renewal fees) resulting in a much higher total cost even after London Agreement[27] (Harhoff et al., 2009; van Pottelsberghe de la Potterie and Mejer, 2009). However, this is expected to change in the future. At the end of 2012 the European Parliament voted for the establishment of the European patent with unitary effect (unitary patent) that will provide protection “in 25 EU member states through one single administrative step”, allowing significant cost and time savings (EPO, 2012). The EPO expects the first unitary patents to be validated in 2014.

The signs of the central governments’ influence in Europe can be traced also on the *academic labour markets*. In the US there is a fierce competition among universities to attract the most talented researchers and students – with the attached public funding (Bonaccorsi, 2007; Mowery et al., 2004). In the continental Europe already the doctoral education’s structure does not enforce competitive selection (Bonaccorsi, 2007). Also the assignment for associate and full professor positions is not free of favouritism, even if there is a centralized competition, since the optimal distance between evaluators in the assignment committee and candidates varies depending on institutional frameworks (Zinovyeva and Bagues, 2012).

[27] The aim of the London Agreement was the reduction of translation costs (van Pottelsberghe de la Potterie and Mejer, 2008).

After recruitment, university researchers will become state employees or civil servants (Franzoni and Lissoni, 2009), and their career advancement will depend much more on ministerial rules than on university strategies (Lissoni et al., 2008)[28] In general, already early career scientist enjoy more research independence in the US and they often use mobility to improve their future prospects (Riccaboni et al., 2003). The rigidities of the continental European systems in general are not sufficiently demolished by the recent modifications of the scientists' legal status (Geuna and Nesta, 2006). The work contract of the European scientists guarantees compensation for the whole calendar year, whereas their American counterparts are paid only for nine months in a year (Grimpe and Fier, 2010). Grimpe and Fier (2010) argue that one of the possible sources of compensation for this missing income is the involvement in informal technology transfer activities in form of interactions with industrial researchers.

Not only the incentives, but also the opportunities for *labour mobility* seem to be much weaker in the continental Europe (Franzoni and Lissoni, 2009). The strong national features of academic labour markets that are incorporated not only in status and salary categories, but also in recruitment procedures, promotion rules and career patterns, severely hinder mobility (Musselin, 2004 and 2005). In the USA there is a high level of mobility even between academia and industry (Mowery and Sampat, 2005) that enables effective cross-sector knowledge flows and also increases competition among scientists.

A further indicator of the dependence of European universities on central governments is the *funding system* (Lissoni et al., 2008). Pavitt (2001; p. 761) argues that the US system is characterized by "massive and pluralistic government funding, high academic quality, and the ability to invest in the long-term development of new (often multi-disciplinary) fields". This ensures autonomy, but also increases competition among institutions (Mowery et al., 2004). Owing to the difficult and risky process of decision making on research agendas, the continental European system voted for an approximately equal distribution of funds, and usually avoids long-run supports that is unfavourable for scientific areas that underlie knowledge-based economies (Bonaccorsi, 2007).

[28] For example, the salary of German faculty members is determined by an administrative scale (Musselin, 2004) that does not seem to provide an incentive for outstanding performance and competition.

The universities in the research system of the continental Europe generally seem to play a less important role. This is related to the traditionally stronger position of *other public research organizations and governmental research sites*. For example in Germany, one of the best representatives of the continental European systems, the division of funds among universities and other PROs, like e.g. the Max Planck Society in Germany, show a more balanced picture than in the US (Buenstorf, 2009). PROs are likely to enjoy higher autonomy than universities (Franzoni and Lissoni, 2009) and include organizations with variable legal statuses and funding schemes (Koschatzky and Hemer, 2009).

2.4. Summary

This chapter introduced the historical evolution of university missions and the related changes in the university system. The first academic revolution added research function to the original teaching task of universities, while the second academic revolution in the 20th century extended these with the regional economic development perspective (Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000). Boosters of this second revolution have been external effects, such as globalization, the increasing importance of knowledge and new technologies or financial constraints (Luger and Goldstein, 1997; Martin and Etzkowitz, 2000) and internal forces, like the new organization of science in multidisciplinary groups that operate with a quasi-firm character (Etzkowitz, 1983 and 2003).

The change in the composition of missions was guided by a shift in the types of universities. The mediaeval universities were followed by the classical universities and later by the engaged universities. External (e.g. the emergence of the knowledge-based society and new technologies, increasing globalisation and financial constraints, changing legislations) and internal (the new organisation of science and the normative shift) forces resulted in the emergence of the entrepreneurial university.

It is important to emphasize that neither the contribution to practical societal needs nor the entrepreneurial activities are the inventions of the entrepreneurial university. These have been already present in the academic domain, but temporarily suppressed in the 20th century by the pure ethos of the university and the dominance of basic science. The above mentioned changes resulted in the renewed ascendance of the utilitarian ethos and more importantly caused a shift in the direction of influence of university-industry interactions. After the second academic revolution universities became the key actors in these relationships that had an effect on their organisational structure and commercialization strategy as well (Gulbrandsern and Slipersaeter, 2007; Goldstein, 2010; Etzkowitz, 2003b). Entrepreneurial universities establish technology transfer offices to manage their IP portfolio and commercialize on inventions, and sometimes built science parks and incubator houses to foster university-industry collaboration and entrepreneurship. They treat science as a commodity and not as a public good and include research groups with quasi-firm character that carry out Mode 2 research in Pasteur's quadrant (Goldstein, 2009; Gulbrandsen and Slipersaeter, 2007; Martin and Etzkowitz, 2000).

This latter is an important feature of biotechnology related research fields. The search regimes of new sciences underlying biotechnology show characteristics, like e.g. new forms of complementarity of high growth rate and diversity that seem to challenge the institutional settings of the continental European university system (Bonaccorsi, 2008). Contrasting the Anglo-Saxon and continental European university systems we find that the significantly lower autonomy, mixed IP ownership structure, lower faculty mobility, fragmented labour market and less intense competitive funding system of the latter is likely to reduce the likelihood of entrepreneurial efforts of institutions and individual faculty member as well (Bonaccorsi, 2007; Buenstorf, 2009; Koschatzky and Hemer, 2009; Franzoni and Lissoni, 2009; Lissoni et al., 2008; Mowery et al., 2004; Musselin, 2004 and 2005). On the contrary, universities and university researchers played a crucial role in the development of the biotechnology industry in the United States. Not only the inventions, but also the spin-off companies of scientists contributed to the rise of biotechnology clusters around universities. They build an important element of the pharmaceutical innovation chain that is best described as the cooperation of universities, spin-offs and large pharmaceutical companies (Powell and Owen-Smith, 1998; Owen-Smith et al., 2002). Owing to the importance of individual researchers in the entrepreneurial turn of universities, the next chapter is devoted to the motivations and characteristics of academic entrepreneurs.

3. The ultimate booster of the entrepreneurial university: The academic entrepreneur

“What is clear, however, is that there is more than one route
to the commercialization of university intellectual property (IP)
but that, whatever the route, core to its success will be the role
played by the creator of the IP, the individual scientist or engineer.”
Wright et al. (2004; p. 235)

3.1. Introduction

The previous chapter provided an insight into the system level changes that opened a new phase in the history of universities that is comprehensively called the era of the entrepreneurial university. Nevertheless, without individual level changes the entrepreneurial turn has been unlikely to achieve the scale and scope as of today. It has also been mentioned before that entrepreneurial opportunities have already been available earlier, but scientists were reluctant to capitalize on them (Etzkowitz, 1983). However, there has been a change in their behaviour around the middle of the second half of the 20^{th} century, and the use of the term academic entrepreneurship also relates to this period, when the scientist took a leading role in the commercialization process (Gulbrandsen and Slipersaeter, 2007).

The ascendance of technology transfer endeavours was made possible by the previously mentioned *change in the behaviour of scientists*, which, in turn, reflects a more fundamental shift, that of norms. This *normative turn* on the individual level guided the entrepreneurial turn on the institutional level. Due to the fundamental role of the inventor in the entrepreneurial activities, the normative change and the motivations of scientists to commercialize deserve closer attention, just as the different system- and university level factors that influence the realization of those motivations. Against their key role in technology transfer, little is known about their motivations and the drivers behind those (Aldridge and Audretsch, 2011; Jain et al., 2009).

This chapter aims to provide an insight into role of individual scientists in the entrepreneurial turn. It provides a detailed analysis of the motivations that lead faculty to participate in knowledge commercialization. A special attention is devoted to the role of academic motivations in forms of extension of knowledge and research avenues, practical application of inventions, increased research funding base, and improved conditions for scientists and students alike. It aims to point out that personal financial wealth is not the main driver of the individual entrepreneurial turn. This chapter also introduces the circumstances that seem to contribute to the acquisition of business knowledge and skills of university researchers that are needed to successfully manage a spin-off company. It also introduces the complexity and diversity of academic entrepreneurship by pointing out that there is not a single academic entrepreneur, but different types of entrepreneurs exist that have been identified in the literature along various dimensions. It will also show that though motivations play a fundamental role, there are other individual characteristics of the scientist, different factors in the university and the broader environmental level that can influence the realization of these motivations – either positively or negatively.

3.2. Who is the typical academic entrepreneur? – Motivations and typology

"[…] [T]he field of molecular biology had created
a type of entrepreneur before World War II,
but the postwar period, that saw the infusion of massive
sums of NIH money, created true research entrepreneurs."
Kenney (1986; p. 94)

Scientists play a decisive role in the entrepreneurial turn of universities. Without their willingness to participate in the technology transfer process, universities are quite unlikely to be able to identify the inventions with commercial potential (Owen-Smith and Powell, 2001)[29]. They are important not only for the identification but for the successful commercialization of the innovations, since most of those are sold at an embryonic stage and further development requires inventor participation (Thursby and Thursby, 2003a). In a survey of university TTO personnel it is estimated that some 71% of licensed inventions could not be successfully commercialised without faculty involvement in the development of them (Thursby and Thursby, 2003b). Additionally, compared to industrial researchers, academic scientists usually choose to commercialize projects that have higher expected revenues (Lacatera, 2009), and an analysis of Cambridge spin-outs also revealed that university spin-offs seem to have a higher growth potential than industry spin-offs (Wicksteed, 2000a). It is also worth to mention that academic entrepreneurs can convert their human and social capital into the capital of the firm (Murray, 2004) that can help to overcome difficulties stemming from the liability of newness (Shane and Khurana, 2003). Related to commercialisation activities Spilling (2008; p. 10) notes that "[t]he key driving force, however, is the entrepreneurs and their ability to identify and develop business opportunities". Also Clark (1998) highlights that the entrepreneurial transformation of universities requires collective entrepreneurial action including active participation of groups of academic members.

However, some insist that scientists often lack specialized business knowledge and some personality traits that are important for commercialization (Shane, 2002; Roberts and Peters, 1981). On the other hand, others argue that due to changes in the organiza-

[29] Furthermore, Shibayama (2012) argues that enforcement of related university regulations is difficult in Japan, which our belief can be true for Hungary as well.

tion of science this is not necessarily the case anymore. As it has already been mentioned, after the Second World War *group research* became a normative model of making science. Etzkowitz (1992) argues that the size of these research groups can range from three to more than twenty members, but ideally include four to six/eight scientists, like graduate students who typically stay for four or five years and post-doctoral fellows being members for two years, whereas technicians can spend 20 to 30 years in the same laboratory. He argues that the ideal group size depends on the research fields and managerial skills of the group leader. And this latter is a very important issue, since a good *principal investigator*, who leads the research group, is responsible for raising funds, dealing with human resources, coordinating scientific research, that seem to be much more the tasks of a private business manager. Due to these peculiarities research groups can be comprehended as '*quasi-firms*' that have "[…] all the characteristics of a business firm except the profit motive" (Etzkowitz, 1992; p. 33). Also Kenney (1986) notes that molecular biology saw the rose of a new type of research entrepreneur who were already familiar with managing employees and large amounts of money. He insists that a molecular biology laboratory might require one million dollar capital investment owing to very expensive equipment, like electron microscopes and gas chromatographs and mass spectrometers. The managerial skills and competences that can be developed by running a research group can help to overcome the lack of direct business experience or that of formal business education. Additionally, traditional entrepreneurial activities, like consultancy can extend the social network of faculty outside the university that also mitigates the risks associated with faculty involvement of business creation.

Though some managerial knowledge seems to be given, the main problem lies in the historical reluctance of university scientist to commercialize their research results. Based on Pasteur's example Etzkowitz (1983) argues that achieving monetary gain on inventions would make scientists feel lowering themselves. Some (Bok, 2003; Slaughter and Leslie, 1997) even recently argue that deep involvement in commercialization would corrupt science, and is not accepted by every scientist (Goldstein, 2010). Others acknowledge the importance of the third mission and the related undertakings of scientists, but they are against "mixing of roles, pronounced in integrated pursuit of private commercial and academic goals" (Laukkanen, 2003, p. 380). Additionally, many question the compatibility of university patenting, licensing and spin-off practices with the norm of open science (Goldstein, 2009; Gulbrandsen and Slipersaeter, 2007; Luger and

Goldstein, 1997). According to the Mertonian norms of science researchers aim to put their research results in the public domain to enhance the scientific base and simultaneously receive acknowledgement of their peers (Merton, 1988). Treating knowledge as a commodity seems to contradict these norms (Goldstein, 2010). The fundamental differences between academic and entrepreneurial role identities are also shown in Table 1.

Table 1 Academic and entrepreneurial role identity

	Academic	Entrepreneurial
Norms	Universalism Communism Disinterestedness Skepticism	Uniqueness Private property Passion Optimism
Processes	Experimentation Long-term orientation Individualistic/small group	Focus Short-term orientation Team-management
Outputs	Papers Peer recognition/status	Products Profits

Source: Jain et al. (2009; p. 924)

However, Etzkowitz (1998) argues that there has been a *normative shift* in the academia and researchers do not consider the ivory tower as the only decent way of making science anymore, which is underpinned by Lacatera (2009) who claims that researchers hope not only scientific, but also monetary rewards from knowledge utilization. This normative change is about crucial importance. As Renault (2006) highlights the best predictor of scientists' participation in commercialization is their belief about the proper role of universities in it. As it has already been mentioned in the previous chapter, around the 1980s the utilitarian or instrumental ethos of universities became dominant, and this was also reflected in institutional level changes, that in turn affected individual norms. These changes together seem to make capitalization of knowledge compatible with academic norms. Also Kenney (1986) argues that against the relatively low number of company equity holders, company affiliations became a norm in molecular biology departments.

Along these lines we could argue that institutional and normative changes opened the possibility, while research organizational tasks shaped the ability of scientists to become academic entrepreneurs. However, the question arises, whether there is a *motivation* to do so. Grimaldi and colleagues (2011) note that university scientists generally choose the university affiliation since they do not find corporate sector jobs attractive.

So it is a question what could drive university scientists to participate in the commercialization of their inventions that inevitably involves the corporate sector as well. Unfortunately the literature on entrepreneurial motivations in academia is fragmented mainly focusing on the USA and Canada (Morales-Gualdrón et al., 2008). Though revenue sharing and profit motive could be plausible answers and they are mentioned in some cases (Etzkowitz, 1998; Kenney, 1986; Renault, 2006), the profit motive itself seems to provide insufficient explanation, especially since establishing a firm is far from being the individually most profitable form of academic entrepreneurship (Bains, 2005). Also Roberts (1991) highlights that technical entrepreneurs exhibit stronger preference towards independence and challenge seeking rather than financial gain as a primary motivation. Additionally, financial pressure belongs to the push motives that are assumed to be insufficient in inducing spin-off formation (de Silva, 2011). Markman et al. (2004) even argue that monetary incentives offered to scientists had actually a negative effect on the number of spin-offs.

The primary importance of personal financial gain is also questioned by some historical evidences, as it is shown by some examples of university-industry co-operations in the 19th century German chemistry, like that of Justus von Liebig Professor's who provided consultation and contract research services for chemical manufacturers with the aim of earning income to support his research and pay assistants at his university laboratory (Etzkowitz, 1983).

Mowery and Sampat (2001) introduce a further example of early academic entrepreneurs; Frederick Gardner Cottrell, chemist at the University of California – Berkeley and inventor of the electrostatic precipitator who seek patent protection on his inventions, but again, not for personal financial gain, but with the aim of supporting scientific research. Since he was also worried about the possible negative effects (e.g. secrecy) on scientific work, he urged the establishment of a separate entity to deal with IP issues and commercialization. As a result, Research Corporation came into existence in 1912 (Mowery and Sampat, 2001) and served "as a buffer between the university and industrial firms" (Etzkowitz and Peters, 1991; p. 157). Later on it became an important actor in academic patent management (Franzoni and Lissoni, 2009). In 1925 Wisconsin Alumni Research Foundation (WARF) was established with the aim to manage the patents of Professor Harry Steenbock, multiple inventor in the food processing field (Apple, 1989 in Franzoni and Lissoni, 2009). Also Palmer (1948; p. 6) argued that "[f]inancial rewards are not the essential or necessary objectives in obtaining patents."

Further evidence is provided by Etzkowitz and Peters (1991) who describe the unsuccessful initiative of MIT to restrict consultation activity of scientists. It was still around the 1920s when the pure ethos of universities dominated and administrators feared that consultation activities of researchers would mean a threat on it, so they implemented a ban on these. Even though they simultaneously tried to increase the salary of faculty members to compensate for the income loss, scientists refused to abandon consulting activities, because they believed that industrial connection was beneficial for their academic work, both for teaching and research. Many spin-off companies arose on the grounds of consulting services, like Arthur D. Little Company or Raytheon Company, but production firms established by scientists were quite uncommon until the 1980s (Etzkowitz and Peters, 1991). Engineers and physicists did not play a major role in the spin-offs of the semiconductor industry established around the 1950s and 1960s (Etzkowitz, 1983).

Around the 1970s the normative pressure on scientists from peers and even sometimes from technology transfer offices has been still so intense that inventors of "scientific breakthroughs that paved the way to commercial biotechnology", like Stanley Cohen (recombinant DNA) or Kohler and Milstein (monoclonal antibody technology) had to abandon directly profiting from their knowledge (Stuart and Ding, 2006; p. 103). Also Kenney (1986) underpins that still in 1977 most of the professors had serious doubts about the appropriateness of commercial involvement and many were kept back from it owing to peer-pressure. Stuart and Ding (2006) note that the strong scepticism of scientists about blurring boundaries between science and industry was said to be rooted in the Mertonian norms of science – concerns were especially strong related to the violence of the communality[30].

Around the 1980s, the ascendance of molecular biology accompanied by institutional changes, by the increasing dominance of the utilitarian or instrumental ethos and a normative shift changed this pattern. New members of the academic entrepreneurial community emerged who actively participated in the formation of spin-off firms utiliz-

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[30] However, they also note that there seems to be a mismatch between the theoretical norms and actual behaviour of scientists (Stuart and Ding, 2006).

ing their inventions[31]. Academic entrepreneurship started to spread among elite universities' scientists who were leading researchers of their field (Stuart and Ding, 2006). Representative members of this community have been e.g. Professors Mark Ptashne, Walter Gilbert and Herbert Boyer. Mark Ptashne, biology professor at the Harvard University and founder of Genetics Institute was mainly attracted by the idea of the recreation of his previous university research group (Etzkowitz and Peters, 1991), but he kept the separation of applied and basic research conducting the former in frame of the firm and the latter in frame of the university laboratory (Etzkowitz, 1983). The likely most well-known among the academic entrepreneurs is Professor Herbert Boyer, biochemist at the University of California – San Francisco, and one of the founders of Genentech Corporation (Etzkowitz and Peters, 1991) who was persuaded by Robert Swanson venture capitalist in 1976 to establish a company to utilize the rDNA technique (Kenney, 1986). Genentech is probably the best example of university inventions with outstanding commercial potential. By the time it went public in October 1980, investors showed a great interest for the company and Professor Boyer earned millions by selling some of his stocks (Etzkowitz, 1983). Nevertheless, also prominent Nobel Laureates took part in commercialisation; Donald Glaser, Joshua Lederberg, and Francis Crick were SAB members of another famous biotechnology company, Cetus (Kenney, 1986).

Though their active involvement in company creation is a new phenomenon, the academic motivations observed in some early scientific entrepreneurial efforts behind spin-off formation are still present. It is important to emphasize that it is rather about an *extension* of the already existing academic purposes with a profit motive and not a substitution of those. As Etzkowitz (1998) claims the new entrepreneurship is the old one *plus* the profit motive. In a similar vein, Göktepe-Hulten and Mahagaonkar (2010; p. 417) insist that "[e]ven though scientists do no longer have a monk-like existence searching for truth about nature, scientist's involvement in entrepreneurial activity is not a transition from their academic roles to another", it is rather about signalling that they possess above multiple skills and knowledge; academic and industrial as well. The molecular biologist who are involved in company creation are aware of the commercial potential of their inventions (actually this recognition sometimes is supported by an industrial partner or a technology transfer officer), but the financial incentive is not about

[31] As it has already been mentioned, the term academic entrepreneurship has been systematically used since the 1980s when scientist took a leading role in commercialization (Gulbrandsen and Slipersaeter, 2007).

primary importance for them. Etzkowitz and Peters (1991) highlight that one of the distinctive features of Genentech was the respect of the academic norms that made it more attractive for scientists from universities and it actually became a model for high-tech university spin-offs.

The above mentioned examples are not exceptional. Though the literature on the personal motivations and the decision of faculty to establish a firm are fragmented (Aldridge and Audretsch, 2011; Jain et al., 2009; Morales-Gualdrón et al., 2008), there are scientific studies that try to shed light on this complex phenomenon, and many of them underpin the importance of *academic motivations*. Franzoni and Lissoni (2009; p. 168) argue that the thorough understanding of the term academic entrepreneur requires a broader interpretation than the simple extension of the traditional entrepreneur definition with an "academic" adjective, since it covers "a more complex bundle of strategies and incentives". In their view entrepreneurial activities, including spin-off formation as well, can contribute to the extension of the scientists' social network outside the academia that can provide access to funds, data, scientific instruments and materials that are all required to make cutting-edge research. Additionally, contacts to businessmen and policymakers can contribute to the ethical validation of research results that – besides fellow recognition – can support the academic advancement of the researcher (Franzoni and Lissoni, 2009). Not least important can be the motivation for the extension of the research avenue with product development or the competitive mindset of professors often coupled with the excitement of setting up a company, especially in the later stages of the career life-cycle (Kenney, 1986).

Based on longitudinal case studies of two American public universities Etzkowitz (1998) argues that the involvement of scientist in commercialisation can vary – partly due to motivational differences. He distinguishes three types of industrial cooperation approaches among faculty members. The *'hands-off'* scientists "strictly delimit their role in putting their knowledge into use" (Etzkowitz, 1998; p. 831) by leaving the tasks of finding a developer and a marketer for the discovery up to the technology transfer office. Even if the commercialisation would happen through the establishment of a spin-off company, the scientists would not be the entrepreneurs, after the non-cooperating scientists they show the lowest level of commercial activity. *'Knowledgeable participants'* show a deeper involvement; being aware of the commercial potential and operating comfortable in a business milieu they wish to play a larger role in the technology transfer process. However, their focus remains at the university and they primarily see themselves as academic scientists. The deepest involvement is shown by the *'seamless web'* scientists who are expected to participate in the strategy setting of the company that they usually solve by integrating the research agenda of the research groups operating at the university on the one hand and in the business firm on the other. (Etzkowitz, 1998)

Jain and colleagues (2009; p. 929) argue that scientists participating in commercialization activities have to modify their role identity that they usually solve by developing a "hybrid role identity as comprising a focal academic self and a secondary commercial persona." They also note that the intention to retain academic priority leads researchers to develop processes to be able to manage hybrid identity. One of them is delegating that means establishment of interfaces with actors knowledgeable in commercialization, like technology transfer offices and their networks. The other one is buffering that targets protection from norms that are typically associated with commercialization. Tools of buffering are e.g. reconfiguration of work practices and routines to retain dominance of basic research even when taking part in technology transfer activities. (Jain et al., 2009)

By analysing inventing disclosure and patenting activity of scientists at the Germany Max Planck Society Göktepe-Hulten and Mahagaonkar (2010) found that instead being triggered by monetary expectations, scientists rather seek for *recognition and reputation*. Stern (2004) highlighted that university scientists actually pay to be scientists. Based on a survey among PhD biologist who just completed their job search he found "a trade-off between offered wages and the scientific orientation of firms. Offers that contain science-oriented provisions, ranging from permission (or incentives) to publish in the scientific literature to the flexibility to choose or continue research project, are associated with lower monetary compensation and starting wages[32]" (Stern, 2004; p. 836).

A further European evidence is provided by Fini and colleagues (2009) who investigated the founding motivations of 88 Italian academics involved in spin-off establishment between 1999 and 2005. Among the individual related factors that shape the decision of a scientist whether to create a company the most influencing ones have been (in

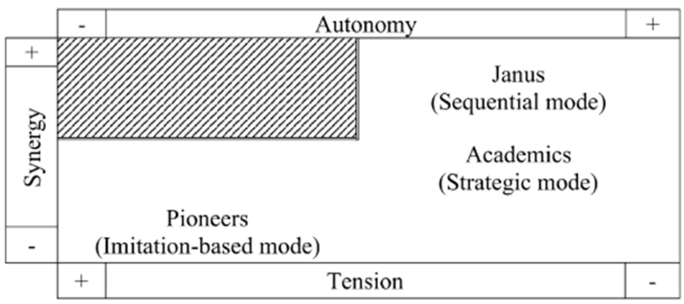
[32] Even when controlling for type of job and excluding academic sector from the analysis (Stern, 2004).

order of lowering means) *new stimuli for ideas and applied research, prestige and reputation, network development, and personal earnings*. This clearly shows that they are not triggered by entrepreneurial attitude, by the desire to become entrepreneurs, but they rather would like to create benefits to support academic activities. Besides the already mentioned stimuli for research activities and achievement of recognition, academic outcomes can include also *creation of funding opportunities (grants) for students and research assistants*, or *getting new infrastructure and facilities for academic research*, thus financial and non-financial ones as well. However, they also note that the very low entrepreneurial attitude in the Italian institutional settings can lead to low growth companies.

Meyer (2003) had a similar discovery by investigating four academic start-up companies in nano-scale technologies. Three of which has been originated in the USA and one of them was from Northern Europe. He found that a distinction can be made between academic entrepreneurs and *entrepreneurial academics*. The major difference is that the latter often do not aim fast growth; the university scientist remains at the university and is not always aware of his innovation and development needs.

Also Shinn and Lamy (2006) identified spin-offs with low growth-orientation. Based on a four-year study of 41 individuals (both CNRS and university personnel) and four firms in France they differentiated between three types of academic entrepreneurs. The grouping was made based on four factors that included the degree of the synergy between the university and the company, the tension between the business and the university, the relative autonomy of the scientific field, and the presence of a particular university-enterprise coordination mode, as it is shown by Figure 1.

Figure 1 Scientist-entrepreneur profile and coordination mode



Source: Shinn and Lamy (2006; p. 1474)

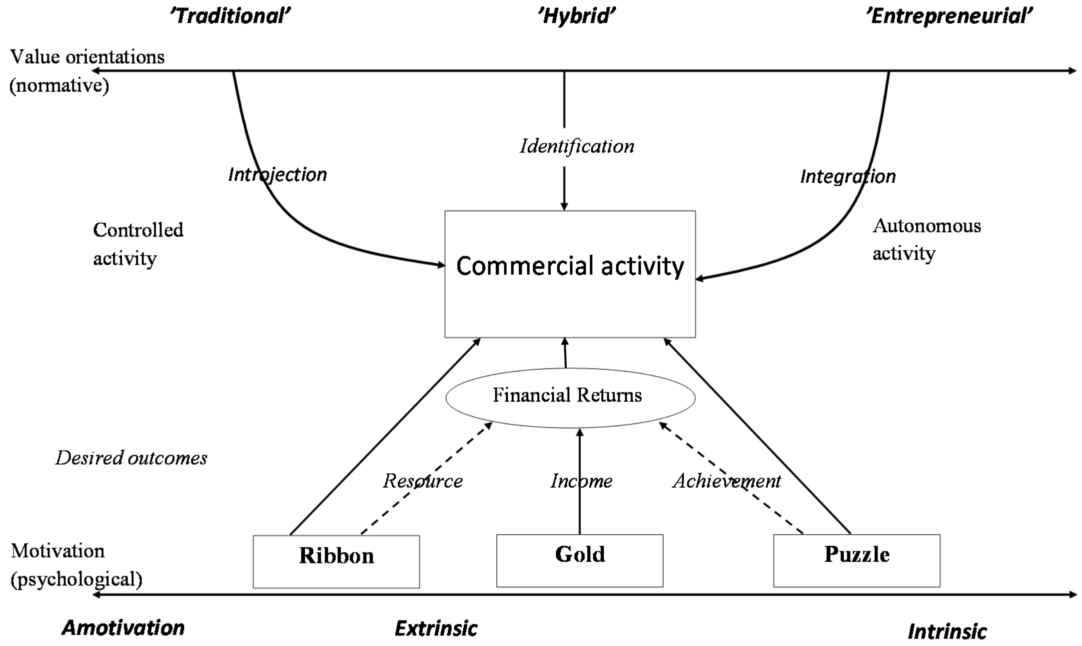
The *'academics'* strategically coordinated academia and business, where the former dominates. The participation in the commercialization serves the intellectual and professional interests of the scientists, and economic considerations are either entirely neglected or subjugated to scientific purposes. In accordance with their aim, the university laboratory directly benefits from the firm in form of cognitive-related material advantage (and usually not monetary). Not only the university, but also the faculty member enjoys the advantages of the commercialization, again, not necessarily by gaining personal wealth, but rather by extending network connections and increasing reputation. Since the company serves discipline-based cognitive aims, and provides access to resources, the tensions between university and business are very moderate. On the contrary, *'Pioneers'* use an imitation-based coordination mode by giving decisive priority to the business that is associated with a low level of synergy, and consequently extremely high tensions between the academia and business. Secrecy and patenting is a norm, and economic incentives dominate even in shaping the research agenda that results in applied research focus and considerably less laboratory work and publication. Pioneers do not aim channelling resources from firm to university and this has consequences on their career – their efforts are not appreciated or sometimes disrespected by colleagues, and neither the institution rewards it in promotion. This hostile milieu awakes disappointment in many Pioneers, because even against the priority of the business, they do have a collective perspective. The sequentially coordinating *'Janus'* represents the third group of academic entrepreneurs. They do not work simultaneously in both academia and business, instead they always choose mainly one at the same time – they consider them autonomous. This enables them to enjoy the lowest tensions between the fields among the academic entrepreneurial types. Among the three scientist-entrepreneurs introduced here they are the most involved in basic research activities, however, the company does not serve direct scientific considerations and academic motivations in this case, since they are usually already highly ranked in the organizational hierarchy. (Shinn and Lamy, 2006)

Also Spilling (2008) distinguished different groups of academic entrepreneurs along their commitment to scientific and business activities. He used a qualitative case study approach and investigated four biotechnology companies in a Norwegian coastal area. The professors interviewed played very different roles in the firms[33]. *'The entre-preneurial professor'* has high level of commitment for both scientific and business activities. The combination of academic and company roles helps maintaining scientific excellence that is needed to the successful development of commercial activities. The other extreme is *'the production manager'* who is characterized by a low level of both entrepreneurial and research commitment. He usually plays a limited role in the R&D, but an important one in the production management activity of the company. Usually he undertakes management activities based on a part-time affiliation, and at the same time keeps position at the parent organization. *'The industrial entrepreneur'* is characterized by a high entrepreneurial and a low research commitment. Though university links are weaker, they are important as much they provide the background knowledge for successful commercialisation. Also industrial and entrepreneurial background of researchers is about importance, since their responsibility is the organization and development of the new venture. *'The research based entrepreneur'*, on the contrary, has a high research and low entrepreneurial commitment. The company is created to develop a research based commercial activity, consequently, the focus of the scientist is on research and disciplinary matters and entrepreneurial management issues are left to other team members. (Spilling, 2008)

Lam (2011) provided a further important contribution to the motivational research in academic entrepreneurship. In a UK context she interviewed 36 researchers and conducted an on-line survey of 735 scientists from major research universities. The novelty of her research was the connection of value orientation of scientists regarding commercial activities and their (extrinsic and intrinsic) motivations to participate in those as it is shown in Figure 2.

[33] The different approaches can partly be owed to the diverse knowledge utilized and the related variations in the role of R&D (Spilling, 2007).

Figure 2 A conceptual framework on scientific motivation and commercial engagement



Source: Lam (2011; p. 1357)

She argues that *'pure traditionalists'* are in favour of separation of academia and industry and aim to achieve success in strictly in the former, consequently they are amotivated to participate in commercialization. Also *'pragmatic traditionalists'* require separation of business and academia, but at the same time they see the practical benefits of commercialization, but their participation covers introjection which means that this "behaviour is not congruent with their values and is not self-determined" (Lam, 2011; p. 1356). *'Hybrids'* have somewhat similar view about the separation of the scientific and industrial fields than traditionalists, but at the same time they believe that university-industry collaboration is important for the advancement of science, consequently they can harmonize commercial activities with their professional values in frame of what self-determination theory labels identification. *'Entrepreneurial scientists'*[34] deeply believe in the importance of academia-business collaboration and assume a permeable boundary between the spheres. Since they emphasize benefits of knowledge application and commercial exploitation, they fully accept the norms of entrepreneurialism that is represented by integration described in the self-determination theory. (Lam, 2011)

[34] They are not to mix up with the entrepreneurial academics of Meyer (2003), as the two are entirely different.

After categorizing the scientists based on their values and norms, Lam (2011) created three motivational factors by using factor analysis. Knowledge/curiosity (labelled *'puzzle'*) includes intrinsic motivations related to personal satisfaction derived from commercial engagement, like application and exploitation of research results, creating opportunities for knowledge exchange/transfer, and satisfying own intellectual curiosity. Funding/reputation (or *'ribbon'*) includes motivations like increasing funding and other research resources, building personal and professional networks, and providing work placement or job opportunities for students – all in hope for scientific recognition. The third motivational factor labelled *'gold'* only includes the motivation of increasing personal income. In the third step of research Lam (2011) used regression analysis to connect motivating factors and commercial engagement. She found that commercializing scientists are motivated by multiple motives: the most important is puzzle, but also gold plays a role[35].

The largest merit of Lam's (2011) work is the connection of values and motives for commercialization by using one-way ANOVA test and interview data. She found that *'traditional'* scientists use commercial engagement as a means to achieve *ribbon*, so they are mainly extrinsically motivated. *'Hybrids'* have the strongest intrinsic motivation triggered by *puzzle*, but at the same time extrinsically motivated by seeking the *ribbon* as well. *'Entrepreneurial'* scientists are highly motivated by *gold*, but also *puzzle* is about importance to them.

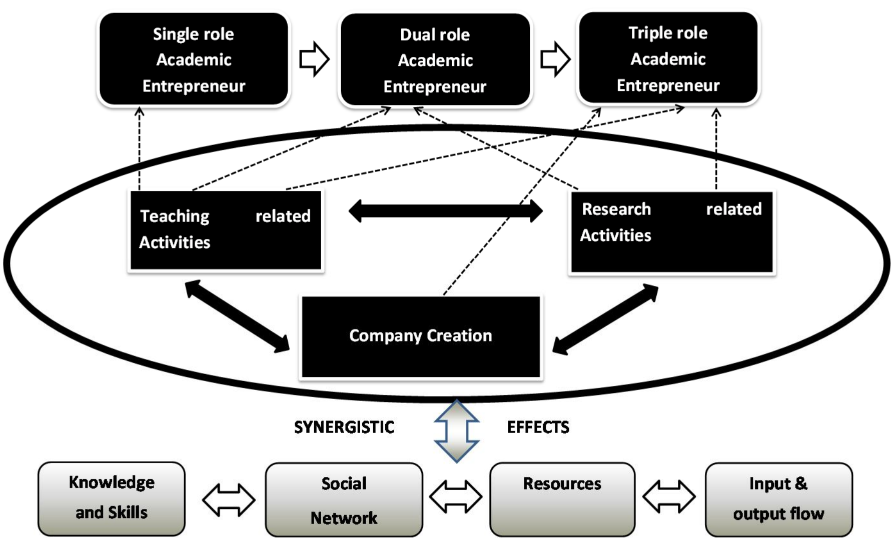
Similarly to Lam's work also the work of de Silva (2011) and de Silva and colleagues (2011) deserve a more detailed introduction due to the different methods and comprehensive approach used. De Silva and colleagues (2011) made their investigation in a resource constrained environment (in Sri Lanka) which is very rare in the academic entrepreneurial literature. Further novelty of their research is the analysis of academic entrepreneurial diversification strategies and connection of those with the achievable synergies. They argue that three types of academic entrepreneurial activities can be distinguished. *Teaching related academic entrepreneurial activities* collected from the literature include e.g. external teaching, industrial seminars or training sessions; *research related academic entrepreneurial activities* are among others research based industrial work or consultancy (either through the university or individually, but without company

[35] This seems to underpin Etzkowitz (1998; p. 828) notion about the new entrepreneurialism („…the old one plus the profit motive").

establishment), commercial product or service development, but also joint research project initiated industrial collaborations are mentioned. The third group is *company creation* that can take the form of contribution to the establishment of joint ventures, either through the university or privately in collaboration with industry, participation in spin-off formation or creation of one's own company, but also contribution to the formation of university centres targeting commercialization can be mentioned here. Of course they do not refuse the possibility of interactions between the groups, but they rather emphasize the level of relatedness of group of activities to the normal academic duties. In this vein, being involved either in teaching or research related academic entrepreneurial activities only represents *related diversification*. On the other hand, company creation or involvement in more than one type of academic entrepreneurial activity is defined as *unrelated diversification*. They found that scientist in resource constrained environment tend to choose unrelated diversification, because it endures larger benefits in form of ensuring additional resources.

Using on-line survey and face-to-face interviews they concluded that "academic entrepreneurship is a process, in which academics gradually diversity their engagement" (de Silva et al., 2011, p. 12). They made a distinction between single, double and triple role academic entrepreneurs, where the base of the categorization was the number of types of academic entrepreneurial activities in which the scientist participates as it is shown in Figure 3.

Figure 3 Academic entrepreneurship in a resource constrained environment



Source: de Silva et al. (2011; p. 29)

Single academic entrepreneurs are involved only in teaching related entrepreneurial activities, *double role* ones in teaching and research related activities and the *triple role academic entrepreneurs* undertake all three types of academic entrepreneurial activities. By investigating the potential synergies among the entrepreneurial activities they found that triple role academic entrepreneurs, thus scientists involved not in teaching and research related entrepreneurial activities, but also in company creation have better opportunities to realize potential synergies. *Triple role academic entrepreneurs* usually have strong industrial connections and are involved in teams with outstanding industrial contacts. Additionally, they usually have better knowledge, managerial and entrepreneurial skills than the other two types of academic entrepreneurs. And finally, triple role academic entrepreneurs are likely to have access to more funds. These all seem to have a self-reinforcing effect, since having better skills and knowledge combined with a continuously extending social network and the additional resources available create an improved status that contributes to more teaching and research related academic entrepreneurial activities and maybe to company creation. They conclude that resource constraint does not barrier academic entrepreneurial activities; scientists rather use them to get access to resources. (de Silva et al., 2011)

In a further study de Silva (2011) investigated the dynamic character of entrepreneurial motivations and that of entrepreneurial activities. The context was again Sri Lanka, a resource constrained country, and in a sequential triangulation research approach she first conducted an on-line survey that was followed by in-depth face-to-face interviews. The types of entrepreneurial activities investigated are the same as in her previously cited paper co-authored by Uyrarra and Oakey (de Silva et al., 2011). Based on a survey of academic and general entrepreneurship literature she composed a list of *push* and pull *motives*. The former includes elements like insufficient income, job related dissatisfaction, lack of resources within the university, lack of industrial partner capable to commercialize the invention, and pressure for academics to engage in entrepreneurial activities. The pool of *pull motives* is much larger and includes career development, the belief that academic entrepreneurial activities will not interfere with academic career, following role models, acquisition of new knowledge and skills, personal satisfaction, make use of industrial resources, providing service to students, capitalization on the opportunity perceived either by the scientist or the university, creating wealth.

She argues that the process of academic entrepreneurial engagement starts with teaching related entrepreneurial activities (single role academic entrepreneur), then it diversifies into research related academic entrepreneurship (double role academic entrepreneur) and finally into company creation as well (triple role academic entrepreneur). She emphasizes that it is about a *continuous extension and combination of activities*, thus researchers do not give up with teaching and research related academic entrepreneurial activities by entering into the domain of company creation. She analysed the dynamism of motivations of every type of academic entrepreneurs and in all cases she found that the initial motivation in the resource constrained environment was push motivation, which was later extended with pull motives, however, here differences can be observed among the entrepreneurial types. Single and double role academic entrepreneurs show a similar diversification of motives, both groups started with push motives and later on some pull motives entered and the combination of both existed. The difference between the two groups is that while some – though not many – double role academic entrepreneurs can be motivated by pull factors only at the end, none of the single role academic entrepreneurs is ever motivated only by pull factors. The triple role academics seem to be different in their motivational dynamic, most of them are motivated by push factors[36] at the beginning, but this is immediately (and not gradually) followed by pull factors, and the push factors themselves would have been insufficient incentives to start a company, the occurrence of pull factors was needed to actually do so. (de Silva, 2011)

The above mentioned cases reflect abundant motivations other than monetary rewards, mainly related to the academic advancement of the scientist. However, motivation does not ensure the success of the venture, since there are various factors that can influence the final outcome of spinning off. A potential set of those factors is introduced in the following part of the chapter.

[36] Typical push factors of company creation have been "commercialization barriers, such as university red-tapes, not having an industrial partner to commercialise their innovations, and university resource scarcities" (de Silva, 2011; p. 16).

3.3. Business versus academia – Factors influencing the realization of the motivations

As it has been shown by the typologies above, there is not a single academic entrepreneurial model, but there are various types of academic entrepreneurs – sometimes partly determined by the larger external environment as it has been described by de Silva (2011) in the resource constrained environment of Sri Lanka. Different entrepreneurial types can have different motivations and they can follow different aims by establishing a firm, however, there seems to be a common pool of potential factors that either hinder or support the scientists to achieve their original aim. Based on an extensive survey of the literature on (broadly interpreted) technology transfer and spin-offs in particular, this chapter introduces various factors that can influence the realization of academic entrepreneurial motivations.

There are differences in the structure the various studies categorize influencing factors, but most of them mention issues related to the inventor, to the parent organization (the university or research institute), and to the environment that includes local, regional and national elements as well. Based on a literature survey, Grimaldi and colleagues (2011) listed system-, university- and individual level factors related to the individual entrepreneurial competency building. System level variables included legal frameworks and institutional characteristics of the countries, regional and local support and incentive schemes, and infrastructural and financial conditions of the local economic context. University level mechanisms encompass organizational structures and support mechanisms that try to increase entrepreneurial awareness of the faculty, like policies, business plan competitions, trainings, technology transfer offices and university venture funds. Individual variables mainly relate to the willingness of academic researchers to participate in commercialisation. (Grimaldi et al., 2011)

There are some further literature surveys that collected and systematized the factors affecting specifically new firm creation. O'Shea and colleagues (2004) identified four domains that influence spin-off establishment. Individual attributes are related to the attributes and personality of the researcher, organisational determinants include the resource endowments and capabilities of the parent organisation (level and nature of research funding, quality of the researchers and the nature of research, and presence of incubators and technology transfer offices), institutional determinants are manifested in university structures and policies facilitating commercialisation, while external determinants of spin-off activity are related to environmental factors facilitating entrepreneurship, like availability of venture capital, the knowledge infrastructure in the region and broader legal changes (e.g. Bayh-Dole in the US and similar acts in Europe and elsewhere).

Rothaermel and colleagues (2007) claim based on a very extensive literature survey that spinning off activity is influenced – among others – by university system variables, like policy, incubation models and research environment, by the presence, expectations, business capabilities, experience and age of the technology transfer office. Also the (quality and quantity of) technology, availability of investors and other external conditions, like federal funds, market opportunities and industrial R&D funding influence spinning off. Related to the personal factors, the quality, personality, expectations and experiences of the faculty are about importance, just as the network parameters and characteristics of the founders and teams, such as experience, homogeneity and evolution of the team. (Rothaermel et al., 2007)

Aldridge and Audretsch (2011) distinguished between personal characteristics (age and gender), human capital of the scientist (citations), social capital (membership in a firms scientific advisory board or in board of directors), characteristics of the technology transfer office (mean number of TTO employees, number of employees dedicated to licensing over the number of administrative employees) as factors that can induce or inhibit spin-off formation of academic scientists.

Fini and colleagues (2009) used a slightly different approach in their study by investigating factors related to environmental influences, university level support mechanisms and individual level related factors (as listed in detail in Table 2).

Table 2 Factors affecting scientists' spin-off formation

Factor	Domain	Item
Environmental influences	Supports coming from the external context	Sector opportunity for commercial exploitation Supportive institutional context Fertile local context Supportive academic environment
	Technology commercialization potential	Availability of excellent personal technological knowledge Founder's previous investments in technology development Market demand for commercially exploiting the technology
	Contagion effect	The possibility and willingness to imitate other firms
University level support mechanisms	University patent protection	University-level patent regulation University patented technology
	University support services	University invests in equity University-level spin-off regulation/policy Business plan competition Technology transfer office
	Access to university infrastructures	Access to academic laboratories/facilities Access to academic incubators
Individual level related factors	University related benefits	Obtain research funds Obtain laboratories' equipments Obtain research grants Attract star scientists
	Economic and technological development contribution	Contribute to the economic and technological growth of the country Contribute to the employment increase
	Personal related benefits	Personal earnings Prestige and reputation Network New stimuli and ideas for applied research

Source: Fini et al. (2009; p. 394–396)

Vohora and colleagues (2004) created a model of spin-off activity of scientists that identifies five developmental phases and four critical junctures that have to be overcome to get into the next developmental phase. The critical junctures are related to deficiencies in social capital, internal capabilities and resource weaknesses. Their investigation starts at the research phase and embraces the developmental process of the spin-off until the sustainability phase. At each phase and juncture they analyse different factors that can influence the success of the company. Though it is not explicitly structured based on the level of the influencing factor, they identified factors that are related to the individual researcher, like his human (including also entrepreneurial and market knowledge) and social capital, to the university, e.g. competency and capabilities of the TTO or the entrepreneurial attitude of university colleagues. They also mention factors that can be connected to the regional or broader environment, like the availability of financing in form of seed money or venture capital, and presence of surrogate entrepreneurs.

Based on the literature survey we created a framework to investigate the factors that are conducive or hindering to spin-off formation, since as it has been shown in the previous chapter, sometimes even motivated scientists have to abandon the realisation of their aim due to external influences. Our approach includes factors related to the individual level, to the university level and to the external environment that encompasses both regional and national levels. Though the motivations to start a company can be different from that of other academic entrepreneurial activities, the factors that influence them are strongly interrelated, thus the factors assumed to be about importance for spin-off establishment are broadly interpreted in our analysis. They include items that seem to influence the likelihood of deciding to establish a company or being involved in other type of entrepreneurial activities, and they also encompass factors that have an effect on the success of entrepreneurial activities, consequently on achievement of the goals related to spin-off formation.

3.3.1. Individual level

"[…] technology transfer between academia and industry is a matter of individuals."
van Dierdonck et al. (1990; p. 564)

Since the previous part of this chapter provided a detailed introduction of the attitudes and motivations of academic entrepreneurs, we do not include it among the individual level influences, though we maintain our argumentation that this is the most important issue on the scientists' side. The factors encompassed in our analysis are the age and gender, the professional characteristics of the scientists, the business experience or education of the faculty members and their social capital. We also deal here with some normative issues, since even after the normative shift there are some concerns related to the entrepreneurial involvement of university scientists. The most frequently cited issues are publication delay and secrecy required by commercialization that can keep motivated scientists back from commercialization.

3.3.1.1. Professional and personal characteristics

"[…] commercial science began within and diffused across the stratum of elite scientists."
Stuart and Ding (2006; p. 99)

The *scientific excellence* of a researcher can be of crucial importance for entrepreneurialism. Franzoni and Lissoni (2009) highlight that specific knowledge and information owned by university scientists enable them to recognize opportunities that outsiders might could not. The importance of idiosyncratic information in spinning off was underpinned by Vohora and colleagues (2004). Furthermore, Murray (2004) argues that, through various mechanisms, inventors bring their human capital – including also tacit knowledge – in the company they are associated with. Vohora and colleagues (2004; p.151) found in their study that all of the interviewed spin-off founders "[…] were at the forefront of research in their chosen fields […]". Publication data seems to be a good approach to measure human capital, since the "publish or perish" mentality urges researchers to publish their work towards the scientific community (Göktepe-Hulten and Mahagaonkar, 2010; Vohora et al., 2004).

Publication is an important way of knowledge transfer (Agrawal and Henderson, 2002) and it was found to be related to entrepreneurial activities as well. It correlates with patenting probability (Renault, 2006), additionally Alshumaimri and colleagues (2012) found a positive relationship between publications and scientist entrepreneurship[37]. As it has already been mentioned, based on the analysis of commercialization in the life science sector, Stuart and Ding (2006) argued that star-scientists have been the first to start with entrepreneurialism. Measuring the prestige of a scientist with publication and *citation* data they found that commercial scientists showed an above average value in the whole period investigated (from 1972 to 1998). However, they also note that this prominence gap between commercial and non-commercial scientists started to decrease over time that suggests a kind of a democratizing process; increasing participation of less prestigious members of the scientific community. The importance of star scientists was also supported by Lowe and Gonzales-Brambila (2007) who claim that

[37] In their study entrepreneur was a scientist who was considered starting a firm.

faculty entrepreneurs are more productive[38] in terms of publications and citations than their peers.

However, there is some evidence that contradicts these results. Louis and colleagues (1989) argue that scientific productivity is not an important predictor of spin-off founding likelihood. Similarly, Landry and colleagues (2006) found no connection between spin-off formation and publication record of a scientist. Using citations as a measure, Aldridge and Audretsch (2011) have not found a significant relationship between human capital and spin-off activity. In a more recent paper Karlsson and Wigren (2012) used a slightly different approach by distinguishing between scientific and popular legitimacy. The former was measured by peer reviewed and non-peer reviewed scientific articles, just as conference papers, while popular science publications[39] created the ground for popular legitimacy. They found that popular science publications had a positive effect on start-up propensity, while peer-reviewed articles and conference papers had no effect. Furthermore, articles in non-peer reviewed journals decreased the likelihood of starting a company. Also D'Este and colleagues (2012) insist that scientific or research excellence measured by citations is important to discover and explore scientific opportunities, but the exploitation of those requires different types of skills and experiences, like e.g. industrial collaboration and scientific breadth.

Though evidence is mixed, it seems that star scientists played a major role in academic entrepreneurship, especially in the life sciences and biotechnology, and particularly in the starting periods of those, so we can assume that scientists participating in spin-off creation are characterized by above average publication and citation records. It is especially true, if we wish to investigate the Hungarian context, where academic entrepreneurship is still in an early phase of development regarding its depth and breadth as well.

A further important indicator of the professional characteristics of the researcher could be the position in the university hierarchy or *seniority of the scientist*. The life cycle models of academia suggest that university scientist are likely to establish companies in the later stage of their career[40], since in earlier stages they focus on increasing

[38] And their productivity does not decrease after spinning off (Lowe and Gonzales-Brambila, 2007).
[39] And also other public media appearances (Karlsson and Wigren, 2012).
[40] Jain and colleagues (2009) reached similar conclusion for involvement in broader commercial activities.

their human capital (Stephan and Levin, 1996; Levin and Stephan, 1991). However, Aldridge and Audretsch (2011) found that age and gender of scientists have no effect on spin-off founding rate. The latter is supported by Alshumaimri and colleagues (2012) as well, while the former is disputed by Fritsch and Krabel (2012) who argue that younger researchers find spinning off more attractive than senior researchers. The larger openness of younger and less experienced scientists towards company establishment is also underpinned by Alshumaimri and colleagues (2012). Louis and colleagues (1989) stress that individual characteristics, including also gender and professional age, are not important predictors of spin-off involvement. Landry and colleagues (2006) found that men faculty are more likely to establish spin-offs than their female peers.

3.3.1.2. Social capital

Murray (2004) argued that besides human capital, social capital is one of the most important contributions of a university researcher to a spin-off. She distinguished local laboratory and cosmopolitan network of a researcher. The former is a local social context that is "structured and emerges through the traditional scientific career development of academic scientists" (Murray, 2004; p. 653). Practically it includes contact to advisors and advisees developed through the education and career of the researcher. On the other hand, the cosmopolitan network connects the researcher to peers with the same or similar research interest and focus. Though the establishment of these networks is not so precisely described, also they evolve through the "practices and social structure of science throughout an inventor's career[41] (Murray, 2004; p. 644), and over time star scientists became deeply embedded into the scientific community. This enables joint research and co-publication activity with these "invisible colleagues". Murray (2004) pointed out that social capital can be more important for the success of a firm than human capital, since it can work as a quality signal of the company to the members of the network. This quality signal might help to overcome liability of newness that is according to Shane and Khurana (2003; p. 539) "one of the most robust empirical finding in the literature on organizational mortality". Varga and Parag (2009) claimed that the knowledge accumulated in academic networks has an effect on the success of academic knowledge transfer.

[41] Latour (1987, cited by Murray, 2004) argues that journal editorship, participation in grant review processes, government committees and scientific policymaking can facilitate the extension of the cosmopolitan network.

Similarly to Murray (2004), also van Rijnsoever and colleagues (2008) distinguished different types of *scientific networks* and also an industrial network[42]. They argue that faculty networks, consisting of contacts within one's own faculty, are likely to represent mentor-mentee relationships, while university network includes contacts to colleagues at the same university, but outside the researchers' own faculty. External networks represent researcher colleagues from other universities, and are most likely to be the result of past occupations. They also found that the Matthew-effect works in network building; thus achieving a threshold of contacts accelerates further extension.

Since work experience at different universities stimulates networking (van Rijnsoever et al., 2008), *mobility*, especially international one can significantly enhance the development of scientists' networks. Musselin (2004) argues that most of the post-docs aim to enhance their career perspectives in their country of origin. Also Schiller and Diez (2008) pointed to the importance of career advancement opportunities in the mobility patterns of star scientists. Following this argumentation, we can assume that the contacts established during international experiences will represent a valuable international network that might enhance entrepreneurial activity. This logic seems to be underpinned by Krabel and colleagues (2012) who found that mobility across countries stimulates not only commercialization and patenting, but also entrepreneurial activities of researchers.

Most of the scientists have underdeveloped networks outside the academia, though not only academic, but *business networks* can influence spin-off establishment and growth. This underdeveloped network can be related to the academic career orientation of scientists, since van Rijnsoever and colleagues (2008) found that industrial contacts are not related to academic rank, and are likely to intensify in later stages of career. D'Este and colleagues (2012) argue that contacts to potential users, especially businesses are more important for the exploitation of entrepreneurial opportunities than research collaboration networks. Rasmussen and Borch (2010; p. 609) simply stated that "the most important way of accessing resources for the USOs stemmed from the industry contacts of the academic entrepreneurs." Contact to surrogate entrepreneurs can help overcome deficiencies in the scientist's related knowledge and experience (Franklin et al., 2001). Shane and Stuart (2002) stated that having a direct or an indirect relationship

[42] The industrial network includes contact to people in private companies (Rijnsoever et al., 2008).

to venture investors already before the establishment of the firm significantly increases the likelihood of getting funding and decreases the likelihood of failing. Also Vohora and colleagues (2004) highlight the role of contact to people with business venturing expertise, like mentors and advisors, who are especially important in the early phase of enterprising and if scientists lack entrepreneurial experience. They also noted the importance of customers, competitors, potential investors and suppliers. This latter[43] was also mentioned by Lawton-Smith and Bagchi-Sen (2008).

Aldridge and Audretsch (2011) emphasize the importance of contacts to scientists working in industry. Landry and colleagues (2006) measured social capital by an index composed based on the frequency of interactions of the researcher with managers and/or professionals from private firms, government departments and university communication department. They found that increasing social capital assets increase the likelihood of spin-off creation. Knowing people with good managerial experience can help to come up for deficient entrepreneurial skills of the scientists (Morales-Gualdrón et al., 2008). Alshumaimri and colleagues (2012) found no relationship between social capital and entrepreneurship.

Due to the special situation of researchers maybe one of the most important elements of their social capital can be a *role model*, a scientist who is himself an academic entrepreneur. Role models, especially if they work on the same campus, increase the likelihood of entrepreneurial participation through their social support (Laukkanen, 2003).

Regarding spin-off activity specifically, Etzkowitz (1998 and 2003) argues that a role model can increase the likelihood of establishing a company from a recognized opportunity. The lack of entrepreneurial role model can keep scientists back from establishing a company, even if they see the opportunity (Vohora et al., 2004). Stuart and Ding (2006) emphasize that the openness of star scientists towards entrepreneurialism and their pioneering involvement was especially important in times before the normative shift, thus when the majority of their peers were suspicious towards commercialization. They insist that having a co-worker at the department or a co-author who became

[43] Together with the role of technology (Lawton-Smith and Bagchi-Sen, 2008).

an entrepreneur[44], increases the likelihood of spin-off participation. Shane (2004b) also underpinned the importance of role models in spin-off creation based on interviews with firm founders from the MIT.

A successful researcher who already spun-off a company is familiar with both spheres and can serve as a bridge between the scientific and business spheres[45], but sometimes he can provide more. Etzkowitz and Peters (1991) also found example of direct financial assistance, when successful academic entrepreneurs supplied capital for their colleagues who have just started a company. Clarysse and colleagues (2011; p. 1092) suggest that universities should "attract entrepreneurially oriented academics as tenured professors or to recruit entrepreneurially oriented individuals in an academic career."

3.3.1.3. Entrepreneurial education and/or experience

> "What makes some academics great scientist or engineers clearly does not usually give them the necessary entrepreneurial human capital to start and grow a business."
> Vohora et al. (2004; p. 163)

Though Etzkowitz (1983 and 1998) argued that group research prepared scientists for the business managerial role, academic entrepreneurs are often assumed not to be the best persons to bring an idea to the market, since they lack the necessary knowledge and expertise that is needed to this (Shane, 2002). Business knowledge and skills seem to be particularly important in industries like biotechnology and pharmaceuticals (Meyer, 2008). Participation in *formal business education* might offset this weakness, so entrepreneurial training provided to scientists who plan to establish a company can significantly increase the venture's success (Vohora et al., 2004). Clarysee and colleagues (2011) suggest that entrepreneurship should be a core subject in the PhD education and more entrepreneurship training and seminars should be provided to academics, and also Laukkanen (2003) underlines the importance of business education.

[44] Especially when this role model has industrial contact established prior spinning off his own company (Stuart and Ding, 2006).

[45] Though further research is needed to explore the precise mechanisms and informal networks that allow would-be scientists to access this expertise (Grimaldi et al., 2011).

Nevertheless, not only formal education can be about importance[46]. Druilhe and Garnsey (2004) argue that the knowledge and experience that are relevant to run a business can be learned by the researchers through entrepreneurial involvement. This view is supported by Vohora and colleagues (2004; p. 157) as well, who insist "[…] that the pre-organization phase represents the steepest learning curve for the *academic* entrepreneur […]", especially for those without related previous experience and social network. D'Este and colleagues (2012) found that *prior invention experience* in form of disclosure and patenting has a positive effect on the realization of an entrepreneurial opportunity, thus on spin-off establishment. They also found that *previous industrial collaboration* also increases the likelihood that a researcher exploits a research opportunity through company formation. Fritsch and Krabel (2012) underpin that experience in cooperative research projects with private partners increases the attractiveness to start an own company, but – contrary to D'Este et al. (2012) – they did not find such an effect regarding patenting. Landry et al. (2006) argue that involvement in intellectual property protection activities increases the likelihood of subsequent spinning off activity, just as consulting experience of scientists. This view is supported by Jones-Evans (1998) who argues that – under appropriate conditions – consultancy and contract research can lead to the creation of technology-based spin-offs. Clarysse and colleagues (2011) also underpin that previous entrepreneurial experience increases the likelihood of subsequent entrepreneurial involvement. Louis and colleagues (1989) point out that involvement of scientists in other non-scholarly entrepreneurial behaviour is the most important predictor of company founding.

The entrepreneurial experiences described above all can accelerate the accumulation specific market and managerial knowledge that is required to start with an own company and run it successfully. At the same time they also broaden the social capital of scientists, the benefits of which have already been interpreted in the previous part of this chapter.

[46] Running a laboratory is an important source of managerial skills, as it has been discussed in details in Chapter 3.1. Here we rather focus on activities that can provide industrial and market knowledge necessary to entrepreneurship.

3.3.1.4. *Attitudes towards a conflict with open science*

"The freedom to publish is a value of
utmost importance to academic scientists […]."
van Dierdonck et al. (1990; p. 558)

As it has already been mentioned, not all scientists welcomed entrepreneurial initiations within the walls of the university. Though there are some evidences that suggest that the norm of practical contribution of universities to the advancement of the society are determined by other factors than that of open science (Shibayama, 2012), entrepreneurial activities can arise many concerns[47] (Goldstein, 2010; Nelson, 2001; Slaughter and Rhoades 1996 and 2005; Washburn, 2005). At the dawn of commercialisation many believed that it threats the norm of communality (Stuart and Ding, 2006). Here we would like to discuss two issues in detail that seem to influence the individual scientists in their spin-off decision *secrecy* and *publication delay* associated with academic entrepreneurialism.

Participation in a company research often requires scientist to be secretive about their work and to delay publication until intellectual property rights are ensured. Louis and colleagues (1989; p. 127) argue that "more commercial forms of entrepreneurship […] may be less compatible with traditional university values." Shibayama (2012) warns that involvement in entrepreneurial activities can induce secretive and non-cooperative behaviour[48], consequently act against the norms of open science. This view is also supported by Buchbinder (1993) who argues that university-industry relationships are guided by academic secrecy, and a shift of responsibilities from peers to private corporations. Louis and colleagues (2001) investigated the behaviour of clinical and non-clinical life sciences faculty and found that those engaged in entrepreneurial activities, especially in patenting, licensing and spin-off were more likely to withhold information from others who requested them.

Louis and colleagues (2001) did not find support for the other risk, namely worsening of academic productivity due to entrepreneurialism. In their sample researchers in-

[47] Interestingly, potential conflict of commitment and conflict of interest issues seem to be much intensively dealt with in the United States than for example in the United Kingdom (Nelsen, 2006).
[48] E.g. in form of denying material transfer or sharing research tools (Shibayama, 2012).

volved in entrepreneurial activities published more than their non-entrepreneurial colleagues. Similarly, Lowe and Gonzalez-Brambila (2007) showed that the above average scientific productivity of scientists measured with publications has not decreased after spin-off establishment.

Also van Dierdonck and colleagues (1990; p. 558) reached similar conclusion in their study by insisting that "the dilemma "publication versus secrecy" is often exaggerated". They argued that there is always room for an agreement that enables both. Also Vohora and colleagues (2004) insist that many spin-off founders focus on the publication of research results before recognizing the entrepreneurial opportunity at all.

3.3.2. University level

> "Legitimacy had to be gained at several levels in the university organization, and this process was sometimes both time- and resource-demanding."
>
> Rasmussen and Borch (2010; p. 608)

One of the strength of research based spin-offs from universities compared to other business start-ups can be the background provided by their parent organization in form of access to physical facilities, but also in form of intangible assets. These benefits can be realized on different organisational levels, however, they cannot be taken for granted. Under certain conditions their positive effect on the development of the spin-off can be mitigated, and under unfavourable circumstances they can be even negative.

On the university level we would like to investigate issues related to the general entrepreneurial policy of the university, to the actual realization of the entrepreneurial mission and strategy on the departmental level, and the role that different institutions established at universities play in the commercialisation, like e.g. technology transfer offices, science parks and business incubators.

3.3.2.1. Policy issues

The university management and the policies adopted by them create the basic framework of academic entrepreneurship. Common forms of entrepreneurship related university policies are e.g. guidelines regarding licensing, material transfer, conflict of interest, intellectual property and also co-research (Shibayama, 2012). Since the practical contribution of universities to the development of their region is an explicit requirement by the governments not only in the USA, but in the member states of the European Union and some other countries as well, it can be expected that most of the universities are supportive towards their venturing faculty. However, many universities put a larger emphasis on licensing instead of *spin-offs* (Wright et al., 2008). Lockett and colleagues (2003; p. 185) found by investigating entrepreneurial universities in the UK that "the more successful universities have clearer strategies towards the spinning out of new companies and the use of surrogate entrepreneurs in this process". The importance of a supportive policy towards *surrogate entrepreneurs* is also underpinned by Franklin and colleagues (2001) who argue that universities with more favourable attitudes in this respect generate more spin-offs, and Vohora and colleagues (2004) who also noted that – among other factors – lack of clear policies and guidelines could impede the entrepreneurial commitment of a scientist, even if the opportunity is recognized.

These universities were also more likely to held *equity* in the companies originating from their institution that is likely to support the alignment of aims of parties interested in the spinning off process and increase the returns in the long run compared to commercialization through licensing (Lockett et al., 2003). This view is supported by Feldman and colleagues (2002) who argue that the shift from licensing to equity investment is triggered by the accumulated technology transfer *experiences* and the recognized long run benefits, rather than by necessity. The importance of university equity investment in the new company is also supported by Di Gregorio and Shane (2003), who also found that low inventor's share of royalties increases the likelihood of spin-off establishment.

Incentive structures within the university should be in accordance with the entrepreneurial strategy of the organization (Lockett et al., 2003; Vohora et al., 2004). Similarly, also tenure and promotion policies should reward spin-off participation instead of simply tolerating it or even less, which is often the case today (Renault, 2006). At the same time, implementing mid-station positions would be beneficial to allow sufficient time to develop a new venture (Laukkanen, 2003). Also sabbaticals and leaves of absences can support the simultaneous pursuing of academic career and business venturing (Etzkowitz and Peters, 1991).

Having a "clear and unambiguous relation to the university was considered important" regarding spin-off establishment (Rasmussen and Borch, 2010; p. 608). *Con-*

flict of commitment and conflict of interest arising when a spin-off founder scientist retains simultaneously his university position must be addressed. Such conflict of interests in relation to the university can be e.g. the use of students and university equipment for private gain, the – for the university – unfavourable division of working time or disclosing inventions to a company rather than to the parent institution (Kenney, 1986). It should be made clear what are the proper and what are the improper behaviours and roles for an academic entrepreneur (Laukkanen, 2003). However, too strict regulations are rather impediment of the spinning off process and often prohibit earlier permitted activities that would "allow a spin-off company to benefit from the relationship with the university", and limit so the firms competitive advantage (Renault, 2006; p. 237). Furthermore, in some cases university intramural regulations for entrepreneurship are sometimes hard to enforce, thus they can be insufficient in promoting entrepreneurial activities (Shibayama, 2012).

Clarysse and colleagues (2005) argue that based on the *incubation model* there are different resources (of financing, organisation, human resources, technology and network) needed in terms quality and quantity as well to successfully manage spinning off process. Also Landry et al. (2006) support the view that depending on the business model of the start-up might different incubation capabilities are needed. They highlight that some companies are relying on patent protection and require large capital investment, while others rather utilize a special expertise and do not need the previously mentioned support.

3.3.2.2. Departmental norms

„Even if the central university management was supportive of the USO project,
it was not necessarily seen as unproblematic at the department level."
Rasmussen and Borch (2010; p. 608)

As it has already been discussed above, the early spread of entrepreneurial activities within universities was largely impeded due to the attitude of scientists who believed that these activities were inappropriate.

Though the general framework of entrepreneurship is provided by the higher management of the university, the departmental level seems to be decisive for spinning-off.

Since this the level of the university structure where tenure and promotion policies are made at the end, it has a significant effect on the entrepreneurial decision of scientists (Renault, 2006). Most of the faculty member seem to put an emphasis on the entrepreneurial attitude of their close colleagues (Laukkanen, 2003), that is also underpinned by the fact that in Renault's (2006) study most of the scientists estimated that they have the same academic capitalism rating than their department, whereas only 37% believed to have the same rating as the university (Renault, 2006). Also Clarysse and colleagues (2011) argue that scientist form universities that are more active in spin-off formation are more likely to create a venture.

Louis and colleagues (1989) found that local norms are important predictors of the investigated entrepreneurial activities that can even mitigate the effect of individual characteristics and also that of specific institutional policies in case of spin-off involvement. They argue that equity holders are more likely to originate from an environment where entrepreneurship is a norm. They speculate that this can be related to self-selection bias, to behavioural socialization, to general organizational culture or to strategic management – most likely to all of them, but this needs further investigation. Clarysse and colleagues (2005) argue that the organizational culture of departments significantly determine how much effort TTOs have to make to facilitate spinning off activity.

3.3.2.3. TTO, ILO

> "On most university campuses, technology transfer offices (TTOs) mediate the interface between university and industry, through procedures and work practices designed to enact university IP and technology transfer policies."
> Owen-Smith and Powell (2001; p. 99)

University technology transfer offices (TTO) are responsible for the practical implementation of the relevant university policies[49]. Industrial "liaison offices have been created to structure the diversity of relationships between a university and its environment, to provide a more coherent representation of the university towards the outside world, and to increase the level of contracts between the university and its industrial environ-

[49] The term technology licensing office (TLO) and industrial liaison office (ILO) or industrial relation office and TTO are used in this chapter interchangeably.

ment by exploiting the research at the university" (van Dierdonck et al., 1990; p. 560). Industrial relations offices are also responsible for patenting and marketing the research results created at universities (Etzkowitz and Peters, 1991). The first offices date back until the 1920s, and were usually legally and administratively separate from the university[50], like e.g. the Wisconsin Alumni Research Foundation (WARF) or the Research Corporation, and managed patenting activities of multiple universities (Etzkowitz and Peters, 1991).

TTOs can guide the spin-off process from the beginning on, helping the inventor to examine the marketability of the invention, to frame the opportunity and to implement the idea, administer the company, get access to people with resources needed for the successful outcome of the venture, like surrogate entrepreneurs, venture capitalists etc. (Vohora et al., 2004). They should serve as contact facilitators among the involved parties, consequently missing in-house expertise should be compensated with external contacts (van Dierdonck et al., 1990). Thus not only the simply presence, but also the characteristics of the TTO are about importance. Owen-Smith and Powell (2001) argue that already invention disclosures are unlikely to happen if university scientists believe that the costs of interacting with the TTO outweigh the benefits of that, mainly as a consequence of process or infrastructure deficiencies. To identify promising inventions requires efficient flow of information and mutual trust among the interested parties within the university (Ndonzuau et al., 2002).

Markman and colleagues (2004) argue that the age of TTOs has a negative effect on spin-off formation, since more experienced TTOs tend to focus on licensing to mature companies instead of spin-offs. However, Aldridge and Audretsch (2011) could not find a statistically significant relationship between the likelihood of a scientist to spin-off a company and the share of the TTO employees dedicated to licensing and patenting. Also the total number of full-time employees was proven to be insignificant for the venturing decision (Aldridge and Audretsch, 2011). Similarly, Fini and colleagues (2009) insist that university level support mechanisms, including also the establishment of a TTO, do not provide additional incentive for the scientists to create a company. Louis

[50] In Japan, the technology licensing offices (TLOs) used to be university external institutions (though in some cases this later changed) affiliated with multiple universities, while intellectual property management offices (IPMOs) were intramural university organizations (Shibayama, 2012).

and colleagues (1989) found that university administrative support – including also the size of the patent office – had little effect on faculty entrepreneurship.

Lockett and colleagues (2003) argue that universities that have better expertise and networks specific to the spinning out of companies are more successful in terms of entrepreneurship that underpins the importance of commercial offices already from the identification of the opportunity. However, also they note that the TTO provides only a limited contribution to the entire entrepreneurial capability of the university. This view is supported by Clarysse and colleagues (2011) who highlight that if we consider also spin-offs that are not based on a formal IP relation between the university and the firm or are not officially listed as spin-offs, we will find that the TTO plays a marginal or no role at all. Lockett and colleagues (2005) speculate that the contribution of TTOs to spin-off creation could be improved by hiring technology transfer officers with private sector experience, including also business launching and also the position of TTOs within the university hierarchical structure and the related incentive systems should be reconsidered.

3.3.2.4. Science/research parks, incubators

Science parks can significantly contribute to the development of an industrial penumbra around the university. "A university research park is a tract of land on or adjacent to the campus, set aside by the university for the development of science and technology-based industry, on land or buildings leased to firms" (Etzkowitz and Peters, 1991; p. 151). Etzkowitz and Peters (1991) highlight that this spatial proximity can be mutually beneficial for the university and for the companies located in the park as well. Firms can benefit from the access to knowledge in tacit and codified form as well through the university library, academic consultants, university research projects and patents, and they can hire talented students and graduates as well. Universities, on the other hand, can hope for support/funds and additional revenue from companies, insertion of new and practically relevant ideas in the research streams on the campus, and also they are interested in good job opportunities for their graduates (Etzkowitz and Peters, 1991).

Druilhe and Garnsey (2000) argue that one of the shared characteristics of the Cambridge and Grenoble high-technology centres were the science parks established by the universities. They also note that these were among the firsts in the UK and France, and facilitated the development of the high-tech activities in their region. Also Löfsten and Lindelöf (2002) found that new technology-based firms located in a science park were more likely to interact with the local university than other NTBFs, and they also created higher employment and sales growth. However, they also note that on-park firms do not show an outstanding performance regarding profitability, and in a later study (Lindelöf and Löfsten, 2003) they also note that these neither outperform off-park firms regarding R&D output as measured by patents/products launched. Furthermore, not all initiatives are fully successful in intensification of university-industry collaboration. Van Dierdonck and colleagues (1990) claim that science parks located near the investigated Belgian universities were successful from real-estate point of view, but their collaborative contribution is mixed. Also Franklin and colleagues (2001) argue that science parks often do not really enhance the interactions between academics and business people, they rather function as property development projects. By investigating 81 research parks founded between 1951 and 2002 Link and Scott (2005) pointed out that university spin-off companies tend to be operate in a larger proportion in parks that are older and are laying closer to the university campus. They also found that university spin-offs are present in a larger share in science parks with biotechnology focus, instead of focus on IT or no focus at all. However, they also note that further characteristics of the spin-offs (above the investigated IT or biotech focus) need further investigation in the future.

From a spin-off point of view, university science parks and incubators can offer a good alternative location to spin-off companies that have already achieved the sustainable returns phase of their development and wish to move off the university campus into a commercial environment (Vohora et al., 2004). "Technology incubators are university-based technology initiatives that should facilitate knowledge flows from the university to the incubator firms" (Rothaermel and Thursby, 2005a; p. 305). Besides offering infrastructure, like rental spaces, equipments, administrative and conference facilities or laboratories, incubators also coach the tenants through trainings and workshops and provide access to their network that includes mangers, consultants, scientists and costumers (Peters et al., 2004). Being located in a university incubator can help to legitimize the company (Lockett et al., 2003), but it can provide more. Rothaermel and Thursby (2005b) argue that geographical proximity and institutional linkages and network allow faculty member convenient simultaneous exercise of managerial and academic roles. These companies are less likely to fail, however, they are also less likely to graduate from the incubator within 3 years or less (Rothaermel and Thursby, 2005b). Fini and colleagues (2009) discuss that many companies prefer to remain within the walls of university incubators, because they are not growth oriented.

3.3.3. External environment

Not only the personal and university level mechanisms, but also the broader environment can have an effect on the opportunity and willingness of university scientists to create a firm. The overall framework of entrepreneurial activities clearly depends largely on the national university systems. However, since many of these differences have already been discussed in Chapter 2.2.6. that deals with the historical evolution of universities, here we would like to discuss two other important environmental aspects: the national regional milieu that involves innovation systems, property right issues, support structures and regional clusters as well, and the financing, namely venture capital that is a critical area of spin-off development.

3.3.3.1. National and regional milieu

> "[…] universities likely benefit from commercialization of their knowledge only when the local context in which they are embedded is supportive […]"
>
> Grimaldi et al. (2011; p. 458)

The legal frameworks and institutional settings of the countries influence the academic entrepreneurial opportunities (Grimaldi et al., 2011). Japan laws for example unable the way of university-industry collaboration of US style by prohibiting star scientists to work in firm laboratories, consequently commercial researchers have to travel to the university laboratory (Zucker and Darby, 2001). This was found to significantly decrease the local economic development impact, and also mitigated the positive effects of such collaboration on the university scientists' productivity[51].

The literature suggests that the development of successful university spin-off companies is a matter of local context as well. Fini and colleagues (2011) investigated the role of local context and universities in developing spin-off companies in the Italian environment. They argue that depending on the local-context support mechanisms the

[51] Measured in terms of citations per article (Zucker and Darby, 2001).

contribution of universities in form of additional university-level support mechanisms the latter can have a complementary or a substitution effect. They suggest that in regions where the local support mechanisms enhance innovation in general, universities should incrementally invest in support mechanisms targeting spin-off creation specifically, like policies and spin-off regulations, TTOs, external collaboration etc. However, if the local-context support mechanisms already provide targeted support for high-tech entrepreneurship, like incubators, financial incentives and alike, universities should limit their related investments to avoid substitution effect (Fini et al., 2011).

From our point of view it is also important to mention that the development of high-technology industries is strongly influenced by the regional context. Though the previous chapters introduced some western examples that suggest that the development of biotechnology clusters is a natural phenomenon around elite universities, since the early rise of the industry is related to star scientists and their entrepreneurial efforts in multiple modes of technology transfer, there are some studies that partly contradict these findings. Expenditure on university R&D in areas that do not achieve the critical mass in economic activity is only likely to result in enhanced innovation and regional economic development if it is part of a complex regional development plan that also targets high technology employment and business services (Varga, 2000).

Trippl and Tödtling (2007; p. 51) argue that regional innovation systems with weak potential for high technology industries might be characterized by the presence of scientific excellence on one hand, but on the other hand, "[t]hese areas often have little experience in commercializing scientific discoveries, a weak culture of risk taking, low levels of social capital, and frequently they lack crucial factors, such as venture capital or a support structure specialized in promoting academic spin-offs." Under these circumstances university scientists tend to prefer publishing instead of patenting or spinning off (Tödtling and Trippl, 2007). This tendency aggravates the situation, since spin-offs are considered as important type of knowledge flows, consequently, the development of a biotechnology cluster in these latecomer regions requires the transformation of the regional innovation system that also necessitates intensive policy actions and governmental programmes, entrepreneurial turn of universities, establishment of spin-offs, just like connection to distant knowledge sources (Trippl and Tödtling, 2007). Also Bajmócy

(2005) argues that in less developed regions the utilization of universities' knowledge-potential may necessitates community intervention.

Degroof and Roberts (2004) investigated spin-off policies in the Belgian context that is a non-high-tech cluster environment with weak technology transfer and entrepreneurship infrastructures. They argue that under these circumstances the spin-off policy of the university has a significant effect on the growth potential of spin-offs, the high selectivity and high support model seeming to be the best solution.

3.3.3.2. Availability of funding

> "Venture capital plays a critical role in both the direct financial support that is provided by capital investments and the additional support that is typically attached to early-stage investments."
>
> Fini et al. (2011; p. 1115)

Getting finance is one of the big challenges that most of starting entrepreneurs face (Aldridge and Audretsch, 2011), and university spin-offs often are in an even worse situation. Research *grants* are often one of the most important sources of funding for just launched spin-off companies. However, overwhelming support can lead to companies with limited market orientation (Meyer, 2003).

Ndonzuau and colleagues (2002) point to a financing gap at the early stage of the spinning off process. They argue that after the initial inventions there is a need for the development of a prototype and business plan as well. However, public many rarely covers the cost of these, since it primarily focuses on fundamental research. *Venture capital*ists, on the other hand, are reluctant to invest at this stage due to the uncertainty of high-tech markets and because they are suspicious about the entrepreneurial skills of the researchers (Ndonzuau et al., 2002). Also Vohora and colleagues (2004) argue that some scientists face already difficulties to obtain *seed financing* to convert the "pre-organization" into an established company.

This raises an important issue, the role of the scientist in the company. Although the involvement of the inventor in the further development of the idea is a positive signal for the investors, having a scientist in the management of the company is not always welcome by venture capitalists[52]. Fini and colleagues (2011) argue that university scientists often target only survival and not rapid growth and this is also reflected by their business models.

Also Clarysse and colleagues (2005; p. 212) insist that some companies around universities are self-employment oriented spin-outs. They also highlight that even companies targeting fast growth are not attractive to investors, because “the amount of money needed is too small to be efficient or the market is simply too small to generate the multiples expected by a financial investor.” Nevertheless in case of companies that target fast growth VC funding can be of utmost importance. Shane and Stuart (2002; p. 154) stated that “receiving venture funding is the single most important determinant of the likelihood of IPO.”

[52] Here we have to mention that also some universities make endowments to create venture capital funds, but these usually provide only limited financing (Etzkowitz and Peters, 1991).

3.4. Summary

This chapter introduced empirical findings related to motivations and typology of academic entrepreneurs and the factors that can influence the realization of entrepreneurial intentions. The motivations behind spinning off involvement of university scientists show a more complex system than it could be explained by simple financial gain (de Silva, 2011; Franzoni and Lissoni, 2009). Science and career related incentives seem to play a more important role than the desire to increase personal wealth. Practical application of the invention can provide personal satisfaction for the inventor, but university scientists also can hope for peer recognition (Fini et al., 2009; Göktepe-Hulten and Mahagaonkar, 2010) and legitimacy of their scientific field in political circles, that in turn can lead to increased research funds. Also direct support provided by the company in form of financial or research tools for university research purposes are not uncommon in the western world (Fini et al., 2009). Additionally, a spin-off can offer job opportunities for talented students and the strategic coordination of the applied and basic research activities carried out at the different sides can extend the scientific frontier.

Academic entrepreneurs are usually motivated by a set of the above mentioned factors and also their emphasis between academia and business can diverge. Consequently different types of academic entrepreneurs can evolve, where some of them strongly limit their involvement and give absolute priority to science, while others gladly take the role of a business manager and focus on company development and also a mix of these is possible.

It is important to see that the realization of the motivations is dependent upon a broad range of factors. Based on empirical findings the occurrence of spin-off founders is more likely among star scientists who have outstanding publication and citation record and are positioned in a higher segment of the university hierarchy (Stuart and Ding, 2006). Besides science related human capital, also the business knowledge and experience can increase the likelihood of company creation, similarly to the extensive social network of the researcher that preferably contains academic entrepreneurial role model as well (Laukkanen, 2003; Murray, 2004). Scientists with a very strong commitment towards the notion of open science are likely to reject the secretive applied research avenue. University level factors like the entrepreneurial and equity policy of the institution (Lockett et al., 2003) and the related support organisations and infrastructure, such as technology transfer offices and science parks can also contribute to the entrepreneurial turn of scientists (Druilhe and Garnsey, 2000; Vohora et al., 2004), but maybe even more important is the supportive attitude of the departmental colleagues (Louis et al., 1989; Renault, 2006). The favourable regional milieu that has a high-tech base and the availability of appropriate funding in form of grants and venture capital as well can enhance the company's growth (Fini et al., 2011; Shane and Stuart, 2002).

In the next chapter we will investigate the motivational background of Hungarian biotechnology spin-off founders to see whether they are indeed led by scientific notions. Additionally, we will empirically test whether the above mentioned influencing factors are at work in the Hungarian context.

4. Is the academic entrepreneur viable in Central Eastern Europe? The case of the Hungarian biotechnology

4.1. Introduction

As it has already been mentioned in Chapter 2.3.6., the evolution of entrepreneurial universities is a highly contextualized phenomenon. Above the knowledge of the state-of-the-art, a path-dependent approach is needed to understand the conditions under which Hungarian spin-offs can emerge, since as Tchalakov and colleagues (2010; p. 2010) highlight "[…] the institutional and organisational specificities of local economies and research systems and their evolution […] strongly influence the patterns of spin-off activity." This chapter first provides an insight into the development of the entrepreneurial universities in Hungary. Though the Hungarian system has German roots, the Soviet model of science had a strong impact in the period of socialism and the aftermaths are still present in the organisation of science and fundamentally determine the research and entrepreneurship potential of Hungarian universities. Thus the peculiarities of the Central and Eastern European research systems are introduced in detail at the beginning of the chapter. Then we describe early forms of academic entrepreneurship of universities in the socialist and transitional periods. The fundamental changes in the legislation after the Millennium and the adjustment mechanisms of universities are analysed to introduce the context that just precedes our empirical investigation that is the closing part of the chapter. Since the survey focused on academic entrepreneurs in the biotechnology sector, first the historical roots, evolution, present state and future prospects of the branch are described. Following this, the survey method and the results are interpreted. The empirical research primarily aimed to reveal the founding motivations of university researchers in Hungary to see whether the academic entrepreneurs described by Etzkowitz (1983) can occur in a Central and Eastern European context. Besides motivations further factors that influence the entrepreneurial turn of scientists and the realisation of motivations are investigated. The factors included in the interview questionnaire follow the structure introduced in Chapter 3.2. These encompass individual and university level variables and some elements of the external environment. The description of the four types of academic entrepreneurs identified in the Hungarian context closes the chapter.

4.2. Evolution of entrepreneurial universities before and after the transition

4.2.1. Peculiarities of the Central and Eastern European research systems

> "There is a structural heritage in the research systems of C&EE rooted in the shared past."
> Balázs et al. (1995a; p. 615)

To understand the Hungarian research system one should get insight into the university systems that strongly influenced the evolution of the national context. Similarly to most of the continental European countries, also the Hungarian university system is dominated the Humboldtian legacy (Novotny, 2010b). Thus the characteristics of the German system largely overlap with the continental European systems in general that already have been introduced in Chapter 2.3.6. Summarily these have been the lack of strategic autonomy of universities resulting in a low level of competences and capabilities to manage IP portfolio (Franzoni and Lissoni, 2009), that inspired universities to abandon IPR from co-operative or contract research works in favour of the scientist or the company (Lissoni et al., 2008). The professor's privilege that institutionally awarded IP to the university scientists (Buenstorf, 2009) was abandoned only in 2002 (Mowery and Sampat, 2005). The state employee or civil servant status of researchers (Franzoni and Lissoni, 2009) jointly with the determination of salary based on an administrative scale (Musselin, 2004) and paid for the whole calendar year (Grimpe and Fier, 2010) seem to provide low incentive for competitive entrepreneurial activities. German universities are somewhat suppressed by other PROs that have variable legal statuses and funding schemes, like e.g. the Max Planck Society, the Helmholz Association of National Research Centers, the Fraunhofer Society or the Leibniz Association (Koschatzky and Hemer, 2009). These organisations play an important role in the research system and enjoy higher autonomy than universities (Franzoni and Lissoni, 2009). Here we would like to introduce in detail the other important university system that determined the Hungarian higher education and research, that is the Soviet model of science.

The period of the Soviet era significantly affected not only the economic, but also the science and technology policy of the member states of the Soviet Bloc, among them

Hungary. The Soviet model of science was framed during the 1920s and 1930s in the Soviet Union, and implemented in other communist countries (Gaponenko, 1995), "along with the common ideological belief in the political role of science in 'scientific socialism'" (Balázs et al., 1995a; p. 615). Though there have been R&D reforms implemented subsequently, the structural and social fundaments of the system remained unaffected until the 1990s (Gaponenko, 1995). Based on the notion of a one-way linear innovation model (Inzelt, 1999a), the innovation system of the former Soviet Union and socialist Eastern European countries can be described by the statist Triple Helix (Etzkowitz, 2003b) or Triple Helix I where the nation state had a central role by encompassing academic and industrial sectors and directing their interactions (Etzkowitz and Leydesdorff, 2000).

The separation of the spheres is also underpinned by Gaponenko (1995) who highlighted that the main features of this model were the administrative and command management methods guided by secrecy and the artificial separation of science, and the division of science into military and civilian sectors. The management method and dominance of party interests in decision making severely *limited internal democracy and creative freedom of science*, while the favouritism of military research in the sectoral division restricted the opportunities of civilian research that was reflected in access to financing, tools and expertise as well. This was further exacerbated by the *excessive secrecy* that "hampered the transfer of its technologies to the civilian sector" and by the presence of monopolies (Gaponenko, 1995; p. 686)[53].

The principles of *central planning*, namely specialisation, rationalisation and centralisation were reflected in the institutional design of civil research (Balázs et al., 1995a) and the emergence of *three subsectors of civilian science* (Gaponenko, 1995). This separation partly served political aims as well; it helped to prevent youth being affected by leading academics potentially criticising the system (Chataway, 1999). *The National Academies of Sciences* were responsible for basic research and their members represented an élite (Balázs et al., 1995a), but the concentration of power by a small group of academicians strongly impeded innovation (Gaponenko, 1995). Applied research was institutionally separated from companies and organized in *industrial research institutes* "under the auspices of 'branch ministries'" (Balázs et al., 1995a; p.

[53] While in the US a huge effort was made since the end of the Second World War to turn military inventions into civil products (see Bush, 1945).

616). It is important to highlight that these were not business R&D departments of industrial firms, but “independent organisations that worked for several enterprises and some of them (central industrial institutes) served whole branches” (Radosevic, 1996; p. 10). Generally these ‘branch science’ institutions were poorly equipped and financed (Gaponenko, 1995). Similarly to these, also *universities* had insufficient financing and equipment (Gaponenko, 1995), since officially these were responsible for education only, however, due to the ‘voluntary undertaking’ of university faculty a certain level of research was achieved (Balázs et al., 1995a). Also Inzelt (1999a) argues that against the poor equipment a significant knowledge-base was developed in the socialist countries.

Nevertheless, knowledge diffusion and commercialisation was underdeveloped, similarly to the technological and industrial infrastructure (Inzelt, 1999a). Enterprises functioned predominantly as “production units with very often limited responsibilities for innovation and the R&D process in particular” (Radosevic, 1999; p. 1). Balázs and colleagues (1995a; p. 617) insist that technical development in this fragmented system that was loaded with “ballast or inefficiency, and the weaknesses of research evaluation” was possible at all due to the *informal ways* developed by the actors *to get around the barriers*. Gaponenko (1995; p. 701) argues that the rigidity of the Soviet model was owing to its characteristics, like “gigantic research institutes, too large to adapt to new conditions; peripheral science weakly coordinated with the needs of a regional economy; […] no traditions of carrying out coordinated actions between departments in the process of elaborating and realizing S&T policy; lack of an independent institute of expertise; and no tradition of scientists participating in policy development.”

A new long-term science and technology policy started to emerge in the 1970s to solve inter-branch and inter-regional problems of the Soviet model, but on the old administrative and power base its success was very unlikely (Gaponenko, 1995). Gaponenko (1995) highlights that against all efforts science and technology policy was still determined by the administrative centres without the participation of scientific communities in strategic goal setting. He also points that the separation of science and business was maintained, just like that of scientific sectors. Consequently, science and technology policy was a kind of sum of the policies of the branches, where resource allocation depended on the power of the branch ministries (Gaponenko, 1995).

Against the transformations of the 1970s and 1980s, the basic features of the model remained quite unaffected during the era of socialism (Radosevic, 1996). However, the situation completely changed in the 1990s. Though the first signs of the Soviet S&T model's crisis became apparent already in the mid-1980s in form of the decrease of major science and technology indicators, the deterioration was accelerated by the system change (Inzelt, 1999a). The *transition* created a *hostile environment* for innovation and the institutions involved in it (Balázs, 1995; Chataway, 1999) and significant differences between the countries emerged (Radosevic and Auriol, 1999). Balázs (1995) introduces in detail the four factors and their state after 1990 that determine the conditions for research organizations; namely *economic environment*, policy making, funding, and the scientific community itself. Balázs (1995) argues that the collapse of market based on the Council for Mutual Economic Assistance (CMEA) and the distortion of market relations led to the dramatic decrease of export and consequently that of industrial production. The problems of restructuring and reorganization were aggravated by *policy making* that focused on liberalization, privatization and crisis management, however that state itself has been in a crisis too. Following of short-term interests in both the private and the public spheres impeded strategic privatization and enhancement of real competitiveness through liberalization (Balázs, 1995; Balázs et al., 1995a).

Though around 1989 the *expenditures on R&D* of the Central and Eastern European countries were still similar, sometimes higher than that of the western countries (Tchalakov et al., 2010), the cuts in expenditures already started in the 1980s and they were even more dramatic on the side of industry. Consequently, the falling out of the science and technology push model could not been replaced by a demand pull system (Balázs et al., 1995a).

Science and technology policy making itself was a contradictory process (Balázs et al., 1995a). General transformation and stabilisation issues seemed to enjoy a priority against S&T policy (Inzelt, 1999a). Actually even the need for a science and technology policy itself has been questioned as a result of unrevealing its potential role in economic revitalisation. Unfortunately also the *scientific community* contributed to this situation by focusing on defending the "privilege of science and the 'power' of scientific degree holder, instead of restructuring the inefficient science system" (Balázs, 1995; p. 659). The survival of inefficiency was supported by trade unions as well, "[…] since their project has been to 'save jobs' rather than 'save science' (Balázs et al., 1995b; p. 874). The power of scientific common was also weakened by the disagreement between its old and middle-generation about key issues in science and technology policy, like autonomy of institutions and freedom of science, democratization and decentralization (Balázs, 1995). Higher salaries, better working conditions and the consequently better scientific performance incited many Central and Eastern European scientists to carry on with their career abroad (Inzelt, 1999a). Not only emigration, but also shift to private sector occupations contributed to the decrease of the number of R&D personnel, however many ballasts seemed to remain (Balázs et al., 1995a).

In sum, the restructuring of the research system was very limited, "[…] the inflexibility and fragmentation of the former research system remain, with very little effective communication between academic, university and industrial sectors" (Balázs et al., 1995b; p. 874).

In this situation active and passive adjustment processes have been developed on both organizational and institutional levels. The *passive strategy* refers to the relative increase of basic research and that of state funding that was against the expected outcomes of the introduction of market mechanisms (Balázs, 1995). Balázs (1995) argues that *active adjustment strategies* created by individuals and organizations had two purposes. On the one hand, alliances, associations and agencies were established by the stakeholders to enhance science and technology policy making and to connect actors from different levels and organizations of innovation. On the other hand, research institutes and individuals worked on local organizational reforms and tried to find ways to a better living by establishing science parks, technology centres and spin-off companies (Balázs, 1995).

Balázs and colleagues (1995a) argue that these latter initiatives were usually based on the imitation of Western European practices from the 1980s that, in turn, aimed the imitation of American and English success stories from around 1960s and 1970s. However, there have been significant differences between those "[…] in terms of market, university behaviour and type of firm activity" (Balázs et al., 1995a; p. 673). In a recent study also Gál and Ptaček (2011; p. 1678) warns that, owing to the historical development path of universities and the underdeveloped business spheres and weak regional innovation systems, in Central and Eastern European countries "[…] ambitious university-based developmental models have to be revised ant the future role of universities has to be considered as potential engines of local economic development from a more realistic perspective." Though in the western countries governments actively tried to counterbalance important missing elements of a favourable regional environment to enhance economic development, in the Central and Eastern European countries the story was rather about trying to mitigate the negative effects of the economic decline and was supported by local associations and agencies, instead of central governments (Balázs et al., 1995a).

4.2.2. Entrepreneurial pre-history in Hungary

Though the above described tendencies resulted in a shared past of the Central and Eastern European countries, against the general uniformity of the system there have been some national differences evolving over time. Hungary (and Poland) for example "[…] never strictly followed the Soviet model" (Inzelt, 1999a; p. 166). As of Hungary, even against the relatively generous funding until the late 1960, some of the scientists made an effort to develop links to industry to utilize research results in applied sciences (Balázs, 1996). Although in the Soviet model of scientific division of labour research has been a task of academies[54] and universities were devoted to teaching only, there was no direct external intervention that made universities unable to conduct research (Mosoni-Fried, 1995). An important difference was observable in the composition of research funding as well. Since the early 1960s companies were required to establish a Technical Development Fund (TDF); two-thirds of which was centralized inducing a sort of competition among R&D institutions in the re-allocation of resources (Balázs, 1993). Unlike in many other countries of CEE, the share of industry funded R&D in Hungary has been traditionally high; some 70.1% of the R&D funding came from industry by 1990[55] (Radosevic and Auriol, 1999).

Since the mid-1960s, there has been an effort to "[…] introduce an efficient socialist economy in which market forces would play a role" (Inzelt, 1999a; p. 187). Most of the distinctive features of the Hungarian economic and scientific systems can be owed to the New Economic Mechanism (NEM) introduced in 1968. Balázs (1993) insists that

[54] The Hungarian Academy (established in 1825) was responsible for scientific policy making and implementation, national research programmes and for the management of research institutes, respectively that of the Hungarian Science Research Fund (Inzelt, 1999a).

[55] During the transformation, following a significant decrease and a short recovery, it stood still at 43% in 1995 (Radosevic and Auriol, 1999).

the NEM made Hungary peculiar among the members of the Soviet Block inasmuch it turned the strict central planning into a so called "market-oriented" system, and brought elements in the governmental S&T policy that are similar to the western comprehension of university-industry interactions. The basic notion was that market mechanisms would ensure economic efficiency with the active contribution of R&D institutions (Balázs, 1993). The NEM transformed industrial research institutes into state-owned R&D enterprises and introduced the system of *contract research* (Balázs et al., 1995a) that established a link between public research and industry (Tchalakov et al., 2010). Besides contract research, further options for universities to come up for the frozen state subsidy were state procurements and participation in strategic technological development programmes that served as the basis for the determination of sharing from the Centralized Technical Development Fund (CTDF) (Balázs, 1993).

Balázs (1996) argues that contract research had a much larger impact on the side of academia by increasing its dependence on the industrial partners and on the income resulting from the cooperation[56] – especially since the CTDF share offered only limited possibilities (Balázs, 1993). The problem was, however, that under the central planning system the manufacturing units using mature technologies and lacking real management function had neither incentive nor opportunity to incrementally innovate (Balázs, 1996). Thus the use of company TDF often took place based on personal informal contacts along allied interests with questionable actual innovation potential (Balázs, 1993).

Among the "pre-transition, non-research, income making activities" (Balázs, 1996; p. 8) *technical services and production* are especially worth to mention, since together with contract research these significantly contributed to the accumulation of knowledge, skills and experiences on the side of scientists that are being seen useful for knowledge-based academic entrepreneurship (Balázs et al., 1995a; Balázs, 1996). In-house production was usually related either to the manufacturing and commercialization of a research or development that was not undertaken by any industrial partner or to the imitation and distribution of western technologies, while services were enabled by the possession above a special research or testing equipment (Balázs, 1996).

[56] Tchalakov and colleagues argue (2010) that contract research created asymmetries between involved and not involved researchers as well by ensuring the former better knowledge about developing and managing business contacts.

The Act XI in 1988 on Centralized Technical Development Fund explicitly declared aiming to increase the technological level of the economy and accelerate technological development, respectively to support the spread of scientific and technological achievements. Additionally, in the 1980s there was a shift in the governmental policy for R&D funding towards competitive allocation mechanisms. As Balázs (1993) insists, the distribution of CTDF changed to project funding along the priorities of the economic development programmes (electronisation, diffusion of technology based on microelectronics, biotechnology, materials, and energy saving programmes, pharmaceuticals and plant-protecting chemicals) and also the National Scientific Research Fund (NSRF), established in 1984 for supporting basic research, followed a competitive approach in its distribution. All these activities taught scientists well before the transitional crisis to "manage business contacts, to apply for grants, and to enrol domestic and foreign partners […] how to negotiate over income and how to avoid tax. They experienced advantages of combining research and business, of adopting (and adapting) advanced knowledge and techniques on the local market" (Balázs, 1995; p. 677) – they could fill in the role of businessmen and accountants (Balázs, 1993). Early signs of spin-offs were already observable since the 1980s in form of 'small working groups' (or GMKs) established by the employees of the institution (Radosevic, 1996).

In 1990 the situation fundamentally changed. The first period[57] of the transition brought a recession with a 20% decrease in the GDP (Szerb and Ulbert, 2002). Also R&D funds significantly dropped already since the late 1980s and this decline was guided with a dramatic decrease in the R&D personnel; though this was partly reasonable, a – hardly assessable – share of it "[…] represented a severe loss of useful knowledge (including tacit one) and skills developed and accumulated over time" that cannot be easily come up with even if resources would be reopened (Havas, 2001; p. 12). Hungary had to undergo a complex modernisation programme (Havas, 2002). Inzelt (2008) argues that between 1990–1996/8 the *first wave of legislation* in the transitional period laid the foundations of the new national science and technology system by enacting laws on the Academy of Sciences, on Higher Education, on Intellectual Property Rights and on Public Procurement.

[57] The periods of transition have been: recession (1990–1993), stabilization (1994–1996) and sustainable growth (from 1997) (Szerb and Ulbert, 2002).

The Act on Higher Education played a crucial role in changing the research strategies of universities and their relationship with other actors interested in innovation. The enactment in 1993 created an opportunity for universities to undertake research activities that was enhanced by the amendment in 1996 that attached *earmarked R&D normative* to this task (Inzelt, 2002 and 2008). Since 1995 government programmes were launched to enhance the co-operation of the university and industry, but the results remained mixed. Though these policies had elements that "[…] go beyond the traditional way of thinking about innovation in transition economies", due to the relatively weak innovative capabilities only a few companies have been really interested in cooperation with universities (Inzelt, 2004; p. 992). Based on co-authorship data Inzelt and colleagues (2009) found that the most frequent cooperative partners of universities were academic institutions (including academies, universities, research organisations) that accounted for 86% of the cooperative publications.

One of the most noticeable changes during the transition period was the shift in the policy of governmental *National Research Funds* and *Technical Development Funds* that broke up with institutional funding and adopted a competitive approach on the individual or the team level (Balázs et al., 1995a). Nevertheless, Radosevic (1996; p. 16) argues that the inconsistent policies of the Hungarian government led to the "[…] deterioration and collapse of the network of industrial institutes because of prolonged and unsystematic attempts to restructure them".

Not only policies but also related *support programmes* tried to enhance the competitiveness and innovativeness of the economy that also affected the opportunities of spin-offs. Governmental initiatives aiming to enhance the commercialisation of R&D results were especially important owing to the generally unfavourable economic and banking environment (Inzelt, 1999a). The Centralized Technical Development Fund (CTDF) provided funding for applied research and experimental development efforts and specific sub-programmes existed for ICT (IKTA) and also for innovative small- and medium-sized enterprises (TECH-START) (Havas, 2001).

Inzelt (2004) argues that the programmes of CTDF can be divided into two categories; where enhancement of university-industry interactions was a primary target (two programmes: Establishment of Laboratories in High-technology and Cooperative Research Centre), and where it was listed among the many priorities (six programmes:

Applied Research and Development, Application of Information Technology – IKTA, Purchase Modern Equipments, Development of Laboratories in High-technology, Bio-technology 2000, Technology for Environmental Protection). The first year when university-industry cooperation appeared among the calls as a priority was in 1995 with the alteration of the Applied Research and Development Programme started in 1991, but it was only in 1998 when it became a primary objective with the extension of the call Establishment of High-technology Laboratories (Inzelt, 2004).

In 1992 the Trade Development Fund (KEFA) and the Investment Fund (BEFA) were established. The first was launched to support the realisation of business ideas that have a significant effect on the nation's economy, while the latter aimed to attract foreign direct investment. In 1995 the two funds were merged as Economic Development Fund. In the following year it was converted into an Economic Development Programme (GFC) aimed the promotion of company investments by allocating state budget for multiple purposes, including among others the establishment of industrial parks, support of small- and medium-sized enterprises and the production of competitive products. The Programme provided non-refundable grants and refundable loans as well. (VÁTI, 2000)

Transforming economic and political conditions increased the autonomy of universities and enhanced entrepreneurialism on the departmental and individual levels, while changing legislation enabled relatively easy and cheap firm funding of university scientists (Balázs et al., 1995a). Balázs (1996) distinguished between *top-down* and bottom-up *spinning off* initiatives. The former often was a result of organizational reforms that aimed to convert and transfer some manufacturing capacities and capabilities (including the skilled workers with related tacit knowledge) to avoid potential losses in the research institution. The shift for firm employment on the scientists' side was not an issue of voluntarism, but the only way to avoid unemployment. Further examples of top-down initiatives are single project firms that took over old Soviet contracts or former research assessment function. The common in all of these top-down spin-offs is their strong dependence on the parent research organization. Flexible top-down approaches sometimes meant the creation of internal divisions with voluntarily applying members, but sometimes it really appeared as a separate legal entity, but with a flexible, symbiotic relationship to the research institute. (Balázs, 1996)

From our point of view *bottom-up* approaches of the *spinning off* process are much more interesting, since these represent individual initiatives to exploit newly arising opportunities created by the new small projects. Balázs (1996; p. 12) argues that the main motivation of scientists is to decrease general financial pressure and complement their low university wages, thus company establishment is led by financial motives. Though flexibility of small firms was an advantage, their creation "[…] has been semi-surreptitious at the universities". Industrial experience and university background of scientists created ground for cheap, but high-quality contract research work on behalf of foreign partners. Industrial experiences and the contacts resulting from them opened the door for consultancy and technical advisory activities, often in a mutually beneficial relationship with the university department by sharing the tasks and the resulting income as well. The third type of bottom-up spinning off also offers symbiotic relationship where the university background provides credentials and benefits from use of technology for educational purposes. (Balázs, 1996)

Balázs (1995; p. 674) argues that against the similar role played in knowledge flow and the creation of a knowledge industry, *Central and Eastern European spin-off firms differ* significantly *from their western counterparts* inasmuch they "[…] have been created to utilize an already existing infrastructure and labour, instead of (as in the West) an infrastructure having to be built before 'new labour' – that is, fresh production skills and employment can be generated." Tchalakov and colleagues (2010) noted further important differences between Eastern European (Bulgarian and Hungarian) spin-offs and the general notion on spin-offs identified in the literature. First of all, instead or above simple knowledge and research transfer, many Eastern European spin-offs served as intermediaries between emerging private companies and newly entering foreign companies or provided products where real private market failed to supply. However, their establishment was not enhanced by national or organisational policies; actually in some cases it was even banned. Consequently, there was a lack of targeted financial support as well. Balázs (1995) also points to the high interest rates and lacking tax incentives as burdens that are not always counterbalanced by the organizational reforms implemented by the local management.

Against these unfavourable circumstances some spin-offs played a fundamental role in rebuilding sectors like e.g. ICT, industrial automation or machine building, and became key actors in those, as it is discussed by Tchalakov and colleagues (2010). Partly related to this, they highlighted two conflicting tendencies in post-socialist spin-off development regarding its acceptance as well. The exploitation of new opportunities – especially in shortage situation – was guided by positive public attitudes, while there was a more controversial rent-seeking strategy that aimed a kind of appropriation of public assets and awoke significant public disfavour. One of these interchangeably dominated the other depending on the phase of transition and the relation of cost and benefits.

This can be related to *the peculiar Hungarian business culture* described by Balázs (1996; p. 16) where "[…] the combination of 'socialist ethics' and private interest had a somewhat perverse impact. It encouraged rent-seeking behaviours, and the avoidance of cooperation and responsibility. […] this primitive entrepreneurial mind-set tends to try to milk the public sector and to avoid paying tax and social insurance contributions."

The presence of companies aiming tax avoidance and the rent-seeking of researchers should not overshadow the *crucial role of scientists* in the system, since their personal fulfilment in research and their informal relationships, skills, knowledge and experiences accumulated already during the years of socialism are the factors that kept university-industry relationships and technical development running during the transitional and post-transitional period (Balázs, 1995; Tchalakov et al., 2010). Actually it is precisely the role of individual researchers that made Tchalakov and colleagues (2010; p. 212) question the applicability of the Triple Helix model of university-industry-government relationships in the transitional period. They argue that this model "[…] reduces somehow the importance of individual entrepreneurial initiative at the expense of various institutional policies at the government and university levels, which is just the opposite to the developments in Eastern Europe after 1989."

Nevertheless at the same time it must be seen that the regional economic development potential of these spin-offs under the circumstances described above is often rather limited. During the 1990s the unsolved institutional problems and IP issues resulted in spin-off companies with questionable economic development contribution that can be rather considered as *"backyard farms"* (Inzelt, 1999b; 2002). Jones-Evans and colleagues (1998) made a comparative study of Bulgarian and Hungarian spin-offs and found that the latter are relatively slightly more sophisticated that is reflected also by their growth orientation and actual growth and also in their international connectedness. However, they also note that the lack of foreign investors, especially in high-technology industries, and that of targeted support structures impedes acquisition and fast development of technologies, just as international cooperation. Consequently, the growth and development of the sector is likely to be restricted, even against the similar characteristics of these and Western European and American spin-offs.

Balázs (1995) also underpins that *many of the new companies do not target expansion*, but only the maintenance of their market position and prefer to stay close to the parent institute. These features are only partly attributable to the hostile economic environment, they rather originate from the character of technology and focus on knowledge-based activity. Even if they undertake other tasks, like e.g. private teaching activities, usually they do that to survive in a shrinking technology and consultancy market, but their final purpose remains R&D activity. The importance of spin-off companies in the post-socialist Hungary is mainly rooted in their contribution to the transformation of "[…] the old 'science sector' and research institutes into a user-oriented innovation system in Central and Eastern Europe", similarly to that of the Western European model (Balázs, 1995; p. 679).

4.2.3. National regulation on S&T, innovation and higher education and its effects after the Millennium

> "Major S & T government bodies have been constantly reorganised throughout the 1990s, but pointing the same direction. They strongly suggest that innovation has not been on the top of the agenda of any government since 1990."
>
> Havas (2002; p. 11–12)

The neglect of science and technology policy seemed to end in 2000 when on the basis of the document entitled Science and Technology Policy 2000 the implementation of the National Research and Development Programme (NKFP) was accepted. The Science and Technology Policy 2000 was based on the recognition of the importance of knowledge in achieving and ensuring competitiveness in the 21st century. Consequently it aimed the long run development of Hungarian science, technology and innovation. (NIH TTP 2000). Instead of the linear innovation model that underlay policies of the

1990s, after the Millennium the government started to enhance inter-institutional interactions of university and industry (Novotny, 2009). The National Research and Development Programme[58] aimed to increase international competitiveness and better utilisation of R&D sources by harmonising basic and applied research with technological development and put a high emphasis on university-industry co-operation (Inzelt, 2004). Calls were opened in the following areas: improving quality of life, information and communication technologies, research on environmental protection and material sciences, research on agribusiness and biotechnology, research on national heritage and contemporary social challenges (NIH TTP 2000). Many support schemes of the already mentioned CTDF have been launched or altered in a way as they include university-industry interaction, like the Biotechnology 2000, Technology for Environment, Purchase of Modern Equipments[59] or the Cooperative Research Centre. This latter was very important, since, as Inzelt (2008) argues, against some initial programmes between 1995 and 2000, the collaborative research of universities and industry became a primary target only in the *Cooperative Research Centre Programme* that was launched in 2000. The centres represented the strategic integration of missions that are close to the concept of the entrepreneurial university: they integrated teaching, research and transfer of knowledge and technology (Inzelt, 2008).

A rather unfavourable change around the Millennium has been the unintended gradual degradation of the National Committee for Technological Development that culminated in the January of 2000, when the former OMFB Council lost its decision-making role (Havas, 2002)[60]. In the same year the *Science and Technology Policy Council* was set up (NIH TTP 2000). The Science and Technology Policy Council substituted the Science Policy Council (Glatz, 1999), and meant an extension of the tasks of the predecessor, since the new council was responsible for the support and evaluation of the measures taken not only in science, but also in technology policy (NIH TTP 2000). The Science and Technology Policy Council was the most prominent related body until its dissolution in the March of 2009 (Havas, 2009).

Between 2003 and 2005 a *second wave of legislation* was implemented to create a favourable milieu for innovation and refine the system evolved during the first period of

[58] Besides CTDF the NKFP included other funding sources as well (Inzelt, 2004).
[59] It included university-industry co-operation already in 1998, but not in 1999 (Inzelt, 2004).
[60] Similar processes took place related to other science and technology policy bodies (for details see Havas, 2001).

the transition between 1990–1996/8. This was realized through its adjustment to the changed international environment and its harmonization with the EU legislation to prepare the country to the accession (Inzelt, 2008). Inzelt (2008) argues that the most important laws in this period have been the followings: Act CXXXIC of 2004 on Research and Development and Technological Innovation, Act XC of 2003 on the Research and Technological Innovation Fund, and Act XXXVIII of 2005 on Higher Education.

The Act XC of 2003 aimed to enhance the stability of R&D funding by the establishment of the fund that is financed by the compulsory innovation contribution paid by business organisations[61] and by the additional payment of the government. The fund is used to support application oriented R&D activity.

The Act CXXXIC of 2004 on Research and Development and Technological Innovation (or as it is shortly called the Innovation Act) was a major step in the entrepreneurial turn of Hungarian universities, since it required the creation of an internal regulation on intellectual property[62] and at the same time it allowed universities (and other public research and non-profit organisations) to establish a company to utilize their research results[63]. If the IP was owned by the institution[64], it could bring it into the company as a non-cash capital contribution. Related to the enhancement of entrepreneurialism among scientists it was important that, with the prior written permission of the employer, state employees of the organization were allowed to be members or fill in a leading position in the utilising organization[65].

Buzás and colleagues (2010) argue that enabling participation of the researcher/inventor was a very forward looking initiative based on the recognition that their knowledge can significantly contribute to the success of utilization and at the same time it enhances the accumulation of market knowledge on the side of scientists. However, they also highlight that unfortunately this period did not last long, since the Act on the Legal Status of Public Employees declared with the beginning of 2009 that working relationship of state employees with companies that target the utilization of methods, pro-

[61] Small and medium sized enterprises enjoyed an exempt.
[62] In 2005 a methodological guideline was published to support the creation of these internal rules.
[63] Additionally, they could apply for public support to establish a spin-off company.
[64] Until 2007 it was part of the state assets and only later was directly owned by the universities (Novotny, 2010b).
[65] It is worth to mention that the definition applied by the act was much narrower than the general approach to spin-offs, since it included only the companies that were established by the university, respectively operated with its participation or contribution.

cesses, knowledge or know-how that belong to the trade secrets of the employer is incompatible. The contradiction in the legislation was eliminated by the countermanding of the respective section of the innovation act with the beginning of 2010 – however, this has not solved the merit of the problem. (Buzás et al., 2010)

The Act XXXVIII of 2005 on Higher Education required universities to create a strategy on research-development-innovation that has to include among others the research programmes, scientific events, measures to increase domestic and international scientific cooperation, and not least the method of the utilization of scientific results. It also included detailed regulations on the participation of universities into utilisation companies. However, Polónyi (2010) argues that the process of turning the Humboldtian university determined by the earlier related acts (1985 and 1993) into an entrepreneurial one remained uncompleted owing to the lack of separation of economic and scientific decision making and to the divided (Rector vs. Senate) leadership. He also notes that among these circumstances the only tool for the central policy to enhance university-industry interactions were central research grants and projects.

The government provided *new support schemes* that tried to enhance university-industry cooperation. Owing to the limited success of the Cooperative Research Centre programme[66], the government decided to launch a new, public-private partnership model based initiative in 2004, the Pázmány Péter – Regional Knowledge Centre Programme. Besides the attraction of "leading-edge, technology intensive enterprises in search of research development and education partners […] the formation of spin-off companies and of innovation clusters with a critical mass of competencies and actors is stimulated in support of regional business areas in different parts of the country" (Inzelt, 2008; p. 4–5). The Pázmány Péter Programme is the predecessor of the Regional Knowledge Centres programme; both aimed the establishment and development of scientific and technological innovation centres at universities (NIH PPP-RET).

Besides the Regional Knowledge Centres (subsequently Pázmány Péter programme), Buzás and colleagues (2010) also highlighted, the TÁMOP-4.2.1. Programme and the INNOTETT as the most important grants available to universities to enhance interactions with industry. The TÁMOP-4.2.1. Programme targeted the strengthening of

[66] The limited success was a consequence of the weakness of universities' knowledge base and capability needed for collaborative projects (Inzelt, 2008).

the conditions and tools of knowledge transfer in pole cities' universities, primarily for institutions with mathematics, engineering, informatics and natural sciences profile (NFÜ TÁMOP). The INNOTETT Programme similarly aimed the enhancement of transfer and innovation management, but it was open not only to universities or colleges, but to PROs as well (Buzás et al., 2010). A summary table on the different support schemes and some of the supported institutions of this period can be found in Appendix A.

The modified circumstances and available grants made universities to (re)act. Many of them created formal policies on the management of intellectual property, and they also established the internal organizations to deal with IP and technology transfer issues, but the outcomes remained mixed. This can be related to the fact that – in accordance with the national and EU recommendations – the IP regulations were based on American examples without thorough consideration of the Central and Eastern European peculiarities (Novotny, 2010b).

In 2010 the Hungarian Patent Office committed an expert team to analyse the utilization of intellectual property in public research organizations. The investigation revealed many *weaknesses in* the current system of *university technology transfer*, here we would like to emphasize only those related specifically to spin-off activity and TTOs. Based on the review of university internal policies and interviews with stakeholders in the technology transfer process Buzás and colleagues (2010) argue that it would be important to overcome the *deficiency in the definition on spin-offs* in the Innovation Act by declaring which companies – above the utilising companies defined in the Innovation Act – are acknowledged by the university as spin-offs of the organization. Also more detailed *decision making criteria* – than it is expected by the Act – should be formulated on the issue of participation in a utilisation company and on the relationship of the university with utilisation companies without university participation. The *use of university infrastructure* by spin-offs should be clearly regulated including also norms and timelines. (Buzás et al., 2010)

Related to the technology transfer offices the experts emphasize the importance of a clear knowledge and technology transfer *mission* and the consequent positioning of the offices. Based on the mission of the TTO and the size and research profile of the university the division of market and non-business functions and their attachment to internal and external technology transfer units is advisable. To be full-fledged and accepted actors of the technology transfer process the offices have to invest in the development of a professional *technology transfer team* and increase their *internal visibility* by intense communication (Buzás et al., 2010).

Not only institutional, but also individual efforts were supported by different grant schemes[67]. The TST Programme (2002 and 2003) was designed for NTBFs and spin-offs. It aimed the realisation of innovative ideas and research results through the development of NTBFs and through establishment of spin-offs based on the research results of higher education establishments and other research organisations (NEFMI). The Irinyi János Programme (2005, 2006 and 2008) enhanced the realisation, practical utilisation, product development of R&D results and innovative ideas of natural persons. The Jedlik Ányos Programme (2005–2007) funded R&D projects that – among others – enhance economic competitiveness, technological advancement along defined thematic priorities (life science, ICT, environmental protection, agrarian economy, biotechnology, material science, social challenges of technological change). Also the harmonisation of basic and applied research, respectively technological development has been a priority, similarly to the attraction of successful Hungarian scientists living abroad and the avoidance of brain drain. The GVOP-3.1.1. Applied Research Programme (2004) was designed to support the development and testing of tools, processes, services, technologies and material with significant intellectual value added and market potential. The projects must have been carried out in cooperation of corporate and public research organisations in frame of material science, biotechnology, electricity, energetics, ICT, environmental protection and transport. Another programme of the GVOP directly targeted spin-offs. The GVOP-3.3.1 TST (2004 and 2005) aimed the enhancement of the competitiveness of the corporate sector, the strengthening of the corporate R&D potential and inducement of innovative, technology-intensive activities by supporting the innovation objectives of NTBFs and spin-offs. The INNOCSEKK (2005–2007) and INNOCSEKK PLUSZ (2008–2011) programmes[68] aimed the enhancement of regional innovation by supporting the innovation initiatives of small enterprises, and the knowledge transfer between the knowledge centres and small firms. (NIH archives)

[67] The years in the brackets in this paragraph are indicative, they exemplify years when calls were open and/or support was granted based on the archives of the National Innovation Office (NIH).

[68] The periods in the brackets indicate the planned periods of the calls, but owing to the exhaustion of funds both programmes were ceased one year earlier, in 2006 and 2010 respectively.

Even against the relative intensive regulative efforts the individual responses remained modest. In a survey of 100 researchers at the University of Szeged Buzás (2004) revealed that only 5% of the respondents ever owned a company. However, owing to the changes in the entrepreneurial environment already 34% seriously dealt with the idea of spinning off. He found that one of the main obstacles of the company establishment is still the motivation barrier that reflects in the fear of failing (62%). Further impediments have been the competence barrier that stands for the lacking managerial competences of scientists and the confidence barrier stemming from the often low reputation of spin-off founders that originates from their age (relatively low, 34 years on average in the sample) (Buzás, 2004).

In a more recent study Novotny (2010b) found that spin-off founders have the largest share in the 40–49 age cohort, but university scientists in general are only occasionally active in any form technology transfer activities. Approximately one fifth of scientists in natural, engineering, medical, agrarian and military sciences or biotech are involved in spin-off establishment. The fields experiencing the largest spin-off activity were general engineering sciences and biotech, while the lowest frequency of spinning off was shown by medical sciences. Only 8% of those involved in spin-off (1.7% of all scientists in the sample) work in a company where there is university ownership as well.

A further important founding of Novotny (2010b) was that more than 40% of entrepreneurial scientists never had any interaction with the technology transfer office of the parent institution. This was partly explained by the rather negative perceptions about the competence of the TTO and the excessive and slow bureaucracy of the university that induce high cost in case of cooperation.

4.3. Empirical analysis on the academic entrepreneurs of the Hungarian biotechnology industry

4.3.1. A favoured sector in Hungary: Biotechnology – History, present and future prospects

"[…] the formation and development of high technology and science absorbing industries (especially biotechnology, microelectronics and modern pharmaceutical products) in CEE countries is perceived as being imperative to the long-term success of their economies."
(Szczawnicki, 1990 cited by Jones-Evans et al., 1998)

Hungary has *far-reaching traditions* in biotechnology and related industries as it is described by Frigyesi (cited by PCA, 2004)[69]. She argued that Hungary was the first to implement some production innovations related to biotechnology, like industrial level using of fermentation in the production of vitamin B12 or using enzymes to produce high protein and vitamin content sugar, alcohol and crop.

The sector awoke the attention of the government as well and enjoyed considerable support in the late socialist period as it has been analysed by Bross and colleagues (1998). They argue that in 1982 the Science Policy Committee initiated a biotechnology R&D programme. It was the task of five related ministries and governmental agencies[70] to first analyse the state-of-the-art of the sector than to make recommendations for a biotechnology mission. The result was the programme for *Biotechnology Research, Development and Application in Agriculture and Industry* that was launched in 1984 and devoted special attention to university-industry links. The key features of the top-down governmental programmes focusing on biotechnology before the transition period are shown by Appendix B.

Frigyesi (in PCA, 2004) argues that the targeted support programmes under the coordination of the Protein and Biotechnology Office at the National Technical Development Committee resulted in a total of HUF 4.5 billion spending between the period

[69] However, she also notes that against this long tradition the first biotechnology companies were established only around the end of the 1980s and the beginning of the 1990s (Frigyesi in PCA, 2004).
[70] The committed organisations have been the Hungarian Academy of Sciences (HAS), the National Committee for Technological Development, the Ministry of Agriculture and the Food Industry, the Ministry of Industry and the Ministry of Health (Bross et al., 1998).

1986 and 1990 and enabled in fast development. However, there was a lack of success in turning scientific results into practice and also industrial commercialization lag behind expectations. (Frigyesi in PCA, 2004)

Though Frigyesi (in PCA, 2004) has not analysed it in detail, it is likely that this failure in practical application can be related to the features of the research and development system of the Central and Eastern European countries where the separation of the industrial and research spheres and the branch ministries leading them impeded real cooperation as it has been described in Chapter 4.2.1. Bross and colleagues (1998) also point to other weaknesses that could have been responsible for the unsuccessful commercialisation. The programme primarily targeted agriculture where large state-owned farms and large and medium-sized agricultural co-operatives have been assumed to utilize the inventions. However, after the transition many of these organisations were dissolved and there were no other suitable business companies to undertake their role. On the other hand, the practical application in the pharmaceutical industry was impeded by scale up problems (Bross et al., 1998). Nevertheless, the direct economic benefits of the National Development Plan made it to a success story, not even to mention the significant indirect benefits (Frigyesi in PCA, 2004).

The unintended negative consequences of the transformation described in the previous chapter have not evaded the biotechnological sector either. The already mentioned *exodus of many of the best scientists* hit also that segment of the scientific sphere that built the knowledge base of biotechnology. While at the end of the 1980s the pool of Hungarian scientists was comparable to that of more developed, industrialised countries in terms of quality and quantity, the turn resulted in a decrease of their number by some 40–50% (Frigyesi in PCA, 2004). Without going into details, the most important events[71] of the transition and post-transition period that deeply and negatively impacted the biotechnological sector according to Frigyesi (2004) have been the privatization of pharmaceutical and food sector, both being active in biotechnology R&D and partnering with biotech companies and the Bokros package that resulted in a second wave of budget cuts of the R&D sector, achieving the bottom by 0.67% of the GDP in 1996.

Around the Millennium a favourable shift seemed to arrive. A programme entitled *Biotechnology 2000* was launched to finance R&D projects among the members of the

[71] Besides the general trends already mentioned in Chapter 4.2.2.

biotechnology sector, like universities, research institutes and private companies, with HUF 4.5 billon financing allocated until 2002 (Frigyesi in PCA, 2004)[72]. The grant archives of the National Innovation Office include further initiatives that explicitly targeted the development of the sector. The already mentioned National Research and Development Programme included calls for research projects since 2001 in – among others – agrarian economy and biotechnology as well, similarly to its ancestor, the Jedlik Ányos Programme between 2005 and 2007. The GVOP-3.1.1 Applied Research Programme listed biotechnology as one of the targeted fields (NIH archives). The GOP-1.1.1. Market Oriented Research and Development Activities provided support in key areas, among them in biotechnology as well between 2007 and 2009. (NFÜ GOP).

Hungary's excellence in biotechnology around the Millennium is also supported by its place on the list of countries that have the best prospects in knowledge-based industries, where it ranked 6th, leaving behind countries like Germany and the UK (Ernst & Young, 2006; PCA, 2004). The rise of the sector was clearly enhanced by the *Hungarian Biotechnology Association* that was established in November 2002 as first of a national organization this kind among the new EU member states (Ernst & Young, 2006). In cooperation with the association, the Proventa Capital Advisors compiled the industry review in 2004 that introduces the structure of the Hungarian biotechnology in detail[73].

They concluded that to maintain the major strength of Hungarian biotechnology, its *excellent knowledge base*, targeted actions are needed to retain and to attract home the best scientists working abroad. They argued that the industry is still immature in the sense that most of the *companies are small* and highlighted that the major threats on Hungarian biotechnology that time have been *insufficient financing* opportunities and the general socio-economic environment. The *low entrepreneurial spirit and networking capabilities* have to be improved to enhance innovation and exploit outstanding scientific results. They also call for a more focused governmental R&D support and

[72] Additionally also other already programmes of the NKFP (that tried to enhanced university-industry co-operation as it has been described in the previous chapters) supported development in – among others – biotechnology. However, against the significant related scientific capacity, interestingly there have been no biotechnology companies among the winners of the programmes targeting the Establishment or Development of Laboratories in High-technology (Inzelt, 2004).

[73] This report focused on red (human related) biotechnology sector (in accordance with the global trends), but also highlights that the green (agro) and white (environmental) biotechnology both have significant bases and development potential in Hungary (PCA, 2004).

launching of a programme based on the already mentioned Biotechnology 2000, but higher selectivity and concentration of funds. (PCA, 2004) To overcome shortages in VC funding, actually the almost complete absence of that, the *Hungarian Investment and Trade Development Agency (ITDH)* was set up that aimed to create a database on investment opportunities to connect potential investors with Hungarian companies on an international scale (Ernst & Young, 2006).

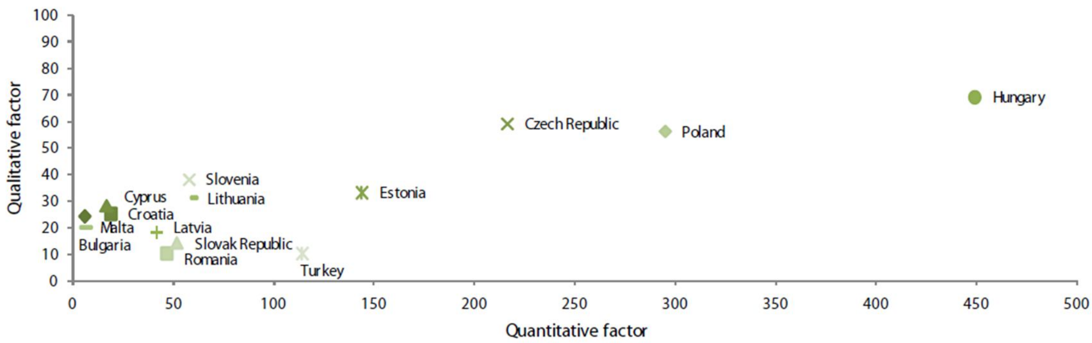
The intensive lobbying activity of the Hungarian Biotechnology Association led to the development of a targeted sectoral strategy in 2005, and the same year the government listed biotechnology as *one of the top five priority sectors* in the nation's mid-term development plan (PCA, 2006). The *National Biotechnology Strategy* (2005–2010) systematically analysed the strengths and weaknesses and the opportunities and threats related to biotechnology and created a clear vision with measurable goals and created a strategic map along two dimensions about the bottlenecks of the sector.

The *second industry review* of the PCA in association with the HBA summarized the achievements along the strategy that were realized among others in human resource recruitment, incubation and financing as well. However, they also collected those areas that need further intervention. Related to technology transfer offices stable financing would require operating cost subsidies and a central TTO would be required for business development. They also mentioned many types of tax cuts that could improve the sector's competitiveness and again, financing should be supported by seed/start-up funds with governmental background and public venture capital matching funds were recommended. (PCA, 2006)

In 2008 a study was written to prepare the revision and update of the national biotechnology strategy that was one of the bases of the *Hungarian pharmaceutical and biotechnology action plan* accepted in 2009. The study provided a SWOT analysis of the sector along four pillars; knowledge base and human resources, infrastructure and knowledge transfer, SME financing and market environment. It argues that against the developments achieved e.g. by the efforts of the ITDH, the development of the sector is impeded by weaknesses in scientific recruitment and the unfavourable share of industrial and academic scientists, just as by the lack of an incubator network, not to mention the evergreen issue of VC (Convincive Consulting and HBA, 2008). To overcome the deficiencies and exploit opportunities the strategy included 20 actions along the four pillars (the detailed action plan is in Appendix C). The study argued that though Hungary has a comparative advantage among the Central and Eastern European countries[74], without a dedicated and focused governmental strategy the sector will lag behind countries like the Czech Republic, Estonia, Poland or Croatia that have already declared the priority of red biotech and accepted relevant programmes to develop biotechnology. (Convincive Consulting and HBA, 2008)

Against the shortcomings identified in 2008, the Hungarian biotechnology sector was still in a competitive position among Central and Eastern European countries. This is clearly shown by the *biotechnology report* prepared by the EuropaBio and Venture Valuation in 2009 that compared newly accessed and candidate countries of the European Union. Based on the Development Capacity Index (DCI)[75] the report ranks Hungary first among the 14 countries investigated, followed by Poland, the Czech Republic and Estonia. The country achieved the highest scores in the quantitative and qualitative factor as well, the former representing the current state of the sector while the latter indicates the development potential of that. The relative position of the countries[76] is shown in Figure 4.

Figure 4 Qualitative and quantitative factors showing the state and the developmental potential of biotechnology in different countries



Source: EuropaBio and Venture Valuation (2009; p. 18)

Further revisions of the Hungarian biotechnology strategy were carried out in 2010 and 2011 under the framework of the *Biotechnology National Technology Platform*. Also those highlight the above mentioned comparative advantage of Hungary, however,

[74] Not taking into account Austria that has a more developed biotechnology sector than that of Hungary (Convincive Consulting and HBA, 2008).
[75] The detailed calculation method of the DCI and its underlying factors is introduced in Appendix D.
[76] The farther upper right being the better.

the latest strategy also notes that it would be unrealistic to envision that Hungary will catch-up to countries with leading (like Germany, UK or France) or mid-sized (like Sweden, Austria or Norway) biotechnology sectors. It argues that "[a] realistic goal for the whole Hungarian biotech sector would be to reach the dimensions of such a mid-sized European bioregion by 2030", since its size is approximately is up to one half or one third of that of an average European bioregion, like e.g. Berlin or Vienna (HBA and Convincive Consulting, 2012; p. 43).[77]

It is not easy to quantify the Hungarian biotechnology sector, since sometimes already the classification of companies is questionable and many companies are reluctant to provide e.g. sales data (PCA, 2004). There are strong interrelatedness and overlaps between the application areas of biotechnology. Additionally, the OECD data on Hungarian biotechnology are very sparse and also the Central Hungarian Statistical Office has limited data on the R&D data of the sector (Antalóczy and Halász, 2011).

The first report estimated that the *number of companies* varied between a few and some 100 firms, majority (59%) of them being service providers, and the remaining almost equally being involved in drug discovery (22%) or being technology provider (19%) (PCA, 2004).

The number of biotechnology companies increased significantly between the first and second reports (PCA, 2006). The first report identified only 29 core biotech companies, whereas two years later the figure was 50, and the total number of biotechnology companies achieved 170. The study underlying the second sectoral strategy counted 55 core biotech companies in 2007, whereas the total number of firms in the sector was around 150 (Convincive Consulting and MBSZ, 2008). There was a slight shift in the business models as well, inasmuch the share of service providers slightly decreased (53%), while service providers (21%) and drug discovery firms (26%) increased their share (PCA, 2006).

Though the classification in *subsectors* is not easy, there is a general acceptance that most of the sector's companies operate in the red biotech sector, however, their share varies between sources. The second country review estimated that 61% of firms

[77] The strategy outlines separated visions and action plans for the different subsectors of biotechnology (red, bioinformatics, green, white) and for the five horizontal key challenges identified (HBA and Convincive Consulting, 2012). For a more detailed structure see Appendix E.

were related to human biotech (PCA, 2006), the study underlying the second national strategy counted some 95% that seemed to be in accordance with the international trends (Convincive Consulting and HBA, 2008), whereas the latest sector report 43% of the companies had a red biotech focus (HBA and Convincive Consulting, 2012). This shift is partly, however not entirely, related to the reclassification of the subsectors by introducing the category of bioinformatics in the 2012 report.

Regarding the *spatial distribution* of the companies, the first review, focusing solely on red biotech, identified four cities in Hungary that show "cluster-like features or the potential to grow into a biotech cluster"; namely Budapest, the capital, Debrecen, Pécs and Szeged (PCA, 2004; p. 26). As in other spheres of the Hungarian economy, the dominance of the capital is also present in biotechnology. The spatial concentration remained since the first review approximately the same, some 60–61% of the firms are located in Budapest, 19–20% in Szeged and 10–10% in Debrecen and Pécs (and Kaposvár) (PCA, 2004 and 2006; Convincive Consulting and HBA, 2008).

This dominance of the capital, *Budapest* is related to its research infrastructure and better socio-economic conditions. The majority of the economic activities, including foreign direct investments and innovation are concentrated here (Lengyel, 2002). Only this part of the country represents a knowledge-based innovation system (Lengyel and Leydesdorff, 2011). The presence of major pharmaceutical companies (Richter Gedeon, Egis and Human) offers sales and cooperation activities to the biotech companies and research units located here.[78] The largest number of biotech companies, just as of research units that are related to the biotechnological sector is to found here. (PCA, 2004) These research groups are operating in different departments of excellent universities and research organizations, e.g. the Budapest University of Technology and Economics, the Eötvös Loránd University, the Gödöllő University of Agricultural Sciences, the Semmelweis University of Medicine, the University of Veterinary Science or the Agricultural Biotechnology Center in Gödöllő. The number of biotech related research groups in the capital and its region has been 28 around 2005[79] (Convincive Consulting and HBA, 2008), whereas in 2009 there have been some 185 research and educational

[78] The importance of the cooperation of universities, spin-offs and large companies has been highlighted in Chapter 2.3.5.
[79] This and the respective data on the number of research groups in the 2008 revision of the national biotechnology strategy are based on various sources and from different years among which the latest is from 2005.

institutions with potential applications in biotechnology (HBA and Convincive Consulting, 2012).

The second place in the Hungarian ranking of potential biotech clusters is taken by *Szeged*. Though large pharmaceutical companies are not located in the city, there is a considerable start-up activity. The greatest strength of the city is its research excellence that is based on the University of Szeged, the Bay Zoltán Institute for Biotechnology and the Biological Research Center of the Hungarian Academy of Sciences (PCA, 2004). The latter is an internationally acknowledged research excellence centre that has gained the EU Centre of Excellence title (Lengyel, 2009). There have been 9 biotech related research groups in Szeged in 2005 (Convincive Consulting and HBA, 2008) and the total number of research and educational institutions related to biotechnology in 2009 was 34 (HBA and Convincive Consulting, 2012).

The thirdly ranked *Debrecen* is building on the knowledge base of the University of Debrecen, and, similarly to Budapest, on the presence of large pharmaceutical companies like the Biogen (PCA, 2004) or Richter Gedeon (Fésüs, 2012). In 2005 Debrecen had 13 biotechnology related research groups (Convincive Consulting and HBA, 2008), whereas in 2009 there were 55 biotech related research and educational units (HBA and Convincive Consulting, 2012).

The major strength of *Pécs*, as the fourth potential cluster is its university, specifically the Faculty of Medicine of the University of Pécs that already spun off several companies. A clear disadvantage of the region compared to the previous ones is the lack of specialized public research institutes and that of large pharmaceutical companies (PCA, 2004). Furthermore, one cannot forget that, as it has been mentioned in the previous chapters, universities were practically officially excluded from scientific research. Though the individual scientific curiosity of university faculty was a seedbed from some research activities, this is hardly compatible with that of the academies' that possessed above sufficient resources and more sophisticated equipment to conduct research. Against these circumstances, there have been 7 biotechnology related research groups in Pécs and its surrounding in 2005 (Convincive Consulting and HBA, 2008), and 20 biotech related research and educational institutions in 2009 (HBA and Convincive Consulting, 2012).

The location around large university cities is in line with the empirical evidences on biotechnology clustering described in Chapter 2.3.5. It is related to the role that university scientists and their *spin-offs* play in the development of biotechnology clusters. The 2006 industry review (PCA, 2006) deals separately with spin-off companies. It argues that since the first industry review at least 18 biotech university spin-off companies were founded that are mostly based on the academic work of the founder. The patenting of underlying technologies was usually funded by national and EU grants, complemented by the founders' private savings. The connection of the firms and parent organizations is very intense; in many cases the university TTO incubates the companies and the firms use university infrastructure. Debrecen was the most active in spinning off with eight companies. (PCA, 2006)

Regarding other important elements of a cluster, like supporting institutions and specialized service providers, the situation is quite unfavourable. Though there have been some achievements in central pre-seed financing, mainly owing to the Irinyi János call, local pre-seed fund are still a missing element of the system (Convincive Consulting and HBA, 2008). Also business angel activity was very limited in Hungary (Makra and Kosztopulosz, 2004). The 2012 sector report also mentions a progress in venture capital financing, since the JEREMIE Venture Capital Programme supported the establishment of eight VC funds that are assumed to invest some HUF 45 billion in the Hungarian small and medium sized enterprises by the end of 2013 (HBA and Convincive Consulting, 2012).

The 2008 study also highlights some of the weaknesses of the TTOs mentioned in Chapter 4.2.3., like the instability created by the project funding and the lack of professional technology transfer officers. A further problem is that against the governmental support[80] provided there are no well-equipped, properly functioning bioincubators in Hungary. Actually also the declaration of the requirements for becoming an incubator and on the process of incubation are missing. (Convincive Consulting and HBA, 2008)

The *growth potential* of the spin-offs is limited by the lack of financing that is related to the infancy of the seed capital industry on the one hand, but on the other hand it

[80] The INNOTETT project had two components: the first aimed the establishment of a pilot innovation management centre, while the second targeted the institutionalization of technology transfer at public research organizations by developing their services and (human) resources (Buzás et al., 2010).

clearly indicates the improviser nature of some companies in the sense that they are founded to grasp a grant opportunity rather than having a long-run vision for the future.

The report mentions a further type of companies that are interesting from our point of view, the so-called *"Home-coming" business model* that means companies that are based on the research results achieved by Hungarian scientists when they have been working abroad. The appearance of this type of establishments is related to the grant system and innovation policy introduced in Chapter 4.2.3. that aimed "brain-gain" by the attraction of Hungarian scientists working abroad. (PCA, 2006) However, there have been some unfavourable changes in the grant system, since with the start of July 2010 a stepwise freezing-in of the grant supports took place (HBA and Convincive Consulting, 2012).

Regarding spin-offs it is important to mention that (also) the latest horizontal strategic action plan (2012–2015) declares the aim to enable a passage between university research, industrial research or biotech management career paths (HBA and Convincive Consulting, 2012) that is likely to contribute to an increased openness of university scientists towards entrepreneurial activities. This is also important because the report identifies human resources as one of the largest potential bottleneck of the forthcoming period.

4.3.2. Characteristics and sample

The empirical results presented here are stemming from the empirical investigation carried out in the frame of the FP7 project Intangible Assets and Regional Economic Growth (contract number 216813) in 2009. The principal investigator of the research has been my PhD supervisor Professor Attila Varga. Our aim was to investigate the presence of academic entrepreneurs in Hungary and the different factors the influence their evolution and actions. This research project provided the ground to prepare the typology of Hungarian academic spin-off founders in the field of biotechnology that is the theme of my dissertation as well.

Our decision to focus our research to biotechnology spin-off was led by the following notions. As it has been mentioned in Chapter 2.3.5., the biotechnology and ICT sectors have been the two seedbeds of the entrepreneurial initiatives of universities, consequently if there has been any spin-off activity at Hungarian universities, it was likely to be realized in these sectors. Focusing on both would not be straightforward inasmuch there are considerable differences between the two branches, as it has been discussed in the industry review study of the Convincive Consulting and the Hungarian Biotechnology Association in 2008[81].

Since I already had some research experience in the field of biotechnology owing to my stay in the Research Triangle of North Carolina in the USA, we decided to focus on biotechnology. Though we did not decided it in advance, most of the companies in our sample are related to red (human or medical) biotechnology, that is in accordance with the general dominance of this subsector in Hungary and in throughout the world. It is also important that this application area is characterized by the strong presence of small and medium sized enterprises based on spin-off business model (Convincive Consulting and HBA, 2008).

Nevertheless, it was an explicit decision to focus on university spin-offs only and exclude those companies that are originated from other public research organizations, like the Hungarian Academy of Sciences or the Biotechnological Research Centre. Although we desperately wanted to find as many spin-offs as it was possible, we also believed that being able to do so in case of universities is a bigger challenge and a better proxy for the real scope of the entrepreneurial turn in Hungary. We believed so owing to the socialist science model that basically excluded universities from research activities under the socialism, and the heritage of this are limited industrial contacts and entrepreneurial experiences of universities compared to other public research organizations.

It was not easy to identify the companies and researchers that could have served as potential interviewees. As it has been mentioned in the previous section of this chapter, the classification and diversification of biotechnology companies is not always an easy task. Additionally, there is no official list available that would include all companies. The industry review study in 2008 estimated that there are some 55 core biotechnology and a total of 150 biotechnology related companies 90% of which is operating in the red biotech area (Convincive Consulting and HBA, 2008).

[81] For the detailed comparison see Appendix F.

Though based on international experiences spin-offs play an important role in the development of the sector, clearly not all members of the Hungarian Biotechnology Association are spin-offs. We tried to match their list with that of the members of the Hungarian Spin-off and Start-up Association to find the companies that are in the overlap of the two. We tried to match the names of the key persons of the companies with the names in the faculty list of large universities close to the companies' headquarters.

This was led by the notion that according to the international empirical evidences most of the researchers establish a company close to their parent organization. This approach of identifying the potential sample clearly has its weaknesses, e.g. dropping companies that do not enlist any university faculty on their webpage or any contact details, though such member of the company exists. The rationality of such a decision could be in the interest of the researcher not to reveal his entrepreneurial activity to the parent organisation.

Of course we also browsed the websites of the large universities' technology transfer offices or respective internal units. However, due to the above mentioned reasons and to the fact that most of the technology transfer offices were established only around 2004–2006, it was likely that their administrative register does not include all companies that are spin-offs according to our definition.

Here we come to an important point; our spin-off definition. The Innovation Act of 2004 argued that spin-offs are those companies that were established by the university, respectively operate with its participation or contribution. This definition does not seem to meet our research aim, since it would overlook companies that are important for our investigation, however, it would include some that are not.

Our selection criteria is rather based on the OECD definition that recommended to consider spin-off every newly established company that has one of the following features: it is established by the employee of a university or an other public research organisation; it acquired the underlying technology from a university or an other public research organisation through licensing agreement; it has a capital investment from a university or an other public research organisation; it is established by a university or an other public research organisation (OECD, 2000).

This definition includes those companies that we missed from the previous one, however, our approach is somewhat narrower than this, since – irrespective of the fulfilment of other criteria – we focused specifically on those firms in which the scientist participates. We do not question the importance of the other companies from a regional development perspective or regarding their contribution to the entrepreneurial turn of the organisations, however, these firms do not support our better understanding of the motivation of scientists to turn entrepreneurial.

Our sample includes five researchers from Budapest and its surrounding, five from Debrecen, five from Pécs and three from Szeged. Compared to the distribution of the biotechnology industry in Hungary, the countryside is overrepresented in our simple, and Szeged is somewhat underrepresented. This latter difference might be partly – though likely not entirely – related to our selection criteria that focused solely on university spin-offs and excluded companies of other public research organizations that are likely to contribute to the strong biotechnological industry around Szeged.

However, this does not seem to distort our research purpose, since, owing to the small sample, making detailed statements and conclusions on the regional differences in spin-off activity would most likely violate the anonymity that we promised to the researchers, so is anyway impossible. A future research that includes also other public research organizations perhaps will provide sufficiently large sample to carry out regional analysis without jeopardizing research ethic. In this case we are only able to make a comparison between the western and the Central and Eastern European spin-off phenomenon as a spatial dimension.

Our sample is unfortunately also unsuitable for the investigation of gender issues, since only one of the eighteen interviewees has been a woman (though this fact is itself a gender issue). Consequently we always will use the personal pronoun "he" to protect the anonymity of the female interviewee.

Based on the above mentioned search method we compiled a list of potential interviewees and sent our list to some experts and advisors who are active in the field of biotechnology and we also contacted some technology transfer offices at large universities and asked them to correct and complement or list. At the end we had 22 companies that in our belief covered the majority of the Hungarian biotechnology spin-offs that time.

We tried to focus on core biotech, however, also some medical device companies got into our list.

We contacted the potential interviewees via e-mail by describing them the purpose of the research and upon request the draft questions of the semi-structured interview. Unfortunately three scientists were not available for interview during the research period due to international conferences, business trips or other reasons and one scientist would not liked to participate in our survey. At the end we managed to interview eighteen researchers.

The already mentioned interview draft included questions related to the individual, institutional and regional/national level factors of the spin-off formation. Specifically, we have been interested in the motivations of the researcher, the factors that might shaped his interest in entrepreneurial issues. We also investigated the effects of the entrepreneurial involvement on his academic career and also on his relationship with his departmental colleagues. The detailed structure of the questions underlying the personal interviews can be found in Appendix G.

The duration of the interviews varied between 30 and 90 minutes and the recorded conversations have been transcribed and sent back to the interviewees for approval and potential correction or complementation. The categorization of academic entrepreneurs in my dissertation is primarily based on these interviews and the publications in co-authorship with my supervisor resulting from this research.

Regarding the parent organisations the Eötvös Loránd University, the Semmelweis University and the Szent István University have to be mentioned from Central Hungarian region, while the researchers on the countryside have been affiliated with the University of Debrecen, the University of Pécs and the University of Szeged.

The report prepared by Buzás and colleagues (2010) contains important information on the intellectual management policy and practice of most of these universities. Unfortunately the Szent István University was not included in their sample that can be related to the relatively late establishment of the technology transfer unit compared to the other parent organisations.

More than one third of our interviewees have been medical doctors, two of them were veterinarians, the others have been chemists, biologists or physicists. Their age at the time of the company's establishment varied between 29 and 85 years; seven of them spun off the firm between the age of 30 and 40 years, seven between 41 and 50 and three of them were above 50 years when launched the spin-off.

Five companies were established in the 1990s, four in 2003, one in 2004 and eight since the came into force of the Innovation Act in 2005. Though there is clear trend towards spin-off establishment since the explicit support of the entrepreneurial turn of the universities, we have to highlight that more than half of the spin-offs in our sample have been founded before the new wave of legislation and almost one third of the whole sample were spun-off before the Millennium. The oldest companies are affiliated with the University of Pécs, while all of the spin-offs of the University of Debrecen were established in 2005 or later. The characteristics of the sample by universities are shown in Table 3.

Table 3 Sample characteristics by universities around the time of the investigation

	Eötvös Loránd University	**Semmelweis University**	**Szent István University**	**University of Debrecen**	**University of Pécs**	**University of Szeged**
Location	Budapest	Budapest	Gödöllő	Debrecen	Pécs	Szeged
Status	State university					
Number of faculties	8	5	9	15	10	12
Academic staff	2,132	1,140	858	1,634	1,877	1,911
Total number of students	30,767	11,278	17,464	30,728	29,032	27,436
Number of doctoral schools						
Average age of the company	2	7.3	4	2.8	13.8	5
Average age of the founder at the year of establishment	46	36.7	33	42.8	44.8	55.3

Source: own compilation based on the interviews, the CVs of the interviewees and http://www.nefmi.gov.hu/letolt/statisztika/okt_evkonyv_2009_2010_100907.pdf, and www.felvi.hu

This age structure of the companies seems to be in line with empirical evidences from the US and in Europe that argue that legislative changes did not induce but only legitimised already ongoing academic entrepreneurial processes that should be rather owed to the rise of biotechnology (Geuna and Nesta, 2006; Mowery and Ziedonis, 2002).

At the time of the interviews nearly half of the spin-offs had two or less employees that can partly be owed to their relatively recent establishment or the role of subcontractors. Nevertheless, five companies reported 10 or more employees that seems to be a relatively good size in Hungarian scale, especially if we consider that the average size of biotechnology companies in Europe is half of that of the US data.

All of the spin-offs in our sample are limited companies (Ltds). Most of them operate in the field of red (medical) biotechnology, but also some green (agro and food) and white (industrial and environmental) biotech spin-offs got into our sample and three of the companies are involved in medical devices. According to the categorization of the latest biotechnology sector report (HBA and Convincive consulting, 2012) most the red biotech spin-offs in our sample operate based on an R&D technologies and services or on a genomics, proteomics, molecular diagnostics business model, but there is also one based on therapeutics, while the green is related to food and the white is to biomaterials business model.

4.3.3. Typology of Hungarian biotechnology spin-off founders

Based on the empirical findings we created a typology of Hungarian biotechnology spin-off founders. The ground for the categorisation was information stemming from the interviews and some background data collected on the internet. The primary focus has been on the motivation underlying the spinning off participation. We especially have been interested whether academic motivations as described in the literature indeed dominate among the reasons of spin-off founding.

At the same time, we also analysed the effect of factors that can influence the realisation of motivations as it has been introduced in detail in Chapter 3.3. Thus we looked at individual characteristics, such as the professional and personal profile of the scientist, his attitude towards potential conflicts with open science, but also his social capital in and outside the academia got attention, just as entrepreneurial experience and education. We also have been interested whether university policies or organisational and infrastructural innovations, such as TTOs or science parks and incubators have an effect on the Hungarian entrepreneurial turn or rather departmental norms determine spin-off founding. Elements of the external environment have also been touched upon, mainly related to the general national or regional milieu and to funding issues.

The empirical research works have led us to the conclusion that academic entrepreneurs can and indeed do exist in the Hungarian university system. There are researchers who aim to create a symbiotic relationship between the scientific and business world as it has been described by Etzkowitz 30 years ago in the US. However, besides classical academic entrepreneurs we have also found that some individual or environmental factors can result in different types of academic entrepreneurs as it is shown in the following sections.

4.3.3.1. The classical academic entrepreneur by Etzkowitz

Our investigation showed that the academic entrepreneur as it has been introduced first by Etzkowitz (1983) *can be found* in the Hungarian university system as well. Actually almost half of the interviewees in the 2009 survey, precisely eight scientists are classified here, almost half of the sample. The profile of the companies is quite diverse and also the ideas that initiated them are different; in some cases the recognition of the biotech trend in general or the outsourcing of the previous contract research work done at the university initiated the spinning off, while in other cases the firm focused on the development of a specific idea that arose during research work.

Regarding their *professional and personal characteristics* we can conclude that most of them are leading researchers in their field that is represented by their impressive publication and citation records as well. They are usually senior scientists positioned high in the academic hierarchy.

The *motivations* related to the establishment of the company are dominantly academic motivations, primarily pull ones, but also push motives appear. The most important triggers to establish a company have been the advancement of science and the application of the research results and potential extension of the academic's work into the applied sphere. These scientists would like to cross the boundary between basic and applied research and see their application idea to become reality. Consequently, these are usually pull motivations, however, besides the internal desire to utilize the invention, there is sometimes a push factor as well, since there are no companies available that would bring the idea to the market, or in one case previous unfavourable experience in the utilization through a foreign company made the scientist to do it himself.

The strong practical orientation of these researchers is also shown by the fact that some of them are multiple or serial entrepreneurs, thus the company we identified during our research as a spin-off is not their first or last venture. Some of them established their first spin-off with foreign colleagues whom their met during their international research work. In one case the first business company[82] of the inventor supported the research project that generated the new invention and it also served as a sort of business angel in the spin-off firm. The personal interest in practical application is also shown by the year of establishment, since the majority of these companies *predate the recent entrepreneurial turn of universities* and domestic focus on the regional economic development contribution of higher education.

A further science related motivation has been the creation of job opportunities to the most talented PhD students or post-docs that is also an explicit aim of these academic entrepreneurs, similarly to the generation of additional income to the university faculty. They try to create a kind of entrepreneurial penumbra around the university that is able to absorb the best workforce and to avoid the brain drain that is a significant problem in the biotechnology related scientific fields, as we have already discussed it in Chapter 4.2.

On the other hand, Hungarian spin-off founders do not seem to expect academic promotion as a result of their spinning off activity. The weak effect of the desire to get higher in the university hierarchy can be explained by the fact that most of the interviewees are already in a high position. However, as it already has been mentioned, many of these companies were established well before the shift in the governmental science and technology policy and the related changes in the legislation. Consequently, the best that these researchers could hope for around that time by spinning off of the company that they will not found themselves in a disadvantageous situation due to their entrepreneurial activity. Believing to get ahead in the hierarchy would have been unrealistic expectation under those circumstances. Actually even in the current situation it does

[82] This first company is based on non-patented ideas that have commercial value.

not seem to be likely that someone is able to get ahead in the academic hierarchy through spinning off a company, since academic entrepreneurship is entirely missing from the promotion criteria of academic advancement.

As in the cases described by Etzkowitz, the financial motivation is present, but only moderately; it is mainly related to the recognition of the researchers that the success criteria in the scientific and business world are different. Though publication and citation records can ensure peer recognition in the scientific world, it is hardly enough to be acknowledged as a successful academic entrepreneur. The financial performance and growth of the business is required to be accepted and respected in the business world. The financial shortage also induced companies to provide research services to other companies, but they do not consider it as the main focus of the spin-off, it only helps to balance the cash-flow of the firm. Similar role is played by the development and manufacturing of research devices, but it is important to note that also these are originated in the applied research activity.

Above that, financial issues are present as a scientific push motivation as well, since in many cases the profit of the company contributes to the financing of the university research group, especially in periods when basic research sources are scares – that unfortunately seemed to be the case at the time of our survey. Many interviewees argued that the lack of basic research sources and the inadequate distribution criteria of them create a resource constrained environment. The additional financial resources available for spin-off companies mitigate the negative effects resulting from the above described circumstances, especially if the company gets in a profitable phase and is able to support the work university research group.

Almost all of them give a priority to academic work, but it does not mean that they would treat the entrepreneurial activity as a kind of hobby or necessary wrong to do science. They work very hard to develop the underlying invention into a marketable phase and at the same time to build a mutually beneficial relationship between the academic and the business sphere. Some of them find enjoyment in meeting the challenge and develop a business enterprise even against the considerable time and effort it requires.

The managerial skills and competences to be successful in this effort are originated in the university work, since many of them have some *entrepreneurial experience* in form of project management or participation in contract research works. Some of them already established a firm to do contract teaching at the university[83]. Also previous patent application is present in many cases. Though the risks associated with this activity are nearly not comparable to those of managing an own company, these help to gain some experience outside the walls of the university, to learn how to negotiate contracts and to get contacts to accountants and lawyers.

These business-like experiences and connections are important, since most of the spin-offs are not only founded but also managed by the scientists. This is not an unusual phenomenon, since newly established spin-off companies rarely have the necessary financial resources to hire a professional management. Most of the interviewees believed that managing a company is not a matter of skills, but a matter of time, even though most of them did not participate in *formal business education*. As the company unfolds, the management becomes too complicated and time demanding, thus a managerial restructuring might be needed. As one of the researchers noted:

"There are different stages in the development. In the typical spin-off company stage the management of the company can be done on your own. [...] In the second step the management and the professional tasks must be separated."

Social capital seems to play a fundamental role in the entrepreneurial decision of the scientists and unfolding of the spin-offs. In many cases the idea to establish a company originates from a conversation with scientific colleagues, and in many cases a researcher colleague is the co-founder of the spin-off, sometimes with business education background.

The local laboratory network as it has been described by Murray (2004) consists not only of domestic colleagues, but at least as important are international connections. These latter usually have been developed during international study or work experiences. Researchers in this group gained experiences in research excellence centres like the Swedish Karolinska Institute, the University of Wisconsin at Madison, the University of California in San Francisco or the University of Minnesota. The already mentioned first experiences in patenting and spinning off often originate from these periods.

[83] There has been a period when contract teaching was allowed and preferred owing to the more favourable taxation opportunity. Though this could extend their networks, this hardly can be considered as real academic entrepreneurship.

These academic entrepreneurs not only visited these places, they established *scientific connections* that remained after their return and ensured their deep embedding into the international scientific life. Of course this is also beneficial for the company, since as it has been discussed in the theoretical sections, it can serve as a quality signal and can accelerate the international acceptance of the spin-off. Regular temporary visits and joint research projects testify the intensity of the network cooperation. In many cases the international experience created the opportunity for the researchers to meet academic entrepreneurial *role model*s; scientists who do science and business simultaneously.

This is about fundamental importance, since these role models are still rarely available in Hungary. Successful academic entrepreneurs in the local laboratory network can support the entrepreneurial activity of returning Hungarian scientists, who in turn will be able to serve as domestic role models for their colleagues. Also in our sample there is a researcher who established a company following the inspiration of a member of the local laboratory network, and who was mentioned by another interviewee as being his role model. Thus mobility allowing these scientists to gather international experiences and to return[84] home seems to strongly enhance the spread of the entrepreneurial spirit in Hungary.

The cosmopolitan network in Murray's (2004) sense that develops through publications, conferences also plays a very important role. Biotechnology spans various scientific fields and especially platform technologies provide a fertile ground for diverse cooperation. In some cases we observed a kind of snowball effect where the first publications and international conferences awoke interest and generated international research cooperation that in turn results in further publications and so on.

In many cases there is an interesting overlap among the business and the academic networks, since members of the local laboratory network or that of the cosmopolitan network are academic entrepreneurs. One of the academics had multiple contacts in Genentech and with spin-offs from excellent research centres. *Business contacts* to large companies, on the other hand, can accelerate the embedding into international business by serving as a quality signal.

[84] One of the scientists was a beneficiary of the Magyary Zoltán grant that supports return of talented Hungarian researchers. In this sense he is a kind of predecessor of the home-coming business model described in Chapter 4.3.1.

Due to their strong commitment towards science (as it has been described above), there is usually a symbiotic relationship between the university and the firm. However, at the same time it is important to highlight an issue that has been raised by some academics; the division of business and academia. Though there is a boundary crossing between the university and the industry through the company, and applied and basic research seem to be more and more blurred, the mixing of roles and tasks is not desirable. Of course clear separation is not easy, since the research areas are strongly related, but the applied research should be kept on the business side, while the basic research should remain the primary domain of the academia as far as it is executable.

We also have to note the dynamic and sometimes controversial character of the *universities' entrepreneurial policy* or attitude. Many interviewees expressed their satisfaction with the changing legislation that permitted the previously prohibited entrepreneurial activity of scientists and reported a supportive university environment, but they also mentioned that has not always been the case. One of the scientists argued that by staying at the university it would have been possible to develop the idea into a product, there were no resources available and the university entirely ignored the idea. However, the establishment of the company approximately coincided with the policy and regulatory changes, and they were welcomed to return to the university and today they are submitting research proposals together to get finance and the publications and success of the company increase the reputation of the university. This is the only academic entrepreneur in this group who gives a priority to the business against academia, but even in this case the related conflicts remain at a minimum.

Even if the relationship is good with the university, they try to avoid university ownership in the company; in only one of the eight companies has a share of the parent organisation. This is related to the unfortunately very bureaucratic functioning of universities that inevitably slows down decision making processes. In the turbulent business world, especially in biotechnology this is an unacceptably large risk.

The cooperation with the *technology transfer office* (or same purpose department) is very limited. This distant keeping behaviour on the side of academic entrepreneurs cannot be owed to the differing profit motives, since many of our interviewees highlighted that the purpose of the university by establishing spin-offs is not simple profit making[85], but to increase the reputation of the university by contributing to regional development and to account towards the society with the research support got from the state. In some cases the university abandoned the IP or sold the patent at a low price to the spin-off or promised to ensure the utilization rights to the scientist's company. Furthermore, many researchers believe that the university background serves as a quality signal and can increase the reputation of the company. Above this all the parent organisations provided laboratory space.

The problem rather lies in the already mentioned bureaucratization of the university and in the infancy of the technology transfer offices. Even the use of facilities and renting of laboratory spaces by spin-offs is a non-routine process and takes long time. Some argued that the university should take a more proactive role in the identification and development of inventions with commercial potential, but at the same time many highlighted the role of positive incentives. They argued that regulation itself is insufficient and overwhelming pressure would create (in some cases it has already created) an unfavourable atmosphere. Many mentioned that they would prefer to cooperate with the departmental or institutional level in technology transfer instead of a central office that is stuffed with unknown people.

The *departmental norms* were also mentioned as being important regarding cooperation with colleagues. Most of the academic entrepreneurs in this group argued that the company is not a source of real conflicts, since most of the colleagues understand its importance, actually one of our interviewees mentioned that non-entrepreneur colleagues tend to see only the bright side of entrepreneurship, since infrastructure at the university is improving, the PhD students can continue their work in the spin-off, but these colleagues do not always think about how hard it has been to create this all.

Even if the spin-off work requires certain *secrecy*, it does not really bother university colleagues, since they admit its necessity, and in any cases where it is possible the academic entrepreneurs rather tend to seek the advice and opinion of their colleagues. This fertile environment is one of the reasons why our interviewees do not want to leave the university. Some of the spin-offs interviewed are also founders in a regional univer-

[85] Especially since also those involved in the TTO structure are aware that most of the TTOs are not profitable even in the US.

sity knowledge centre that also shows their preference towards mutually beneficial relationship with the university.

A somewhat more real, but still manageable problem to most of our academic entrepreneurs related to the norms of open science is the *publication delay* that is required to ensure the protection of intellectual property generated. One of our interviewees mentioned that this conflict is exaggerated, since one does not have to wait until for example a patent is granted, it is enough if the request is submitted and results are publishable. However, most of the academic entrepreneurs in our sample expressed their unlike of the need of publication delay. At the same time they admit that it is necessary and they highlighted that they publish everything that is possible, the only thing is that they do it with some delay. It is also in their interest, since as it has been discussed above, publications can extend the cosmopolitan network of the scientists, consequently publication can lead to research or business cooperations.

The delay required in publications is partly dependent upon the patent system. Unfortunately the European solution is seen by many researchers to be more time demanding than the European or American patent system. This is also related to the fact that most of the scientists and starting companies do not have the financial resources needed to pay a professional to prepare the necessary documents and they have to do it themselves.

Most of these companies started with private savings and *state grants*. These latter remained important throughout their development, but it is important to emphasize that this is not their only source of funding. Though the importance and altogether positive effect of grant support is acknowledged by them, they mentioned many weaknesses that worsen the effectiveness of grants. Most of them agreed that the Hungarian tendering system is more uncertain and unpredictable than for example that of the US. The calls for applications are hard to foresee, and the administration of the research grants is very excessive. They stressed that the delays in the payments would cause serious liquidity problems if the company would rely solely on the research grants.

Related to financing most of the interviewees agreed that *seed money* is not available in Hungary and this is a big impediment, similarly to the lack of *business angels*. Among the eight companies only one has business angel money and another one has venture capital backing. It is also interesting to note that in case of the former it was not the academic entrepreneur who was seeking for business angel but reverse.

Though in the general literature *venture capital* is seen as a crucial factor, most of the academic entrepreneurs in our sample tried to avoid it. This is not owing to the lack of awareness, since they seem to properly understand the functioning of venture capital backing. They argue that it is only worth to bring in venture capital in the company if there is an idea that has an outstanding commercial value that can be realized in the near future. Many of them argued that if that happens, they would consider seeking for VC, however, only in form of a project firm to avoid losing control over the spin-off in question.

Not only venture capital seems to be missing from the Hungarian *economic environment*[86], many researchers argue that it is very hard to find professional management. Biotechnology is a very special field and most of the economists are not familiar with it. On the contrary, most of the researchers specialised in scientific fields underlying biotechnology have not participated in business education. Since there have not been to many biotechnology spin-off companies in Hungary so far, the managerial layer that is specialized in spin-offs is entirely missing.

The *science parks* do not seem to be a central issue, since only to interviewees mentioned them.

4.3.3.2. Unbalanced academic entrepreneurs

The second group of academic entrepreneurs identified in our sample consists of two subcategories. Their common feature is that the academic inventor is a bit one-sided in the sense that he plays a much more limited role in one or the other field than the classical academic entrepreneurs. The first subcategory includes three researchers who are all medical doctors with similar *professional and personal characteristics* as the classical academic entrepreneurs. They are well established scientists who enjoy high recognition in their research field and also fill or filled in high positions in the university hierarchy. All of these companies are related to the broadly interpreted biotechnology since they develop medical devices.

[86] Some argue that the venture capital is present, but they are uncertain about where to invest. They do not know the Hungarian market and the state support in form of research grants in a company seems to be an insufficient signal to them.

The *motivation* of these scientists with establishing the spin-off company was related to their desire to develop their patented invention into a marketable product that helps increase the quality of life of patients in Hungary and throughout the world. Due to their long lasting professional experience as practitioner medical doctors they are aware that their invention could fill in a niche on market in the sense that there are no products available with the same features for a comparable price.

The inventor scientists argued that the intellectual property rights around the time of the discovery have not been really regulated at the parent organisations. In one of the cases the inventor filed the patent, but the university contacted the researcher with the aim of having a share in the patent and they also assisted the establishment of the company. In the other two cases the researchers disclosed the invention to the university as an acknowledgment that the underlying research has been made there and since against the deficient intellectual property management they wanted to create a clear situation. In one case the university abandoned the IP, while in the other one the parent organisation patented the invention and immediately sold it to the spin-off. The scientists argue that this was a good way to develop the ideas that might have been lost if they would not have acted and spin-offs are useful since they create a clear situation regarding in the IP ownership.

The establishment of the companies aimed the development of the invention and in this respect they can be comprehended as necessity companies or tools that are used to make good for the society. Though one of these researchers is formally the CEO of the spin-off firm, also in that company there is an external person committed to practically operate the business side. The other two scientists restricted their activity to CSO position only, thus they not even formally acted as CEOs. One of the companies was established by an industrial partner that was responsible for running the business, while the university scientist undertook the scientific work. The other researcher was contacted by a surrogate entrepreneur who was interested in the development of the patent and they agreed to establish a firm.

This seems to be a major difference compared to the classical academic entrepreneurs. Although also some of those established the spin-off to meet the requirements of a grant and almost all of them preferred academic work against the business, but they have been deeper involved in the development of the company, most of them fill or filled in the CEO position of the company, or if not, than usually it is because of the hiring of a professional management. The unbalanced academic entrepreneurs give such a high priority to the scientific work that they almost neglect the business side and leave in entirely to the industrial partner or a surrogate entrepreneur.

However, they also understand the basic and importance of patenting and commercialization activities in general. As one of them noted:

> *"It is a capital error to believe that a scientific notion has the largest benefit for the society if it is immediately published, since in that case there will be no investor who would develop a product from that, since product development is a different profession."*

The same scientist argues that since the industry has a better understanding of product development, it is a natural phenomenon that at a certain stage of the company's development the inventor loses its major influence. It seems that though the utilisation happens through a spin-off, the attitude of these scientists is rather closer to the more traditional comprehension university-industry cooperation where the coincidence of interests brings the spheres together, but the inventor contributes exclusively through his scientific excellence rather than by being involved in managerial strategic decision making. They argue that it takes too much time from research.

Though they do not undertake business management, *business contacts* played a significant role in all of the cases; once they were co-founders of the spin-off, in another issue the spin-off was involved in a grant supported joint research project with another business company, and the third spin-off is managed by the surrogate entrepreneur.

Since also unbalanced academic entrepreneurs understand the rules of the game, their attitude towards potential risks on open science seems to be similar to that of classical academic entrepreneurs. They argue that *secrecy* is a natural element of the system and also *publication delay* is accepted as a necessary companion of patenting. It is not welcomed of course, but it is not considered as a major impediment.

Their interpretation of the university's motivation in collaboration is slightly different from the view of classical academic entrepreneurs. Though one of the inventors explicitly mentioned regional development and another one the prestige of the university as an advantage, their emphasis in general seems to be put more on the financial benefits provided to the university that was rather a secondary argument of the classical academic entrepreneurs.

There is no university ownership in any of the companies, and against the positive attitude of the parent organisations towards the spin-offs they provided only very limited or no help to the establishment of the venture. Their practical contribution slightly differs among the cases; usually they offered laboratory space and hosted clinical trials. However, two of the inventors noted that universities could provide more background support; in one of the cases even seeking for industrial partners remained the task of the researcher.

The problems related to the university are similar to those mentioned by the classical academic entrepreneurs. Also the unbalanced academic entrepreneurs argue that universities are overwhelmingly bureaucratized and their participation in a company would be disadvantageous, since it would slow down their decision making processes. Furthermore, the university technology transfer processes are in general immature, they have to develop, but due to the lack of critical mass maybe a centralized, domestic technology transfer organisation would be more practical.

Against these shortcomings, there is a good relationship between the university and the company. Especially the cooperation with the immediate colleagues seems to be advantageous, in some cases they also share their experiences related to the development of the product with the inventor and they are open towards the invention, thus they seem to accept product development through spin-offs as a *departmental norm*. However, from the *scientific networks* only local laboratory seems to play a role, while there was no mentioning of a cosmopolitan network.

The availability of *grant support* had a major influence on the development of the product and the establishment of the companies. All of the researchers mentioned that applied research funds significantly contributed to the utilisation of the invention. However, similarly to the classical academic entrepreneurs, also they mentioned that the research support system is skewed in the sense that basic research is unworthy underfinanced, though on the long run these should built the base of all applied research for which there are abundant grants available. On the other hand, the management of the latter is bureaucratic and the lack of pre-financing jointly with the often severely delayed payment causes a problem.

The fourth member of this groups is similar to the other unbalanced academic entrepreneurs inasmuch one of the fields has absolute priority above the other one, but in this case it is not the academic, but precisely on the opposite; the business one. This researcher became a full time entrepreneur, though remained involved in research, but with applied focus.

This scientist has already left the university shortly before establishing the company. The idea of the business arose during an international scholarship where the researcher also became involved in industrial research through a company affiliation. The research profile of the company was related to the academic research topic of our interviewee. The experiences collected during the dual affiliation made it clear that the researcher felt to be more attracted to the industrial research and would prefer to work there in the future.

This coincided timely with the acquisition of the French parent company by an American one that liquidated the branch in which our interviewee has been involved. The Hungarian company was established to fill in the resulting market gap – at least partially. A one year long preparation work predated the registration of the company, and besides the already given *industrial experiences* more knowledge had to be acquired on the operation of spin-offs.

He decided to quit the university before finally returning Hungary, consequently academic *motivations* related to career advancement hardly played any role in the establishment of the company. The absence of career advancement related motivations does not mean that there is no relationship with the university or a lack of science related motivations in general. The company has contacts to different universities in the country and the researcher also would be gladly interested in some teaching activities as well that is unfortunately not possible owing to the rigidity of the schedule at the university. However, motivations like mentioned by the classical academic entrepreneurs, like e.g. ensuring additional income to university employees or to apply for grants with the university are not explicitly targeted. There is no university ownership in the company.

Owing to the circumstances, *business contacts* seem to play a more important role in the spinning off and development of this company than *academic networks*. The chief scientific officer of the already mentioned foreign company provided interest-free loan and also assisted the establishment of the firm with advices. Additionally, the orders from the abroad contact meant a solid income base at the start and. They also have a joint patent with a divided utilisation between the foreign and the Hungarian company.

Interestingly this academic entrepreneur sees many aspects of the technology transfer and spinning of process differently as the classical or the other unbalanced academic entrepreneurs. In his belief it is not the optimal way of technology transfer if the motivation comes from the side of the university. He argues that the market should come up with a need that optimally coincides with the interest and idea of the scientist. Invention disclosures at the universities might be patentable, but the commercial potential is a different issue and *technology transfer offices* often lack the appropriate knowledge to decide about this.

If it is about a spin-off, is would be important to use positive incentives, and *university policies* should focus strongly on incubation, since these are the adequate institutions to undertake this risky process. Nevertheless, the use of facilities should be clarified not only by internal regulations, but by bilateral agreements between the company and the firm. This would be beneficial for the companies, and at the same time it could prevent undercover free use of university tools. Similarly, clear contracts should regulate the joint tendering activity and the related responsibilities.

Many elements of this reasoning are similar to those of the classical academic entrepreneurs, but at the same time more emphasis seems to be laid on the formal contracts. It can be related to the fact that the company is rather an outsider than in case of classical – or even the medical doctor unbalanced – academic entrepreneurs in the sense that there is no employment relationship between the university and the spin-off founder. Also owing to the exit of the researcher already before establishment, *secrecy* and *publication delay* are no real issues, similarly to the collaboration with the departmental colleagues. But at the same time we also have to mention that consideration of the universities' interest and regional development aspects are present.

Since the market opportunity was well established at the foundation, spin-off *grant supports* did not play a major role in the spinning off of the company or later in its development. Unlike the other three unbalanced academic entrepreneurs, this one generally tries to avoid applying for a grant, owing to the weaknesses of the system that have been mentioned by the classical and the other unbalanced academic entrepreneurs. The lack of pre-financing, the very bureaucratic administration and delays in the payments can jeopardise the liquidity of the company. Consequently he only uses them for smaller projects, since, even against the shortcomings of the system, these grants can help to bring a product on the market faster than without those.

Summarily we can argue that unbalanced academic entrepreneurs differ from the classical ones mainly by focusing almost exclusively on business or academia, while the classical academic entrepreneurs give a priority to academia, but at the same time they are deeply involved in the development of their business enterprise as well. The difference within the unbalanced groups lies in the focus of the scientists; three of them concentrate only on science, while the fourth gives a priority to the business, though to some extent both activities are present in each case.

This can maybe related to the fact that none of them mentioned any *role model* during our conversation, consequently it seems that they do not even think about a more close and symbiotic alignment of the fields. They choose the line in which they had more experience, the medical doctors voted for the university, while the researcher with industrial background decided for business.

Further common characteristic of the four unbalanced entrepreneurs is the lack of formal *business education* and that of *seed*, *business angel* or *venture capital money.* Only one of the spin-offs, that of the business-oriented member of this group, is located in an *industrial park*, thus the effect of these is not pronounced. Also mobility seemed to play a role only in the case of the exited researcher. *Prior invention* or *industrial experience* is present in half of the cases, but they do not seem to be decisive in the sense that managerial tasks are usually not undertaken by the academic entrepreneurs.

4.3.3.3. Academic entrepreneurs impeded by environmental factors

Unlike the unbalanced academic entrepreneurs, the three researchers belonging to this group would like to achieve the synergistic effects that are realised by the classical academic entrepreneurs, but due to some unfavourable circumstances this is impossible. Thus it is not their internal decision to limit their commitment primarily to one field, like in the case of the unbalanced academic entrepreneurs, but it is rather a necessity.

The *motivations* to establish a company are similar to those of classical academic entrepreneurs. The companies have been related to research results that have been generated during university research work. Self-realisation, prestige and peer recognition have been mentioned as the most important triggers behind setting up the company. Additionally, getting ahead in the university hierarchy was about explicit importance in some cases.

However, a younger scientist also mentioned the need to create additional income due to the insufficient wages in Hungarian science that do not allow the creation of any solid financial base. The idea was to bring the basic research question further and extend the investigations in the applied area. The strong interest in practical application of university research is shown by the fact that two of these scientists have already established more than one company to exploit inventions, as we have seen it in the case of some classical academic entrepreneurs. Unfortunately against their efforts they did not manage to get ahead in the university hierarchy and at the same time build a successful business.

Two of these researchers have American experiences as visiting researchers that had a direct effect on their entrepreneurial transformation. They have seen successful *role models* and the potential symbiosis of university and industry that they would have liked to achieve at home as well. One of them already spun-off a company and served as a chief scientific officer in the US, while the other scientist built the venture on the idea developed in the US. The third researcher would had the opportunity to go abroad but this timely coincided with the period when he started to work on the development of his invention, thus he decided not to leave.

The internal motivation is also indicated by the funding of the companies; only one of the spin-offs was supported by a state grant and has a university ownership, while the other two companies were established with private funds only. It is also worth to mention that the founder of the grant supported spin-off already took part in three companies by the time of the spinning off that clearly shows that the availability of the grant was a favourable coincidence rather than the main trigger of the establishment. Also another member of this group initiated more companies since the first one.

None of them participated in *formal business education* and the researcher who took part in the American spin-off was primarily involved in the scientific part of the venture, thus *industrial experience* is limited and their *business networks* are practically missing. However, he had a joint patent application with an American company where the student of his former boss was involved in and another scientist shared his research idea and results with a Hungarian colleague who argued that it had a potential practical application and should be patented. These examples highlight the importance of *scientific networks* in form of local laboratory network.

Also their belief on the aim of *universities* with intense technology transfer activity is similar to those of the classical academic entrepreneurs. They argue that universities primarily engage in patenting and spin-off by the hope for increasing prestige. The supportive attitude of the university is also expressed by the sometimes free availability of facilities and by the cash investment into one of the companies.

Until this point these researcher do not seem to differ too much from the classical academic entrepreneurs, so the question arises why they ended up as impeded academic entrepreneurs, what have been the reason for the incomplete alignment of tasks or the partial success in one or another role. The problem seems to be rooted in the shortcomings of the research grant and university system in general or in the lack of some professionals in Hungary who are specialized in biotechnology spin-offs.

By investigating the individual cases we find that two of them have an excellent *scientific performance* measured by publications and citations, however, it is not in accordance with their *position in the university hierarchy*. One of them is at the bottom level already for a while and does not expect to get ahead in the near future, while the other one is in the middle. This is a source of job-related dissatisfaction, as it is expressed by this citation:

"Academic career is today a non-existing career in Hungary,
establishing any kind of measurable existence as a university researcher is not real.
The university lecturer-researcher does not have any prestige."

This is not because of wrong intentions, but due to the selection criteria at universities that still prefers people with more lecturing attitude and devotion, unfortunately even in researcher positions. This selection bias severely impedes the evolution of a research university and a community that really wants to do innovation and not only making some research as an obligation but trying to avoid its actual utilisation that would take time from activities that are considered at promotion decisions.

Additionally, the regulation on intellectual property management based on western examples requires invention disclosure in the belief that people obey rules – that is not always the case in Hungary. Consequently, positive incentives should dominate that requires effort, but even in this case it cannot be taken for granted that the dedicated *office* is well equipped to deal with *technology transfer*.

A further problem is related to the already by the previous two academic entrepreneurial categories mentioned very bureaucratic functioning of the organizations, where the slow decision making processes impede the realisation of the supportive *entrepreneurial policy* of the university management.

This is not the only example of the divergence of the university leadership's intention and the actual situation. The other impeded academic entrepreneur was also at relatively low stage of the university hierarchy and his promotion was always denied by his departmental head who officially has been a supporter of entrepreneurialism and was active in patenting as well. It seems however, that he has been less successful in this than his underling and it created an unpleasant atmosphere that finally led the exit decision our interviewee, even though he liked university teaching very much.

These conditions in the university system impede the development of the entrepreneurial university and are very hard to counterbalance, since beside the promotion or tenure criteria also the mentality of already affiliated lecturer-researchers should be changed. The durability of the non-entrepreneurial mentality is well reflected by the fact that it has been mentioned by two interviewees; one of them established the company in the first half of the 1990s, the other one in the first half of the 2000s. As the earlier academic entrepreneurs stated:

> *"By the time I filed the patent application, I pretty much hanged out from the academic group. At that time going to work in industry was strange."*

On the individual level it results in a limited success in the academic career or even the abandon of it that. This, in turn, decreases the likelihood of the above mentioned turn. At the same time it is worth to mention that this is not due to conflict with the norms of open science, like *secrecy* and *publication delay*, since none of these researchers held them for a more serious issue than those belonging to the previous two categories.

The inability of these academic entrepreneurs to become classical academic entrepreneurs who manage both business and university career successfully can also be rooted in the *shortcomings of the biotech spin-off environment* that results in a limited success of the company. The financing of research is an evergreen problem. Beside the insufficiency of the basic research sources also the applied research *grant system* is imperfect. It is very difficult to predict and the amounts available are low that creates a disadvantage and worsens the company's position in development against competitors that can turn out to be decisive. The delays in payments jeopardise the liquidity of the firms. There are support schemes available at the start, but at a certain stage of the development larger amounts would be needed for which the available grants are insufficient.

A further environmental problem is the *lack of specialized experts*. The most commonly mentioned is the lack of a managerial layer that would be able to run young technology intensive companies, among them spin-offs, either as chief executive officers or chief financial officers. The education in economics does not prepare for that. One of the interviewees also mentioned the lack of specialised patent officers in Hungary. Though these experts are available abroad, Hungarian spin-offs hardly are able to pay the financial compensation required by these professionals.

The lack of *venture capital*, on the other hand, was not seen as an impediment, one of the researchers explicitly stated that if it is possible they try to avoid it due to the risk of losing control over the firm.

Though these general environmental weaknesses are also present in case of the classical academic entrepreneurs, it seems that they are more successful in mitigating the negative effects on the company. It can be related to their better business skills or also to the presence of a strong service provider branch in the spin-off that is able to counterbalance e.g. liquidity constraints.

Though two of the researchers try to focus on the research side of the company, we can argue that under favourable circumstances they would have turned into classical academic entrepreneurs instead of unbalanced ones. The reason behind this notion is the already mentioned multiple founder phenomenon in one of the cases that seems to represent a larger commitment towards business activity than the unbalanced ones.

The other scientist left the university, but only due to the unfavourable circumstances and unlike some unbalanced academic entrepreneurs who maybe plan to sell their invention with the company in the future or believe that the decreasing of their influence on the directions of research is a natural phenomenon, this academic entrepreneur puts a high emphasis on the participation in the strategic direction setting of the company and does not intend to sell his share in the firm, even against the considerable interest by some potential buyers.

Only one spin-off was located in an *industrial park*, thus these do seem to play a neutral role, similarly to the *technology transfer offices*.

4.3.3.4. Externally motivated academic entrepreneurs

The last group of researchers we identified includes three academic entrepreneurs who are different from the other previous categories regarding their motivation and many characteristics. Two of these scientists are at the beginning of their academic career and are *position*ed in the bottom segment of the *university hierarchy* and only the third is in the middle line.

The *motivation* behind spinning off the company in these cases does not seem to be rooted in the internal desire of the researcher but it is rather a necessity or an external incentive. One of the two younger scientists has always been employed through temporary contracts, and was responsible for the management of many large grant supported projects. This kind of organisational and scientific socialisation seems to lead to his strong commitment towards management tasks and applied research. Thus he gladly accepted the offer to take the executive seat of the spin-off. The other young scientist has never been a principal investigator in any research projects yet.

These young researchers seem to respond to the expectations of the external environment set by the university management and represented by the executive body of the *organisational* entrepreneurial *policy*, the *technology transfer office*s. In both cases the legal establishment of the companies was intensively supported by the technology transfer office and the university has ownership in both of the spin-offs. Due to their position in the university hierarchy and the temporary work contract of one of them, it was very likely that they will not abandon or refuse a task that creates opportunity to increase their embedding into the organisation and make a career progress.

The third company was not initiated by the technology transfer office, it was rather an individual respond to a system deficiency; the *resource constrained environment*. This researcher had more research experience at the time of the establishment than the other two scientists in this group that is reflected by his publication and citation records as well. Though there was an idea on which the company could be built on, the spin-off can be considered as a necessity company that helps to counterbalance the lack of basic research sources available for young or middle aged scientists. The researcher had some internal motivation, but without the availability of the spin-off grant he might never have started a company, as he argued. In this third case the university ownership in the spin-off was initiated by the researchers and not by the technology transfer office. This is in contrast with most of the internally motivated academic entrepreneurs in our sample who usually try to avoid university ownership.

Since these three researchers operate in fields where contract research is common, like genomics and chemistry, most of them had some kind of *business experience* and one of them had a company already before the spin-off, but that was not a research intensive venture. Against some experiences, they lacked real *business networks* and two of them argued that they had to learn how to manage a spin-off company. One of them stated that it can be easy learned how to do that, while for the other it has a somewhat tougher experience, since their company has been among the firsts and also the technology transfer office was still inexperienced in spinning off.

The *academic contacts* in form of the local laboratory network seem to play a very important role. Two of them established the company with their departmental colleagues and they argue that it is advantageous that they can share the tasks related to the spin-off. They also have a very good relationship with their colleagues and bosses who are very supportive towards entrepreneurship. One of the companies was established with the assistance of specialists from different departments of the university and the technology transfer office only provided help through its lawyer.

Nevertheless our conversation revealed the lack of an important element of the social capital; a successful academic entrepreneur. These researchers have not mentioned any *role model*s during our interview. Two of them did not mention international research experiences and the one who did visited a university where the university-industry interactions were realized through contract research work, whereas spin-off companies were not common, thus neither he had the chance to personally experience the mutually beneficial relationship between a spin-off and a university. This can partly explain the lack of academic motivations of these researchers in form of creation of a symbiosis between the university and the firm or to ensure employment opportunities to talented PhD students as it has been mentioned by the classical academic entrepreneurs.

There are no conflicts or tensions reported that is reasonable since the university management strongly supports these activities and also most of the colleagues are also very open towards new ideas and entrepreneurship. One of our interviewees highlighted that operating in a university environment is a comparative advantage of a spin-offs, since they have access to various specialised expertise that other companies might do not have. Also another researcher argued that due to the complexity if scientific questions *secrecy* towards departmental colleagues would only make research more difficult by restricting the pool of knowledge.

Our interviewees do not seem to worry about *publication issues* either. One of them mentioned that company research results are not always published, but the publications needed to scientific advancement can be written based on other university research, since there are more projects running at the department. The other researcher also highlighted that the research tool developed by the company is used in university research as well and contributes this way to the publication activity.

The university plays an important role as initiator of the spin-off, but it also provides laboratory space for a reduced free. Furthermore, one of our interviewees also mentioned that the university background protects the scientists in university-industry cooperation. Related to the motivations of universities towards entrepreneurialism they argue that the universities realized the recent innovation trends and put an emphasis on the development of the regional economy, but at the same time all of them mentioned that the universities might hope for future income. Nevertheless, the university does not intervene in the day-to-day operation of the business and is very flexible, thus they do not experience the possible problems mentioned by the academic entrepreneurs in categories as a reason to evade university ownership in the company.

Though the cooperation of the spin-offs and the parent organisations is generally considered to be a fruitful phenomenon, the strong overlap of the two in these cases raises some questions. Some of our interviewees argued that the separation of the employees of the enterprise and the university is not easy and one of the companies is strongly connected to the basic research activity as well. This latter seems to reinforce our impression that some spin-offs primarily target the acquisition of substitute financial resources to come up for the missing basic research sources. It can also reflect the fact that two of the companies were established based on the initiative of the technology transfer office and do not have a clear vision how to create a separate business model.

Though the scarcity of basic research sources has been mentioned by the previous types of academic entrepreneurs as well, most of them still tried to create a division line between the activities. This does not mean that in those cases there was no permeability, it rather suggests that the companies were created to do applied research and product development, thus to function indeed as autonomous business entities and not just as extensions of the university.

Most of the previous categories of academic entrepreneurs also tried to evade university participation in the company, while these externally motivated scientists welcomed the offer of the technology transfer offices or explicitly asked for that. It seems that they feel to be more comfortable or secure with *university backing*.

These companies do not target fast growth and they do not have professional management. Consequently, they do not seek for *venture capital* either. Besides doing also in-house research, they seem to be uncertain regarding the direction of their future development and mainly carry out contract research or provide services.

In our belief the above described motivational and ownership conditions clearly distinct these researchers from the classical academic entrepreneurs who were intrinsically motivated to start a business, sometimes against unfavourable circumstances or without participation of the university. Unlike in the former three types of academic entrepreneurs, push motives seem to clearly dominate externally motivated academic entrepreneurs.

It is very likely that in case of a different university environment these externally motivated academic entrepreneurs never would have established the spin-off. And different university environment in this sense does not necessarily have to mean a hostile one, as in case of some impeded academic entrepreneurs. It is likely to be enough if the university is not explicitly supportive and pro-active in spinning off.

They also differ from the unbalanced entrepreneurs who had an invention that they desperately wanted to develop further to do good for the patients or from the one in that category who left the university and undertook the risks associated with the single affiliation at a company.

One of the decisive triggers of these externally motivated academic enterprises seems to be the change in financing. All of these researchers put a high emphasis on the shift in the availability of funds from basic to applied research that provided a direct incentive to turn entrepreneurial. Though they try to exploit the opportunity, they also see the weaknesses of the system that already have been mentioned by the previous academic entrepreneurs, like e.g. the delay in payments or the lack of transparency.

The indirect impact of the *grants* is effecting through the technology transfer offices. Most of these university internal organisations have been established by grants and even today are strongly dependent on those. Consequently they try to get as deep insight into the research projects running in the different departments as it is possible. They hope that this way they will be able to identify projects with an outcome that has a commercial potential or they will be able to initiate projects like that. If that happens, they try to convince the principal investigator to establish a spin-off and they provide intensive support in form of laboratory space or marketing materials. By showing up a high number of newly established companies, sometimes using them as an alternative way off commercialisation instead of licensing they might will be able to underpin their importance.

However, an excessive pro-activity of the newly established offices sometimes can be seen to be aggressive by some of the scientists and the role of positive incentives and the importance of personal relationships with the researchers should not be underestimated. Also the question arises whether the external push motivation coming from the technology transfer office is really in accordance with the internal motivations of the scientist or is it only a desire to meet the expectations of the university management.

In the latter case one might speculate whether this mix of external and internal, primarily push motivations will be strong and durable enough to give the scientists strength and enthusiasm to overcome the difficulties that are inevitably avoidable in case of most of the spin-offs and to help them to create a company that is more than a formal business with hidden basic research activity. De Silva (2011) argues that in resource constrained environment academic entrepreneurs involved in spin-off formation initially have been triggered by push motives, but these immediately were followed by pull motives as well and the former would not have been sufficient to induce company establishment. However, at some of our externally motivated sample we had the impression that the spinning-off was initiated dominantly if not exclusively by push motives – that seems to suggest a different type of academic entrepreneur in the post-socialist domain. Nevertheless, we cannot exclude the possibility of alteration in the motivation portfolio that leads to an academic entrepreneurial phenomenon similar to that observed in the resource constrained Sri Lanka.

4.3.4. Discussion of the empirical findings

Summarily we can claim that academic entrepreneurs can and do exist in the Hungarian context against the seemingly unfavourable conditions stemming from the different evolutionary path of the Central and Eastern European research systems. The limited autonomy and strong centralization, the neglecting of universities as research organisations and the separation of spheres of innovation and the resulting limited entrepreneurial experience all seem to counteract the entrepreneurial turn.

Even against these, the classical academic entrepreneurs are present in Hungary, and similarly to the international experiences they are outstanding scientists motivated by academic goals that include among others the intention to development of their invention into a product, the creation of job opportunities for students and that of additional income for scientists or the extension of their research avenues by harmonizing business and academic activities.

However, the same motivations can remain unfulfilled in the presence of some university and external environmental deficiencies. Also different motivations can be observed where the researchers do not necessarily target the simultaneous pursuit of science and business with the same intensity and deepness that can lead to different types of academic entrepreneurs. In some cases the motivations are stemming not from an internal impetus but are the result of the related explicit expectation of the university or are tools to overcome resource constraints. The following table summarizes our findings related to the importance of the different factors in spinning off.

Table 4 Typology of Hungarian biotechnology spin-off founders

FACTORS			**Classical academic entrepreneurs**	**Unbalanced academic entrepreneurs**	**Academic entrepreneurs impeded by environmental factors**	**Externally motivated academic entrepreneurs**
Individual level	Professional and personal characteristics	Scientific excellence (publication and citation)	***	***	***	*/***
		Seniority	***	***	*/**	*
	Social capital	Scientific networks	***	**	*	**
		Industrial/business networks	***	**	0	0
		Role model	***	0	***	0
		Mobility	***	0	*** (0)	0
	Entrepreneurial education and/or experience	Formal business education	*	0	0	*
		Prior invention experience	***	**	*	0
		Previous industrial collaboration	***	**	*	*
	Attitudes towards conflict with open science	Secrecy	0	0	0	0
		Publication delay	*	*	*	*
University level	Policy issues		0	0	0	***
	Departmental norms		***	**	—	***
	TTO, ILO		0	0	0	***
	Science/research parks, incubators		0	0	0	0
External environment	National and regional milieu		—	—	—	—
	Availability of funding	Seed financing	0	0	0	0
		Business angel	0	0	0	0
		Venture capital	0	0	0	0
		State grants	**	***	**	***

Notes:
— - unsupportive/negative impact
0 – not important/neutral/marginal role
* – low value/weak support
** – medium value/importance
*** – high value/strong impact/very important incentive

Source: own compilation based on interviews

Besides the strong internal individual motivation, further crucially important factors in the evolution of *classical academic entrepreneurs* seem to be rooted in the individual level. It is very important that through international mobility most of these researchers have been visiting scientists in American or North-European universities that enabled them to get in contact with role models that provided example on the advantages of involvement in academic entrepreneurship.

Furthermore, it allowed the extension of their scientific networks and development of contacts that led to deep embedding in the international research community. Since the scientists turned their social capital into that of their spin-offs, it supported their companies to overcome the obstacle of liability of newness and also led to joint research programmes and joint business activity. Thus, sometimes there has been an overlap between the scientific and business networks, or the former provided access to the latter that subsequently also played an important role in the development of the spin-off.

The international experiences also often provided the first invention experience in form of patenting and licensing or even spin-off. These experiences significantly contributed to the business relevant knowledge of the scientists that are needed in the Hungarian resource constrained environment where the availability of professional biotechnology managers is very unlikely[87].

The creation of a symbiotic relationship between the company and the university was also enabled by the very supportive departmental atmosphere and the generally positive attitude of the university management. There were no tensions reported, even against the necessary secrecy and publication delay. Most of the colleagues understood their role and also the interviewees argued not to be bothered about these. Nevertheless, owing to their strong commitment towards science and desire for peer reputation, in my belief most of them would very welcome the improvement of the European patenting system that would enable faster publication.

Academic entrepreneurs impeded by environmental factors show similarities to classical academic entrepreneurs in term of motivations, since they target the extension of their basic research work into applied direction by establishing a spin-off and harmonizing the research agenda of the company and university laboratory. Two of them follow role models and are multiple or serial founders. In our sample only in this and the classical academic entrepreneurial group occurs that a scientist has been involved in more than one business founding.

[87] However, the lack of top managers seemed to be a problem even in excellent biotech clusters like that of Cambridge that suggests an international shortage of these professionals (Wicksteed, 2000b).

The problem is that unfavourable circumstances impede the realisation of these motivations and do not enable the unfolding of the classical academic entrepreneur. In two of the cases the scientists have been partly successful in their academic roles due to these impediments, while in the third case the entrepreneurial personality remained unfulfilled.

The first two cases are related to the university and include various reasons from personal frustration of the departmental head due to the success of the subordinate to more fundamental system deficiencies that are related to the mismatch between the organizational aim of creating entrepreneurial university and the selection criteria that still favours lecturer types of personality instead of risk taker, innovative researcher personality.

Further disadvantageous factors that can lead to the limited success of these researchers in one of the spheres are to be found in the external environment. The financing gap in Hungary mainly follows after the first few applied research grants when there are already some promising applied results, but to get ahead a larger amount would be needed that is not available through the grant system. This can cause a break in the developmental work and business success.

Similarly, the lack of some professionals like business managers who really understand the biotechnology industry and are able to run a high-technology spin-off company or that of specialized patent experts can impede the realization of academic entrepreneurial motivations. Though these unfavourable conditions apply for all academic entrepreneurs, it seems that depending on the profile of the company or on individual factors, like prior invention or industrial collaboration experiences of the founder and the resulting social capital these cause problems of different scale. The classical academic entrepreneurs seem to have larger experience in form of patenting and previous industrial collaboration, and they seem to have larger business network than the impeded academic entrepreneurs. These might help them mitigate the negative consequences of the above described factors.

Besides these categories whose motivations were the closest representatives of the academic entrepreneurs described by Etzkowitz we also found researchers who were triggered by somewhat different motivations; the unbalanced and the externally motivated academic entrepreneurs.

Similarly to the classical academic entrepreneurs, also *unbalanced academic entrepreneurs* are well established and renowned scientists in their profession. However, these scientists show much weaker interest in the business and they are not involved deeply into the managerial issues of the company that aims the development of the invention. They try to focus almost exclusively on the scientific work and some of them argue that they are not interested in the company development at all. Consequently they do not mentioned aims that have been raised by the classical academic entrepreneurs like the creation of job opportunities or the generation of additional income for university scientist. Though their admitted the importance of regional economic development contribution of universities, they more often mentioned the additional income available as the assumed reason of the organisation's entrepreneurial involvement.

Maybe the difference in the scale and scope of their belief and expectations on the potential synergies resulting from academic entrepreneurship is related to the lack of entrepreneurial role models. None of the unbalanced academic entrepreneurs mentioned that they would have seen academic entrepreneurs. Thus they primarily seem to use spin-off as an alternative way to develop their invention instead of licensing it. It is also worth to mention that one of these academics develops his invention with the active participation of a surrogate entrepreneur who is the CEO of the spin-off, while another one does the same with an industrial company, and both of the unbalanced academic entrepreneurs undertake CSO position.

The other extreme of this group has been a scientist who decided before the spinning off to leave the university and start an own business. In his case academic career advancement motivations clearly did not play a motivating force, but we have to mention that this researcher does care about the PhD students in his company and around it and tries to maintain university contacts, but further academic motivations seem to be missing. The decisive in his entrepreneurial turn rather seems to be his former foreign industrial employment and the affection to work in the private sector. Unlike the other researchers, he was rather supported by his business network in his entrepreneurial endeavour.

Externally motivated academic entrepreneurs are different from the above described categories. Their motivations to establish a firm are rather extrinsic than intrinsic. The spinning off is either initiated by the technology transfer office, as we have seen it in the case of the two younger scientists in the bottom segment of the university hierarchy, or is a tool of the researcher positioned in the middle level of the university hierarchy to counterbalance resource constraint in the basic research field.

Similarly to the unbalanced academic entrepreneurs, the lack of internal motivation to become academic entrepreneurs who simultaneously do science and business in a mutually supportive manner and create better opportunities for students and colleagues can be rooted in the lack of meeting such successful role models.

The local laboratory network was important in these cases, two of the researchers had co-founders who are or were their colleagues. However, unlike in case of classical academic entrepreneurs the international embedding of these researchers is very low, if not non-existent. The relatively low social and human capital compared to the classical academic entrepreneurs clearly limits the opportunity to convert those into the capital of the company. This does not support overcoming liability of newness that mitigates the success prospects of the spin-off.

Additionally, all of these companies have at least 10% university ownership that derogates a further comparative advantage of spin-off companies; the ability to react quickly and always diversify into the most promising research direction. Though the interviewees claimed that the university did not intervenes into the daily operation of the business, this does not necessarily mean that industrial partners or at a certain stage of the development potential investors are not afraid of the opposite option.

Though we clearly cannot exclude that these companies will be successful, the above mentioned factors are likely to mean a threat on their fast growth. This can have an effect on the individual and on the organisational level as well. If the business fails, the likelihood that these researchers ever will try again to do venturing is very unlikely in the Hungarian general business culture. It would also significantly decrease the likelihood that over time, due to the success of the first company, these scientists would be internally motivated in the future to start a company and extend their vision beyond income generation for the university or finding sources for research towards distinct, but complementary research agendas between the university and a growth oriented company. In case of limited success these academic entrepreneurs also would represent a negative role model for the colleagues, severely decreasing the likelihood that an opportunity based entrepreneurial culture evolves within the university instead of the push one.

An interesting general finding has been the almost entire disinterestedness towards *research parks*. Most of the companies are not located in science parks and they do not seem to seeking for the possibility of being located there. It would be worth to analyse it in more detail to see whether it implies only a lack of awareness of the potential benefits or the phenomenon is rooted deeper and traces back to the early disappointment on research parks that can be owed to the already mentioned imitation of western models before the transition that created a quite alien type of institutions in the system that time.

Also the *lack of professional biotechnology business managers* would deserve additional research, since based on the empirical results it is a major issue in many companies. Though there are recently some trends towards trying to including the development of business competences into the education in biotechnology, the general lack of similar efforts in most of the natural science curricula induce significant problems ranging from communication deficiencies between biotechnology experts and business people to difficulties in understanding and applying basic management issues. On the other hand, the lack of courses offered in basic biological, microbiological and biotechnological studies is a general problem of business education. Without being able to understand the merit of the company's research agenda and products or services offered by the spin-off, even the best prepared business manager would find it difficult to effectively co-operate with researcher colleagues that can induce a risk on the firm's success.

5. Summary and conclusions

Permanent innovativeness seems to be an important element of the nations' competitiveness in the 21st century. The creation of new ideas and the development of those into products in an ever increasing pace to increase the wealth of people are of utmost importance. Universities can contribute to this aim in multiple ways. Besides improving the human capital through educational services, they are involved in research activities since the 19th century and they proved to be one of the most fertile grounds for inventions.

With the second academic revolution in the 20th century, contribution to regional economic development became an explicit task of universities (Etzkowitz and Leydesdorff, 2000). This mission is indirectly supported by the creation of a favourable milieu, by infrastructural developments, but also participation in local governance can benefit the region. Direct contribution to development of a region's economy is usually embodied by entrepreneurial activities that can be divided into two broad categories. Public service includes e.g. consultancy and external teaching that are long present and accepted in the academic domain. However, the second academic revolution is usually associated with academic entrepreneurship in forms of patenting, licensing and spin-off that are subject of controversy owing to their potential negative impact (Gulbrandsen and Slipersaeter, 2007).

Some argue that increased commercialization will alter the research focus of universities and overshadow the norms of open science (Goldstein, 2010). However, others insist that the appearance and embedding of the new tasks is a consequence of a natural evolutionary process that is triggered by external and internal forces and the benefits outweigh the potential setbacks. Globalization and increased international competition in the knowledge-based economy guided by the emergence of new technologies highlighted the developmental potential of universities (Luger and Goldstein, 1997; Martin and Etzkowitz, 2000). Legislative changes opened the door for the active involvement of universities in the IP management and commercialization of research results. Constraints on public expenditure exacerbated by falling enrolment figures and increased cost provided an incentive to universities to capitalize on the new opportunities (Etzkowitz, 1983; Chiesa and Piccaluga, 2000).

This incentive was further supported by internal changes that relate to the new ways of organization of science represented by the emergence of multidisciplinary research groups. These operate on a quasi-firm basis under the management of a principal investigator that carries out many business-like activities (Etzkowitz, 2003a). This contributes to the acquisition of managerial skills on the side of scientists that increases the likelihood of the entrepreneurial turn on the individual level.

The individual interest is crucial, since one of the most important actors in the entrepreneurial turn of universities is the university researcher himself. The participation of the inventor is generally accepted as an important ingredient of the receipt of successful commercialisation. The problem is that against the already quite long availability of related opportunities, researchers seemed to be reluctant to capitalize on their inventions (Etzkowitz, 1983) and administrative rules and organizational units are insufficient for the substitution of missing personal commitment (Owen-Smith and Powell, 2001). However, the unfolding of the utilitarian ethos that called for practical contribution of universities to the regions' development brought a change not only on the institutional, but on the individual level as well. Following the urge of governments and the legislative changes, universities have reinforced their patenting, licensing and spin-off activity (Mowery et al., 2001; Mowery et al., 2004; Thursby and Thursby, 2011) and expected also their faculty to do so.

The general support of academic entrepreneurship by the policy makers and university administrators created an atmosphere that contributed to the normative shift in academia. As a result, scientists not only recognized the entrepreneurial opportunity, but more and more decided to realize it. However, the primary aim with the participation in patenting, licensing and spinning off was not to gain personal wealth, but to enhance their academic career (Franzoni and Lissoni, 2009).

The entrepreneurial university seems to be strongly connected to the American research university, or more generally in the Anglo-Saxon system that has many features that distinguish it from the continental European tradition. Important elements of the American system that help to increase competitiveness among individuals and institutions alike seem to be absent or distorted present in the continental European system. The fierce competition for funds is largely mitigated due to the political compromises (Bonaccorsi, 2007), the mobility of scientists is impeded by the strong national differences in the labour markets (Musselin, 2004), and the key role of universities in the innovation systems is overshadowed by the other public research organisations and specialised agencies (Buenstorf, 2009; Koschatzky and Hemer, 2009). Deficiencies in the financing and intellectual property right systems just aggravate the situation (Lissoni et al., 2008; Pavitt, 2001; Harhoff et al., 2009; van Pottelsberghe de la Potterie and Mejer, 2008).

In case of the Central and Eastern European countries we also should not forget about the impact of the Soviet model of science on the universities (Gaponenko, 1995). The lack of real innovation, the rigid separation of the research and industrial spheres, and that of civil and military research guided by an overwhelming secrecy, the segmentation of civil research and subordination of those to branch ministries all meant a further ballast on the already loaded system (Balázs et al., 1995a; Gaponenko, 1995). The favouritism of the academies of sciences against universities in research severely limited the accumulation of market knowledge and experiences (Balázs et al., 1995a).

Though some studies shown that individual professional and scientific curiosity meant a fertile seedbed for research and university-industry co-operation even before the transition (Balázs, 1996), the above mentioned institutional differences all would suggest that the academic entrepreneurship is absent from the Hungarian university system.

Thus the main aim of our research was to see whether we are able to find real academic entrepreneurs in the Hungarian context and not only backyard farms. The field chosen for investigation was biotechnology, partly due to my personal interest and partly owing to practical reasons, namely that this was one of the areas where the occurrence of spin-off was the most likely. Some even claim that the entrepreneurial turn of universities is largely attributable to the emergence of biotechnology.

We were seeking for the classical academic entrepreneurs described by Etzkowitz (1983), thus we tried to find researchers who spun off a company to utilize their specific knowledge or to develop a product with the aim of simultaneously advancing their academic career. Additionally we have been interested in the factors that based on an extensively literature survey are likely to influence the realisation of these motivations. The investigation included factors that can support the success of the academic entrepreneurs, but also factors that might divert them from their original aim or impede the fulfilment of their mission.

The most important contribution of this dissertation to the common pool of knowledge on Hungarian academic entrepreneurship is the identification of classical academic entrepreneurs. As in the concept of Etzkowitz (1983), these scientists are at the competitive edge of their profession, many of them are star scientist with excellent professional characteristics. In accordance with this, they are usually already at a quite high position in the university hierarchy. Consequently getting higher in this system is not an explicit aim of them, but in other aspects they are strongly influenced by academic motivations. The most frequent expression of this is the aim to extend their knowledge beyond basic research and to develop their idea into a product. Furthermore, they are interested in the advancement of the broader scientific community, since they explicitly mentioned the creation of additional income to researchers and ensuring job opportunities for the talented PhD students to avoid brain drain of the field. They also apply joint project proposals with the university that creates a mutually beneficial relationship.

Thus our *first hypothesis is accepted*; against the relatively unfavourable conditions classical academic entrepreneurs as described by Etzkowitz (1983) indeed can exist in the current university system of Hungary.

The analysis of the age structure of classical academic entrepreneurs' companies does not seem to support our *second hypothesis*, since nearly half of these spin-offs were established in the 1990s. However, the fact our sample of companies established during the transitional period does not include "backyard farm" type of firms does not necessarily exclude the possibility that they do exists. Consequently we can argue that our sample did not support our second hypothesis, however, it neither rejected it.

Further novelty of our research is that besides founding classical academic entrepreneurs it also found three more types of academic entrepreneurs in the Hungarian context. Some of them differ from classical academic entrepreneurs already in their motivations, but others are triggered by the same incentives, however, fail to fully realize those. Regarding academic motivations the closest to the academic entrepreneurs are the *academic entrepreneurs impeded by environmental factors*, since also they try to establish a symbiotic relationship between the university and the company. Their aim is to extend their university basic research towards applied direction and create a complementary research agenda that synchronizes the university basic research targets with the applied business ones. However, some unfavourable elements of the university or external environment unable the fulfilment of both the academic and the business aims, thus the synergies remain limited.

Unlike the classical academic entrepreneurs, *unbalanced academic entrepreneurs* do not necessarily create a very close symbiosis between the university and the company, since their emphasis dominantly lays on one or another field. Those who clearly subordinate business activity to the academic work are all medical doctors who aim the development of a medical device that can improve the quality of life of patients or increase their life expectancy, while one researcher altered the focus of his career and left the university to devote himself to the development of his business.

The last group of scientists we identified shows very different characteristics and motivation than the previous ones. Unlike other researchers in our sample, *externally motivated academic entrepreneurs* are positioned in the middle or bottom segment of the university hierarchy. These researchers do not seem to have the strong internal incentive to create and develop a business enterprise that will benefit their career advancement and simultaneously provides better conditions for students and colleagues alike. Their involvement is rather motivated by the external environment and by push type of factors. Two of them were not intending to reject the initiative of the technology transfer office to undertake position in the spin-off company to be established. The third researcher clearly stated that – besides the presence of some internal incentive – the company can be comprehended as a necessity spin-off that helps to overcome resource shortage in the academic environment. The important issue is here that without the presence of strong external impetus or availability of grant support schemes for spin-offs these scientists might never have started a company.

It is important to highlight that the occurrence of the classical academic entrepreneurs is not a consequence of legislative changes, since many of these companies predate the modification of the Act on Higher Education or the enactment of the Innovation Act. This seems to suggest that, similarly to the US and Western Europe, the legislation only legalised an already existing phenomenon that is rather rooted in the development of the biotechnology industry. Nevertheless, as it has already been mentioned, the time elapsed between the legislative changes that were part of a multiple transformation is too short to make definite statements on the role of recent regulation.

Regarding the influencing factors we can claim that role models and deep embedding into networks of scientific excellence seem to be very important in the emergence of the classical academic entrepreneurs. Consequently mobility programs enabling networking and accumulation of international experience complemented with grants supporting return to Hungary are very important. The creation of a solid academic entrepreneurial base can induce cumulative processes that enhance the practical realization of the entrepreneurial turn of the institutions that seems to lag behind compared to the individual efforts.

This lagging is partly attributable to the general deficiencies of the Hungarian research system like the severely limited autonomy and excessive bureaucracy of these institutions, that cannot be outweigh by simple modification of regulation on university IPR ownership. More fundamental changes in the selection and promotion criteria of scientists would be needed, guided by a general increase in the financial autonomy of universities.

An interesting result have been that the technology transfer offices only played an important role at the establishment of the spin-offs of externally motivated academic entrepreneurs. This is reasonable in case of the companies that predated legislative changes, but there are many in our sample that did not. This clearly shows that legislation and support schemes to establish internal organisational units for technology transfer cannot be expected to generate immediate effects. Especially, since the normative support of these offices is still an unsolved issue. The unstable financing and continuous pressure to apply for grants absorbs a significant portion of the working hours of the employees and impedes the development of a solid professional technology transfer officer base. This decreases the likelihood of a more direct personal relationship between the researcher and the officers that, in turn, derogates the chances of these technology transfer offices to successfully claim normative support for their activity, resulting in a catch-22 situation.

It is also an unrealistic expectation that these newly established offices will be able to manage the whole spectrum of the university-industry collaborations from one moment to the other. Especially, since as it has been mentioned in the theoretical parts and in the description of the Hungarian research system, the informal mechanisms developed in the past are likely to operate even after the legislative changes. It is likely to take generations until mass of researchers voluntarily turn to technology transfer offices above the required minimum – or even for that.

The missions and tasks of technology transfer offices should be reviewed in the light of the first few years of operation. Clear and explicit missions should be formulated and matched with appropriate funding. Nevertheless, it is also important to note that the approximately five years elapsed since the legislative changes enhancing entrepreneurial turn of universities and our investigation and this is not enough to judge the results, especially if we take into consideration that Clark (1998; p. XIV) "[…] viewed a decade as a minimal period of time for serious change in the way of a university to be instituted and worked out." Additionally, most of the institutions in our sample are comprehensive, multifaculty universities that in Clark's (1998) view might find it more difficult to move entrepreneurial than specialized, one-faculty universities.

Based on the arguments above our *third hypothesis* can be *partly accepted*, since many companies in our sample have been established after the legislative changes. However, most of them were not inspired by the technology transfer offices, rather individual scientists seem to decide to take advantage of the opening opportunities. We also have to note that most of the new founders do not belong to the classical academic entrepreneurs, and only one of the companies initiated by a technology transfer office is established by a classical academic entrepreneur. However, we would like to emphasise again the relatively short period of time elapsed between the legislative changes and our empirical research.

Related to the national and regional milieu many academic entrepreneurs consider the lack of professional biotechnology managers as one of the crucial problems of the sector. Newly graduated economists are unprepared to manage a high-technology company, and most of the biotechnology professionals do not have business education background. The evolution of the biotechnology manager layer could be supported by the attraction of Hungarian professionals working abroad.

Maybe related to the business model and mission of the Hungarian biotech spin-offs, but venture capital does not seem to play as important role as it is often echoed. Most of the scientists try to avoid VC funding owing to the fear of losing control above the company. They are aware how VC backing mechanisms work, and many of them argue that in case of an idea with fast and high return they might will establish a separate company with VC money.

Though the need for state support in forms of grant systems is in accordance with the international trends and welcomed by the academic entrepreneurs, their double transformation would be needed. On the one hand, rationalisation of administration could help the avoidance of liquidity problems on the side of companies; while on the other hand, rethinking of the selection criteria should avoid the unjustified support of semi-market companies and spending public money without real results in form of marketable products.

Even against the best intentions there are some *limitations* of my dissertation that have to be mentioned. Unfortunately at the time of our survey there have been only a handful number of spin-offs in biotechnology that severely restricted the research method. First of all, statistic and econometric methods hardly came into question. Since the historical evolution of entrepreneurship at Hungarian universities also included periods when spin-off activity has been banned, it was likely that anonymity will be required by those participating in the survey. Owing to the small sample size, spatial analysis on the occurrence of the different types of academic entrepreneurs would be likely to jeopardise anonymity, thus we had to abandon it. A future study that includes all biotechnology spin-offs not only from universities, but also from other public research organisations should solve this problem. Additionally it could provide opportunity for an interesting comparison between the spin-off activities of these two types of organisations that had very different access to research infrastructure during the Soviet influence.

A further spatial issue is related to the generalization of the research results for Central and Eastern Europe. The dissertation clearly proved that the occurrence of academic entrepreneurs in the classical sense at is has been described by Etzkowitz is possible in the Central and Eastern European context. Nevertheless the generalisation of the Hungarian findings for the whole Central and Eastern European region should be made with thorough discretion. Though many of the countries are common due to the German and Soviet influence, one should not forget more than 20 years gone by since the beginning of the system change and the former Soviet member states transformed into market economies in different pace.

Some of them had a good start, but slowed down later, while others has a slightly worse take off, but well-balanced development. The success of privatisation, the enactment of the appropriate legal frameworks, the ability to attract foreign direct investment, just to mention a few, all can have an effect on the possible role of universities in the national systems of innovation. In case of biotechnology one cannot neglect the role of state intervention either, since governments that act rapidly and effectively can outrival countries with good basic features but hesitation in actual support of high-technology industries. It would also be interesting to see whether the other main subject area of academic entrepreneurship the ICT sector shows similar motivational patterns than biotechnology. Comparing the two most important spin-off areas could provide a better proxy to the actual depth and breadth of the entrepreneurial turn of Hungarian universities.

We think that potential conflicts and tensions would deserve more detailed analysis in the future. Interestingly they seem to be only marginally dealt with issues in Europe compared to the US. Maybe it can be related to the different developmental level of academic entrepreneurship in the two continents. Nevertheless we think that an important extension of our related knowledge would result from the simultaneous survey of academic entrepreneurs and their non-entrepreneurial departmental and broader university colleagues to see whether the perceived and real conflicts are in accordance.

One of the most promising future research avenues would be a full survey of all research groups at every universities and public research organisations that can be relevant to biotechnology. This could complement the previous research works we have been involved in multiple ways. It could provide a more detailed insight into the real depth and breadth of academic entrepreneurial activities, including not only spin-off, but also industrial cooperation in form of contract research and patenting as well. The larger sample would enable the analysis of spatial differences and gender issues as well. Maybe even more important information would be the identification of the obstacles that keep back scientists from being involved in entrepreneurial activities even against the presence of internal motivations to do so. From a policy perspective it could build the base of targeted programmes to eliminate the barriers of academic entrepreneurship in Hungary.

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Appendixes

Appendix A List of support schemes available after the Millennium (Source: Buzás et al., 2010; NIH PPP RET)

Grant	Announcer	Aim	Call period	Potential applicants	Supported institutions
Regional Knowledge Centres	NKTH (Office of National Research and Technology)	Enhancing knowledge- and technology transfer, respectively intra-organisational support units of those. The establishment of research excellence centres that intensively co-operate with industry and support the technological and economic development of their region and increase competitiveness.	2004–2005	Universities	University of Debrecen (2004), University of Szeged (2004, 2005), Semmelweis University (2004), Budapest University of Technology and Economics (2004, 2005), University of Miskolc (2004), University of West Hungary (2004), University of Pécs (2005), Széchenyi István University (2005), Eötvös Loránd University (2005, 2006), Szent István University (2005), Esterházy Károly College (2005), Pannon University (2006), Corvinus University of Budapest (2006), College of Nyíregyháza (2006), College of Dunaújváros (2006), Technical College of Budapest (2006)
Pázmány Péter Programme			2005–2006	Universities and colleges	
TÁMOP-4.2.1.	NFÜ (National Development Agency)	Development of the knowledge- and technology transfer capacity of higher education organisations in pole cities. Establishment and development of a tool- and condition system enhancing knowledge utilisation and knowledge transfer (2008) Support for research and technology transfer services, im-	2008–2009	Universities	University of Debrecen, University of Miskolc, University of West Hungary, University of Pécs, Széchenyi István University, University of Szeged, Budapest University of Technology and Economics, Semmelweis University

		provement of the research conditions of higher education institutions.			
INNOTETT Tender for the development of innovation management and enhancement of technology transfer	NKTH (Office of National Research and Technology)	Development of services and market orientation of institutional and network structures connecting R&D organisations and companies that utilize the R&D results.	2006	Universities and PROs	Bay Zoltán Foundation for Applied Research, University of Debrecen, Eötvös Loránd University, Pannon University, University of Pécs, Semmelweis Innovation Centre Consultancy and Service Provider Ltd., University of Szeged, ValDeal Innovation co Ltd.

Appendix B Top-down governmental biotechnology programmes before the transition

Framework:	- OKKFT (Public Medium-term Research and Development Programmes during 6th five-year plan period) OKKFT A/16 - GF (Public Medium-term Research and Development Programmes during 7th five-year plan period) - G3 "Protein Programme"
Responsible government agency:	- Protein and Biotechnology Technical and Economic Advisory Board of Biotechnology at OMFB
New research organisations set up:	- Agricultural Biotechnology Centre Gödöllő (founded by Ministry of Agriculture in 1986; scientific work started in 1990)
Education programme:	- Start to educate engineers for biotechnology at Budapest Technical University; Agricultural University Gödöllő; - Support education of up-to-date biotechnology at universities in natural sciences (started Budapest, Debrecen, Szeged), - Agricultural sciences (started Gödöllő and Pannon University, Keszthely, Horticulutre and Food Processing University), - Animal science university
Knowledge distribution:	- Education programmes were supported by a special training package, video programmes, slides launch publications - Series: Folio Biotechnological - Biotechnology in our days - Annual issue in English of Hungarian articles published by Hungarian journals
International relations:	- Bi-lateral agreement: Austria, Finland, US, Czechoslovakia, GDR - Membership: ICGEB (International Centre for Genetic Engineering and Biotechnology in 1983 - Direct linkages with many foreign research institutes and universities

Source: Bross et al. (1998; p. 113)

Appendix C Detailed action plan to improve biotechnology sector (Source: Convincive Consulting – HBA, 2008; p. 7–8)

1. Knowledge base and human resources
   1.1. Increasing the attractiveness of biotech research career among high school graduates
   1.2. Enhanced mobility between university and industrial researcher or biotech manager career paths
   1.3. Increasing tolerance against risk and entrepreneurial failure in Hungary
   1.4. Strengthening of the biotech management training
   1.5. Attraction of foreign and Hungarian biotech researchers working abroad
   1.6. Attraction of foreign and Hungarian biotech entrepreneurs and managers working abroad
2. Infrastructure and knowledge transfer
   2.1. Stabile state support of technology transfer organisations (TTOs) in research institutes
   2.2. Launching business-development oriented practical training and pre-incubation programmes
   2.3. Establishment of a focused, state supported bioincubator system
   2.4. Strengthening the system of pre-seed financing
   2.5. Grant support of intellectual property management
3. SME funding
   3.1. Increasing the availability of R&D and utilization grants (GOP, NKTH) for growth-oriented biotech SMEs
   3.2. Implementation of national EU- and state-funded seed- and growth-capital programmes (e.g. JEREMIE programme) in a manner as they indeed support biotech SMEs
   3.3. Increasing the availability of MFB investment loans for biotech SMEs before market entrance
   3.4. Exchange rate and profit tax allowances for business angels and private biotech investors
   3.5. Hungarian implementation of the Young Innovative Company (YIC, FIV) status
   3.6. Abolishment of pre-selling tax on equity options

4. Market environment
    4.1. Increasing global PR and marketing activity of the Hungarian biotech sector
    4.2. Establishment of "Ready-to-Build" greenfield areas for large biotech investments
    4.3. Loosening GMO regulations at least on the level of EU recommendations

Appendix D Calculation of and factors determining DCI (Source: EuropaBio and Venture Valuation, 2009; p. 19–20)

The index measures the current status (quantitative factor) and the development potential (qualitative factor) in biotechnology. The qualitative factor included measures such as the existence of a pharmaceutical industry, level of government support, availability of public and private financial support, existence of a qualified workforce, establishment of technology transfer offices and technology parks, and general awareness of patenting and IP protection processes from a scale rating from 0 (non-existent) to 4 (exceptional). The points were weighted from 2 to 4.

The quantitative factor measured based on company data, such as the number of biotechnology companies in three categories: therapeutics, services and other; the number of employees, the number of product on the market and under development. Company scores were summed up for each country.

The higher scores meant more advanced biotechnology industry in case of the quantitative factor, and a more favourable environment for future growth in case of the qualitative factor.

Appendix E Visions for biotechnology (HBA and Convincive Consulting, 2012; p. 42)

1. Broad vision for 2030

“The Hungarian biotech sector will strengthen further, becomes one of Europe’s significant bioregions, which is globally recognized, and several of its segments emerges into global prominence.

The strong Hungarian biotech sector measurably contributes to the well-being of the Hungarian society via – among others – its economic strength, the improvement of people’s stat of health and the quality of food, the reduction of the country’s energy dependency and via biological environmental protection.”

2. Specific visions for 2030
    - 2.1. Red biotech
        - 2.1.1. Hungary to become the “island of health” in Europe
        - 2.1.2. The Hungarian red biotech industry to become a significant bioregion in Europe
    - 2.2. Bioinformatics
        - 2.2.1. Hungary to become a leading service provider in several selected bioinformatics methods/services, also integrated ones
        - 2.2.2. Hungary to become a leading service provider in the genomics of several selected disease groups
    - 2.3. White biotech
        - 2.3.1. Hungary to reach the European average regarding the share of renewable energy
        - 2.3.2. After ensuring food supply safety Hungary would be able to cover 40–50% of its current energy need from its own sources by existing technologies
        - 2.3.3. The scale of biomass utilization to be widened
    - 2.4. Green biotech
        - 2.4.1. Hungary to become a leader in the “organic-biotech’ concept
        - 2.4.2. Social acceptance of plant biotechnology to increase

Appendix F Comparison of ICT and red biotechnology sectors (Source: Convincive Consulting and HBA, 2008)

	Red biotech sector	ICT sector
Technological risk	High	Low
Marketing (business model) risk	Low	High
IP protection	Strong	Not applicable
Initial capital requirement	High (laboratory, tools and equipment)	Low ("garage companies")
Return on investment	Slow (3–10 years)	Fast (1–3 years)

Appendix G Detailed structure of the interview guidelines

The interview guidelines served the orientation of the conversation and created a solid structure that enabled the systematic investigation of the collected data and the analysis of their impact on the realization of the motivations. Factors that seemed to have a larger impact were discussed in more detail and also issues arising during the conversation but not included in the original framework were considered in the final analysis if they turned out to be important.

1. Entrepreneurial profile

- Personality, motivations of the interviewee, why he became university researcher
- Development of his research career (especially those points that seem to be unusual or outstanding based on the background data collected previously)
- Attitude towards academic entrepreneurship (the effect of push and pull factors, intrinsic and extrinsic motivations)
- The effect of entrepreneurial activity on university career, potential synergies between academic and business activities
- Previous entrepreneurial experiences in form of patenting, licensing, different forms of university-industry interactions, the evolution of these activities after spinning off
- Primary motivations behind spinning off the company (financial incentives, new connections, extension of research from basic through applied research to product development), whether these have been motivated by academic goals and do they differ from the motivations of "regular" entrepreneurs
- The most important conflicts of interest and commitment for academic entrepreneurs, specifically for spin-off founders and the management of those on the individual level
- Similarities between PI and business manager roles, the potential applicability of knowledge accumulated as the head of the laboratory in the business management; the position of the scientist in the firm

2. Company

- Recognition/exploration of the spin-off opportunity
- Motivations behind the decision to exploit the opportunity through spin-off establishment
- Belief on the importance of intellectual property rights and the role of those in the spinning off
- Realization of the founding intention and stages of the company establishment
- Individuals and organisations who provided support in the different stages
- Source of connections to key persons and organisations who supported the spinning off process
- Hindering and supportive factors in the different stages (funding, professional consultancy, availability of skilled labour)
- Regional entrepreneurial environment (company density, business connections, availability of sources, market opportunities, regional availability of skilled workers)
- National environmental impacts on academic entrepreneurship (tax system, regulation of financial and labour markets, state grant supports and incentives); whether these are different in case of more traditional entrepreneurial forms or in case of other technology-based start-ups
- Future plans related to the spin-off company; plans for further founding

3. Entrepreneurial university

- The opinion of the interviewee on the organisational structure and founding of university research in Hungary (in comparison with the US and other countries, if it is possible, considering advantages and disadvantages as well)
- Whether the current system of research organisation enables the unfolding of the entrepreneurial university
- Status of the researchers regarding freedom, availability of tools and equipments, networking, mobility and competition (in comparison with the US and other countries, if it is possible, considering advantages and disadvantages as well)

- Changes in the national university and founding system since the beginning of the researcher's career, especially related to the spread of entrepreneurial activities
- Opinion on the founding of biotechnology research (in comparison with the US and other countries, if it is possible, considering advantages and disadvantages as well)
- Effect of competition between individuals and organisations for grants, status/star scientists on spin-off establishment (in comparison with the US and other countries, if it is possible, considering advantages and disadvantages as well)
- Primary objective of universities with the support of entrepreneurial activities (regional development or income generation) and the realisation of that
- Regulation of entrepreneurial activities (revenue share, conflict of interest; in comparison with the US and other countries, if it is possible, considering advantages and disadvantages as well), role of disclosure in opportunity recognition
- Acceptation of entrepreneurial activities within the parent organisation, entrepreneurial spirit and attitude of colleagues and the change of those over time
- Importance of the TTO for unfolding of the academic entrepreneur phenomenon, structure and activity of the parent organisation's TTO. Relative importance of institutional and individual connections.

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