Chapter 11
The Role of Academic Spin-Off Founders' Motivation in the Hungarian Biotechnology Sector

Katalin Erdős and Attila Varga

1 Introduction

Increasing attention towards the role of universities in regional development has resulted in a large number of publications over the past quarter of a century. A sizeable body of literature shows a specific focus on academic entrepreneurship. Entrepreneurial activities in academia may take the forms of externally funded research, earning of supplemental income, trade secret generation (Louis et al. 1989), contract research, sales and testing, external teaching, patenting, licensing or spin-off firm formation (Klofsten and Jones-Evans 2000). Some of these activities have long been present in the scientific domain. However, there seems to be a recent turn in academic entrepreneurship as specific tasks related to science-directed commercialization in forms of patenting, licensing and spin-off firm formation have become significant elements of scientists' everyday activities (Gulbrandsen and Slipersaeter 2007). Etzkowitz (1983) argues that entrepreneurial universities created by the second academic revolution are the result of a natural evolutionary process of these institutions as a response to declining resources, increasing competition and requirements set by the knowledge economy (Etzkowitz et al. 2000; Goldstein 2009).

Biotechnology has its roots at university research that has generated a significant number of licences since the enactment of the Bayh-Dole Act (Powell and Owen-Smith 1998; Mowery et al. 2004). Many discoveries that form the basis of biotechnology originate at universities, like the recombinant DNA technique of Stanley Cohen and Herbert Boyer (Powell and Owen-Smith 1998; Zucker et al. 1998) and the cell fusion technology of George Köhler and Cesar Milstein (Owen-Smith et al. 2002). A special feature of biotechnology is the difficult, if not impossible separation

K. Erdős • A. Varga (✉)
Department of Economics and Regional Studies, Faculty of Business and Economics, University of Pécs, Rákóczi St. 80, 7622 Pécs, Hungary
e-mail: vargaa@ktk.pte.hu

J.J.M. Ferreira et al. (eds.), *Cooperation, Clusters, and Knowledge Transfer*, Advances in Spatial Science, DOI 10.1007/978-3-642-33194-7_11,

of basic and applied research. Powell and Owen-Smith (1998) argue that the relatively clear division of labour between university and industry where the former is responsible for basic research and the latter for applied research does not hold in biotechnology. At the same time even the reward structures of the two spheres start to be blurred.

The evolution and early development of biotechnology have been greatly influenced by star scientists who kept their affiliations with their universities while establishing a spin-off company. Location of scientists—usually around great universities—and their intellectual human capital determined the growth and location of the biotechnology industry (Zucker et al. 1998). Many authors argue that biotechnology tends to cluster around large universities and research institutions (Owen-Smith et al. 2002; Zucker et al. 1998) partly due to the role of tacit knowledge and spillovers (Cooke 2001; Lawton Smith and Bagchi-Sen 2008) embodied in leading scientists of their field (Zucker et al. 1998, 2002). The cooperation of universities, start-ups and large pharmaceutical companies seems to be the best structure for commercializing new medical treatments (Powell and Owen-Smith 1998). Considering also the very high survival rate of spin-off companies compared to that of other new firms (O'Shea et al. 2004), the role played by them in the evolution of biotech clusters is even more evident.[1] Biotechnology is a field that has a clear potential to enhance the economic development of a region (OECD 2004; Owen-Smith et al. 2002). Besides the famous American success stories, like the Boston or San Diego area (Powell and Owen-Smith 1998), there are some European biotech regions, for example, Cambridge, where almost all high-technology companies are somehow related to Cambridge University (Wicksteed 1985). The 114 spin-off companies of the Oxfordshire region employed 9,000 people and realized a nearly one billion pound turnover in 2002 (Lawton Smith and Glasson 2005).

There are significant differences among regions regarding their potential for developing biotechnology clusters. Varga (2000) argues that American metropolitan areas with large concentration of high-tech activities create more innovation from the same level of university research expenditures than small metropolitan areas. Trippl and Tödtling (2007) underline that spontaneous emergence of high-technology clusters based on local knowledge is only likely in regions that are historically high-technology centres. The development of biotechnology clusters in latecomer regions is a less understood phenomenon that definitely should consider distant knowledge sources and policy aspects as well. Trippl and Tödtling (2007) labelled areas with some weaknesses or shortcomings in their regional innovation systems as "RIS with weak potentials for high technology industries". These weaknesses may be rooted in the lack of some crucial factors, such as VC or spin-off support structure, low social capital or avoidance of risk taking, or the lack of experience in bringing

[1] Though Aldridge and Audretsch (2011) found that the average annual 426 spin-offs coming from US universities between 1998 and 2004 according to AUTM data is a very poor result compared to the funds provided.

inventions to the market. They argued that these shortcomings inhibit the spontaneous take-off of a cluster, even against the available scientific excellence. This view is supported by Bajmócy (2005) who argued that in less developed regions community intervention may be needed to utilize the knowledge potential of universities.

However academic entrepreneurs can significantly contribute to the development of biotechnology clusters even in regions with weak potential for high-tech industries (Trippl and Tödtling 2007). It is because development of biotechnology clusters in areas with weak RIS is to a large extent tied to distant knowledge links that can provide access to locally missing expertise and resources. A special feature of academic spin-offs compared to other new technology-based firms lies in the specificity of the academic entrepreneur who brings not only his/her human capital but also his/her social capital that can be about utmost importance for the firm (Murray 2004). Though networks of a researcher outside the academia are usually limited (Vohora et al. 2004) Murray (2004) argues that their social capital consists of two very valuable elements. One of them is the local laboratory network including contacts to current and previous students and advisors. The other one is the cosmopolitan network of scientists established through their scientific career with colleagues and co-authors. Both in the spin-off process and in the development of the company social capital of a scientist serves as the base of the company's growing scientific network. It ensures international embedding of the firm signalling to members of the scientist's network that the company is worth to cooperate with.

Empirical evidence suggests that motivations behind university spin-off formation are different from those of other high-tech start-ups. Etzkowitz (1983) and Franzoni and Lissoni (2009) underline the importance of academic motivations behind scientists' entrepreneurship. Lacatera (2009) argues that university scientists usually select projects for commercialization with higher expected revenues than industrial spin-off founders. This underpins their economic importance and the need to reveal the underlying motivations to create appropriate policies fostering spin-off-based regional economic development in less developed regions. This paper focuses on Hungarian biotechnology university spin-offs and the motivations behind their creation. By doing so it fills a gap in the literature, since to the best of our knowledge, there are no recent publications investigating the presence or absence of entrepreneurial scientists motivated by academic goals. By conducting interviews with Hungarian biotechnology spin-off founders, we collected data that enabled not only the identification but also the classification of academic entrepreneurs that was previously not done in Central Eastern Europe.

2 Academic Motivations in Spin-Off Firm Formation

Even though there seems to be some risks associated with the involvement of university scientists in the spin-off process, their importance is unquestionable in the case of biotechnology. Though knowledge commercialization requires specialized business knowledge and personality traits which academic researchers

often lack (Shane 2002; Roberts and Peters 1981), scientists' importance is still relevant in the commercialization process. It is partly because the starting point of any university technology transfer process is the disclosure made by scientists (Owen-Smith and Powell 2001). Another reason is that academic inventions are usually in such an embryonic stage that product development requires active participation by the inventors (Thursby and Thursby 2003).

Without scientists being motivated to take part in the commercialization process it is highly unlikely that the university is able to identify potentially marketable inventions. Thus the question arises: why do scientists want to be involved in any kind of entrepreneurial activities? Why should a researcher feel motivated to join or establish a company? These questions are extremely relevant considering that scientists have traditionally been identified by the norms of the Mertonian world of science. According to this world the pure aim of research is advancement of science by placing discoveries in the public domain to reap the acknowledgement of peer scientists (Merton 1988). Many researchers still believe that deep involvement in commercialization activities would corrupt science (Bok 2003; Slaughter and Leslie 1997) and erode scientific norms. Others argue that it is questionable whether patenting, licensing and spin-offs at universities are compatible with the notion of open science (Goldstein 2009; Gulbrandsen and Slipersaeter 2007; Luger and Goldstein 1997). Based on a large-scale survey Goldstein (2007) shows that most of the scientists in the USA do not support far-reaching integration of science and business; instead they prefer the land-grant-type university system that treats science as public good and not as commodity.

However, there are clear indications of a gradual change in the values of academic science. Etzkowitz (1998) argues that a normative shift has taken place in academia where university researchers do not necessarily consider ivory tower as the only way of making science anymore. Renault (2006) emphasizes the importance of norms and attitudes by arguing that academics' belief about the appropriate role of universities in technology commercialization is the most important predictor of their related behaviour though she also highlights the role of revenue sharing. In a similar vein, Lacatera (2009) argues that scientists hope for both scientific and monetary rewards from knowledge utilization. Among the motives the desire for profit is also observed in Etzkowitz (1998), but his emphasis is more on "academic" motivations in commercialization. Franzoni and Lissoni (2009) support the importance of academic motives insisting that successful entrepreneurial activities may increase the reputation of scientists and enhance their scientific and non-academic networks perhaps creating additional income for research purposes. Nonmonetary incentives behind spin-off establishment are observed by Bains (2005) as well who is a multiple spin-off founder and academic entrepreneur himself, arguing that taking part in venture-funded start-up is monetarily the worst option for an "average" academic.

Even if scientists decide to participate in the commercialization process, there is a large variation in their level of involvement, which is explained by the origin and intensity of motivation to a large extent. Etzkowitz (1998) evidences that some of the researchers do not participate at all, others only fill in a disclosure form and leave everything else on the TTO ("hands-off"-type scientists) while another group

of scientists is familiar with the business environment as well and willing to take part in the negotiation of selling the patent ("knowledgeable participants"). Deepest involvement is observed by "seamless web"- type researchers who take part in the strategic knowledge setting of the company as well.

Shinn and Lamy (2006) classify academic entrepreneurs according to the following aspects: the share of science- and business-related motivations, their coordination and by the synergy and tension between science and business. "Academic" entrepreneurs strategically coordinate the two activities, but lay the emphasis on the scientific value of the firm that creates resources and broadens their audience. "Pioneer" entrepreneurs rather focus on business activities and related applied research tasks that result in limited synergies between the firm and the university. "Janus" entrepreneurs separate academic and business activities and sequentially give priority to one or the other field. Meyer (2003) identifies a group of scientists that do not necessarily aim fast growth of their enterprise and stay at the university after spinning off a company. He terms them "entrepreneurial academics".

Lam (2011) goes a step further by investigating the relationship between personal value orientation of scientists towards commercialization and their motivations. She categorizes peer recognition and the related career advancement together with broadened research resources and increased salary as extrinsic motivation, whereas intrinsic motivation is related to the successful solution of a research question. She finds that "traditional" scientists are usually extrinsically motivated and commercialization is only a tool to increase their scientific reputation. "Entrepreneurial" scientists are the other opposite. They strongly identify themselves with commercial norms and enjoy participation and personal financial gain is about importance for them. Between the extremes, there are the "hybrids" with a mix of intrinsic and extrinsic motivations, strongly protecting scientific norms but also satisfying their intellectual curiosity and doing good for the society.

University scientists who are interested in entrepreneurial activities usually have some common professional characteristics as well. Professional characteristics are described in the literature by publication and citation records, position in the university hierarchy, the existence of available role models, business education and business experience. Publication is a common way of knowledge transfer (Agrawal and Henderson 2002; Landry et al. 2006) and case studies demonstrate that, as a result of the "publish or perish" mentality, academic innovators usually aim to perfect academic research and publish their work towards the scientific community (Gökpete-Hulten and Mahagaonkar 2010; Vohora et al. 2004). Publication records are important predictors in the sense that more successful researchers tend to be more active in establishing spin-offs (Di Gregorio and Shane 2003). Publication record is also a general measure of scientific quality that correlates with the probability of patenting (Renault 2006) that may actually result in establishing a firm. However, Landry et al. (2006) found no connection between the number of publications and spin-off creation. Agrawal and Henderson (2002) argue that not patents but their importance measured by citations is a good predictor of publication activity. On the other hand Lowe and Gonzalez-Brambila (2007) found that faculty entrepreneurs are usually star scientists, who are more productive in terms of publications and citations as well.

Position of individual researchers in the university hierarchy had a modest effect on patenting activity with somewhat deeper involvement of full professors. However to some extent tenured faculty had lower patenting rates than non-tenured faculty (Morgan et al. 2001). This is in line with previous findings that entrepreneurship can be an alternative job option for scientists with temporary employment contracts (Helm and Mauroner 2007).

Etzkowitz (1998, 2003) argue that the availability of role models increases the likelihood that a faculty member forms a company if the opportunity arises. Also business education would be beneficial to increase the performance of spin-off companies due to the already mentioned low entrepreneurial skills (Shane 2002).

However, not only formal business education but also business experience and industrial cooperation can be very useful in the spin-off process by supporting the identification of opportunities (Bodas Freitas and Verspagen 2009) and also later on in the development of the company as this view is strengthened by Helm and Mauroner (2007) where a positive relationship between growth of the spin-off and start-up experience was found. D'Este and Patel (2007) argue that researchers who participated in collaborative research are more likely to interact with industry and they do it through various channels.

Incentives for entrepreneurial involvement may depend upon the academic and business environment as well. Grants and support programs aiming at increasing technology transfer seem to be a good device to facilitate knowledge flows (Vohora et al. 2004), but there are some risks that should be kept in mind. Koschatzky and Hemer (2009) found that direct grants for start-ups can result in companies that operate in non-commercial environment. Meyer (2003) also found that after several years of spin-off, support may not result in self-sustained companies. Easily available financial assistance may result in the establishment of excessive infrastructural and personal capacities.

There is a common belief that the Bayh-Dole Act opened the door for American universities to be engaged in entrepreneurial activities especially in the field of licensing. However not all of the universities took a chance on this as many of them did not increase significantly their activities while others implemented strategies to influence the behaviour of faculty and to set up TTO to fully exploit the opportunity (Goldstein 2009). Thus there are significant differences in the entrepreneurial policy of universities. Renault (2006) highlighted the importance of incentives (like revenue share), but Klofsten and Jones-Evans (2000) argued that university pressure can exert even a negative effect on firm establishment. On the contrary, acceptance of equity for licences can increase the number of start-ups (Thursby and Thursby 2003). Feldman et al. (2002) found by analysing the technology transfer strategy of American research universities that universities with greater technology transfer experience tend to have more and more equity instead of licensing, even though the return in this case is slower and riskier. A possible reason for taking the risk can be explained by the advantages resulting from alignment of the interests of the university and the firm.

After the Bayh-Dole Act of 1980 that obliged universities to make an effort to commercialize their IP, the number of university technology transfer offices in the

United States boosted (Etzkowitz et al. 2000; Phan and Siegel 2006). These organizations are aimed to facilitate knowledge transfer, and their experience and expertise have an even greater importance if university–industry relations are weaker (Colyvas et al. 2002). Since most of the technology transfer offices lack the necessary resources and competences to search for inventions with commercial potential, the technology transfer process starts with "volunteer" disclosure of the faculty, which is in turn influenced by their perception about the quality of the TTO (Owen-Smith and Powell 2001). Also the organization and financing of the technology transfer office can play a role, since self-sustaining TTOs tend to prefer licensing due to the immediate income.

All of the above-mentioned factors may influence entrepreneurial attitude and action of university scientist and thus are important aspects in our investigation of Hungarian biotechnology spin-off founders.

3 Motivations Behind Founding Academic Spin-Offs in the Hungarian Biotechnology Sector

In this section we investigate the motivations of Hungarian biotechnology spin-off founders and the effects of these motivations on the growth potential and international competitiveness of the sector. Hungary has long pharmaceutical traditions. Governmental support programmes of biotechnology were launched already in the 1980s, resulting in a total support of some HUF 4.5 billion between 1986 and 1990 (PCA 2004). The first biotechnology companies were established in the second half of the 1980s (Ernst & Young 2006) and by the time of the political system change in 1990 some 800 researchers were familiar with the latest techniques in biotechnology (Frigyesi in PCA 2004). However, the change in the political system was followed by the period of R&D budget cuts, fierce international competition and privatization that severely hit the biotechnology sector as well (Frigyesi in PCA 2004).

University–industry relationships in the years of the socialism were characterized by Triple-Helix I where the state encompassed both spheres and directed their relationship (Etzkowitz and Leydesdorff 2000). Consequently, interactions were typically led by state intentions where universities responded to industrial needs, usually with a troubleshooting like service (Balázs 1996). Even today there is a significant knowledge base at universities not only in Budapest but also in some large cities outside the Central-Hungarian region, for example, Debrecen, Pécs and Szeged (Erdős and Varga 2012). However, the contribution of these cities to the development of the biotechnology sector is largely hindered by the traditional division of labour between universities and other public research organizations (Owen-Smith et al. 2002). The biotechnology cluster around Szeged is a good example in this regard as it is largely based on the Biological Research Centre of the Hungarian Academy of Sciences and on the Bay Zoltán Institute for Biotechnology and not primarily on university departments (Lengyel 2009).

Though the (earlier forbidden) entrepreneurial activities of researchers in the public service became supported after the political system changed, many of the founders were rather necessity entrepreneurs in the 1990s (Balázs 1996). Inzelt (2002) also argues that, due to the heritage of some peculiar unsolved institutional and IP problems, many spin-off companies in the 1990s could rather be characterized as scientific "backyard farms" with questionable economic development contributions. Entrepreneurial culture and risk-taking attitudes were indeed low (Szerb and Márkus 2007) paired with the lack of the availability of venture capital that is still typical in Hungary (as in most of Europe). Thus practical utilization of university inventions was rare before the system change (Frigyesi in PCA 2004), and it is still very immature. The first technology transfer offices were established only around 2004.

The detailed description above clearly highlights that Hungarian regions may be characterized by "RIS with weak potential for developing high technology clusters" (Trippl and Tödtling 2007). This is an important contextual feature, since as emphasized in the previous chapter, academic entrepreneurs may significantly contribute to the development of high-tech clusters in these regions. However, exactly the unfavourable conditions mentioned above like the low entrepreneurial culture or the lack of experience in entrepreneurial activities among researchers and universities alike may impede the evolution of a solid spin-off base.

3.1 Empirical Research Setup

The source of empirical results in this paper is interviews with Hungarian biotechnology spin-off founders in 2008. All of them took part in spin-off establishments and held a CEO, CSO or equivalent position in the firm. Identification of the entrepreneurs was not easy, since no unique database for academic spin-offs exists in Hungary. We used data available on websites of the Hungarian Biotechnology Association and the Hungarian Spin-off and Start-Up Association or on university technology transfer offices. We tried to match the names found in these sources with names of faculty members of universities located nearby the company headquarters.[2]

The compiled list was sent to business consultants and researchers interested in biotechnology to get confirmation about its properness and further suggestions for interviewees if it is possible. At the end we had a list including 22 names of which 18 persons agreed to be interviewed during the research period. The involved companies are likely to cover the vast majority of Hungarian biotechnology spin-offs, since the whole broadly interpreted domestic sector counted some 150 companies in 2008, the narrow definition identified around 55 firms (Convincive Consulting-HBA 2008).

[2] Zucker et al. (1998) found that biotechnology spin-offs tend to cluster around parent universities.

The interviews were semi-structured with an average duration of 30–90 min. Voice records have been transcribed and sent back to the interviewees for checking and confirmation. The interview questions were centred around the motivation of the researchers and the different factors that helped or hindered them in the achievements of their authentic aims. Influencing factors in focus are based on the literature described in the previous chapter. Thus they are related to the professional characteristics of the academics, to the university's entrepreneurial policy and practice and to the local and broader entrepreneurial environment. Five firms were located in the Central-Hungarian region, five in Pécs, five in Debrecen and three in Szeged.[3]

The companies in our sample are related to red biotechnology and medical devices[4] which is a good reflection of the overall sectoral distribution, since more than 90 % of the Hungarian biotech firms belong to red biotech (Convincive Consulting-HBA 2008). Specialization of sample companies shows a large variety: three of them develop and market medical devices (related to surgery, gastrotonometrics and allergology), one is active in the field of medical biology, biotechnological research and bioinformatical software development, one in genomics, three develop diagnostic devices, molecules, one of them is active in the field of toxicology, two of them are related to food industry, six to pharmaceuticals and cancer therapy and one company is involved in gamete and embryo manipulation. The firms were established between 1992 and 2008. Majority of the companies in Pécs were founded in the first half of the 1990s, whereas the firms in Debrecen were maximum 3 years old, but some of them started in the year of the investigation. Nearly half of the companies had less than three employees, but five of them employed more than ten people.

3.2 A Typology of Hungarian Academic Spin-Off Founders

Based on the interviews and the aspects of investigation detailed in Chap. 2 we identified four different groups of researchers (Erdős and Varga 2012). The eight

[3] To the best of our knowledge there is no information on the spatial distribution of biotechnology spin-offs. In our identified sample most of the companies were located in the Central Hungarian region, but some of the researchers could not be interviewed due to international travels or other reasons. Considering the spatial location of biotechnology companies about 60% of them are located in Budapest, 20% in Debrecen, 10% in Szeged and the remaining in Pécs, Kaposvár, Veszprém and Gödöllő (Convincive Consulting-HBA 2008). This suggests that in our study spin-off companies on the countryside might be slightly over-represented showing a somewhat more even distribution than the overall sector. This might be related to the fact that most of the researchers keep also their university affiliations and establish their firms at their current location (Zucker et al. 1998), even against the disadvantageous entrepreneurial context compared to Budapest and its surroundings.

[4] Red biotechnology is related to medical applications and health care. We interpreted the term biotechnology broadly following its definition in the Hungarian biotechnology strategy, including also medical devices (medtech).

classical academic entrepreneurs believe that academic entrepreneurial activities are beneficial for their scientific achievement and do not conflict with traditional scientific norms. They harmonize academic and business life and try to reinforce the mutually beneficial areas. Academics in this category tender together with their university and hire PhD students in order to retain talented graduates in the region. Their internal motivation is rooted in the joy and happiness about successfully turning inventions into products. Sometimes they also consider the establishment of a company, a "living organism" as one of them labelled it, as a challenge. In many aspects they are similar to Lam's (2011) "entrepreneurial scientist". In some cases the decision of spin-off establishment is a consequence of the lack of companies willing or able to do it.

The achievement of their goals is supported by their experiences accumulated abroad where many of them have met successful academic entrepreneurs. They visited research excellence centres (like the Karolinska Institute in Sweden or the University of Wisconsin in Madison, University of California in San Francisco and, the perhaps most well-known biotechnology company, Genentech) and during their stay they established connections to leading experts in their fields. These relationships were maintained even after returning home. Deep embedding into international networks helped them later on in the development of their enterprise.

In some cases their cosmopolitan network grew simultaneously with the enterprise, as the connections were established through conferences and publications resulting in joint research later on. Colleagues at home universities are supportive; sometimes they are even co-founders. In one of the cases a researcher in this group became a role model in his university. Two of them are or were in high positions at their universities' technology transfer offices. This shows their strong belief and commitment towards the entrepreneurial turn at universities. This attitude is very important considering that many universities do not have experiences in university–industry technology transfer. Thus the presence of someone who is familiar with both spheres is a source of a good opportunity to reconcile the objectives of the actors.

The companies in this category became stable self-sustaining or even well profitable. In some cases their target market segment represents an enormous potential though they are still before market entry. Financial reward clearly plays a role but usually only as an indicator of success in business life something like publications in the scientific world. Money earned through the company is important to prove that the researcher is able to show an outstanding performance also outside the walls of the ivory tower. There is no doubt about their success within the university, as many of them are at the highest level of the university hierarchy and are well acknowledged by their peers.

However, academic success is not always satisfactory for the business world as reluctance to cooperate with scientists as businessmen is often experienced. This scepticism can be somewhat moderated if the scientist has some kind of business experience or even business education. Many successful academic entrepreneurs in our sample possessed project management experience accumulated within the science funding system. However at a certain stage of company development many of these scientists decided to hire professional management to run the company.

They felt that the firm would take too much of their time otherwise that would be harmful for their scientific performance. This clearly shows that though classical academic entrepreneurs feel committed to both areas academic career is always a priority. It also shows that the extrinsic motivation for peer acknowledgement and achievement in the university hierarchy is also a crucial incentive for entrepreneurial participation. Nevertheless, they also do care about the advancement of the biotechnological sector as a whole. Some of them filled or fill in positions in the Hungarian Biotechnology Association that aims the enhancement of the sector.

The second group of researchers is labelled *unbalanced academic entrepreneurs*. They have somewhat different motivations than the "classical" academic entrepreneurs. The majority of them restricted their activity within the company from the beginning on of the product development process (specifically on the related research and testing) and give an absolute priority to their academic work. These scientists are intrinsically motivated but not by the challenge of creating and developing a business organization. They are only interested in developing their idea and bringing the product to the market. This can be either rooted in the fact that these entrepreneurs did not mention any role model, which suggests that they are perhaps not aware of the scientific and business potential hiding in the opportunity. It is also possible that their attitude is related to the type of activity. These companies are operating in the medical device sector, so for an academic entrepreneur, the main objective is to develop a device that can cure patients or at least increase their quality of life. However, some extrinsic motivation in the form of peer recognition is also present. In this sense they seem to be close to the "hybrid" scientists by Lam (2011).

None of them in this category is a solo entrepreneur. One is cooperating with a surrogate entrepreneur, the other established the company with a colleague, while the third one decided to work with an already existing company located in the area. They are not involved in the everyday management of the firm. One of them even believes that it is natural that after a certain stage of development they lose control above the invention since it is the task of the industry to develop a market-ready product.

Their local laboratory network seems to play a more important role than their cosmopolitan network. University colleagues help them with feedbacks about the product in clinical tests and they are sometimes even co-authors suggesting that there is some prestige advantage on the university's side which in turn supports entrepreneurial engagement of its faculty.

There is a fourth researcher in this group who prefers business life over academia. He has international experiences though he has not seen successful academic entrepreneurs, but only successful scientists making business. He left the university to establish his own company, whereby his international business contacts helped him with advice and with a starting loan as well. He is strongly intrinsically motivated by the challenge and enjoyment of doing business on a scientific knowledge base, whereas extrinsic aspects do not seem to play a role. Even though he is not a university scientist, he cooperates with universities and also affiliates young PhD candidates. Thus in all four cases of "unbalanced" entrepreneurs the integration of university and business remains limited and there is a strong focus on one or the other activity.

We call the third group of academic spin-off founders as *impeded entrepreneurs*. Two of the three scientists in this category have international experiences enabling them to see successful academic entrepreneurs. They do not only understand the beneficial side of being an academic entrepreneur but are also highly motivated to become one of this type of scientists. Their motivation, skills and relationships would enable them to succeed, but some unfavourable conditions in the university or the business environment make it impossible. They are two highly acknowledged, internationally experienced researchers with breakthrough ideas, but in one case lack of financing while in the other availability of an IP blocks the development process.

The third case is a very interesting one that deserves a deeper analysis. This researcher has a good publication record though he does not have international experience. He has not seen any role models; nevertheless he had the motivation to become a successful academic entrepreneur. He established the company with a surrogate entrepreneur; consequently the management of the firm did not take too much of his time from research and teaching duties. This is also reflected by the acknowledgement received from his students. This scientist had a good working relationship with his colleagues, so there was no sign of any unintended side effects of the entrepreneurial activity. However, he permanently faced negative discrimination at the appointment procedures. The likeliest reason for this was his departmental head's disappointment about his unsuccessful company and jealousy about the success of this colleague. At the end this permanent latent tension led to the exit of the academic entrepreneur. The other two scientists in this group who remained at the university also feel stacked in the lower-middle level of the university hierarchy even though their scientific performance would enable a higher ranking.

This third example highlights an interesting situation. For this case we would assume that everything is provided to build a mutually beneficial relationship between industry and the academia at the most important hierarchical level regarding entrepreneurial activities, the university department (Renault 2006): the department head is an entrepreneur and the relationship with immediate colleagues is satisfactory. However, resulting from the destructive atmosphere, integration of the firm into the local laboratory network remains limited hindering the development of mutually beneficial relationships. This situation provides a negative role model for the colleagues and potentially destroys the seeds of an entrepreneurial culture.

The fourth group of academic entrepreneurs consists of three *externally motivated entrepreneurs*, who seem to be considerably different from the previous scientists. Two of them are at the beginning of their scientific career. They seem to be extrinsically motivated in the sense that one of them was explicitly asked by the TTO to carry out a specific research led to the novelty and to develop the invention in frame of a spin-off company. The co-founder was a colleague and later on an additional local industrial partner became also involved. The second researcher in this group is extrinsically motivated in the sense that he is responding to the expectations of the university by managing a 100 % university-owned company. This position does not seem to be the perfect ground for unfolding own research

ideas and reaping the acknowledgement for the development of a product from an own invention. The third researcher in this group established the company with his colleague in order to get access to research funds, since the scarcity of resources and their low stand in the university hierarchy do not make them very likely to win research grants. Thus in this case the company was a means for seeking for alternative resources to do research.

None of these externally motivated researchers have seen a successful academic entrepreneur before, though the one who has been abroad visited a state university but entrepreneurial activities were not typical there. It seems that their entrepreneurial intention is led by their university management. As young scientists they clearly tried to meet the requirements of their institution to enhance their own academic career. The local laboratory network plays here a very important role as colleagues at the university are also co-founders or co-workers even in the company. In some cases the borders between the two worlds seem to be demolished. However, due to rare international experiences, their cosmopolitan network does not seem to play any role, which also means that international embedding of their companies is very low, sometimes even non-existing. This can cause a hindrance in the firms' development limiting their growth potential and the related ability to create wealth. On the other side, it can happen that their current entrepreneurial involvement will help them establish business networks and develop entrepreneurial skills. If this experience is combined with an international fellowship later on it will enable them to become really successful entrepreneurs. The important lesson from this case is that the university should not put too much pressure on the researcher but provide sufficient help to come up with missing skills needed for entrepreneurial success through connecting scientists with business people. Otherwise an initial failure might result in a general disappointment and the negative example might keep back other scientists from the same department.

4 Summary

The ability of regions to develop high-technology industries and increase their competitiveness even at international scale seems to be a vital element of regions' wealth. Biotechnology is an industry employing highly skilled workers significantly contributing to the development of an area. In some regions it evolves naturally, but in others there are weaknesses in the regional innovation systems that inhibit this process. Hungary typically belongs to this second category having roots and traditions in biotechnology but lacking entrepreneurial culture and venture capital. Sometimes institutional routines also hinder the unfolding of the excellent knowledge base. Based on international experiences, academic spin-offs play a multiple role in the development of biotechnology clusters of this type of regions. The academic founder's human and social capital is likely to increase the survival rate and success of the firm. The willingness of an academic to engage in entrepreneurial

activities is a key momentum in the transfer of knowledge to the regional economy. To shed some additional lights on this issue we studied the motivations of Hungarian academic spin-off founders.

Based on interviews with Hungarian biotechnology spin-off founders we identified four categories of scientists according to their motivations and the outcome of their original intentions. The "classical" academic entrepreneurs have primarily intrinsic motivations; they find enjoyment in the development of their invention and the creation of a company. Their experiences and related cosmopolitan networks enable international embedding of the company and increase its competitiveness. Their role goes beyond this, since they might serve as role models for their colleagues helping so the integration of entrepreneurialism into the organizational culture of their parent institutions. Their successful companies and personal contributions carried out in frame of the Hungarian Biotechnology Association strengthen the position of the whole sector. This is a mutually beneficial relationship, since their success in the business world can support the realization of their extrinsic motivation that is their achievements in academia. The "classical" academic entrepreneurs identified here show many similar features to Lam's (2011) "entrepreneurial" scientists; however, profit motivation got a much smaller emphasis; usually it was an implicit success indicator. It might be that the still Mertonian institutional norms in Hungary are also responsible for this result.

"Unbalanced" academic entrepreneurs give an absolute priority to either academia or business but not both. While in case of the ones preferring academia the intrinsic motivations are the desire to develop their invention and do good for their patients, in case of the businessman interviewed, it is the challenge and enjoyment of creating a business. The primarily academic-oriented "unbalanced" scientists are also extrinsically motivated by peer recognition. They also needed the opportunity opened by the support schemes to enhance university–industry cooperation and spin-off establishment.

"Impeded" academic entrepreneurs are very similar to "classical" academic entrepreneurs. Perhaps they are even more intrinsically motivated in the sense that they follow their original aims even against unfavourable conditions, sometimes on the expense of external rewards. Unfortunately their full potential remains unexploited, or even worse, the discrimination they face might keep back other scientists from being involved in entrepreneurial activities.

The strong intrinsic motivation of the "classical" and "impeded" scientists is also shown by the fact that many of these companies were established long before entrepreneurial incentives started to be integrated into academic culture.

The "externally motivated" academic entrepreneurs seem to be similar to Lam's (2011) "traditional" scientists. They strongly identify themselves with scientific norms, but they also realize the need for taking part in entrepreneurial activities to make progress in academia. They work in an environment where entrepreneurial involvement seems to be a requirement, not an additional value added in the promotion process. However, this is sometimes a pressure, not an option, which results in a questionable synergistic output especially considering the usually

missing cosmopolitan network and the related potential of international embedding of the firm. To avoid overwhelming pressure exerted by the TTO it would be worth to analyse alternative funding models to the currently dominant project finance.

In summary we assume that the most valuable contribution to the sector's advancement is offered by the "classical" academic entrepreneurs. The advantage of "unbalanced" entrepreneurs is primarily realized through the practical utilization of inventions, whereas "impeded" academic entrepreneurs could create mutual benefits for both university and industry providing better circumstances. "Externally" motivated academic entrepreneurs realize the full potential only if the external impetus meets their internal need, which is not always the case. The age of the companies does not seem to play a role in the classification, since the different entrepreneurial groups include companies with diverse years of establishment.

One of the policy findings of this paper is that intrinsic motivations of scientists to participate in the entrepreneurial process underpinned by the support of universities and extrinsic motivations can significantly contribute to the development of biotechnology clusters, whereas pressure on scientists either to participate or not to participate can limit their contribution. Scientists focusing only on academia play a modest but stable role in the sense that integration of science and business is unfortunately limited, but they might bring useful inventions to the market.

To exploit the full potential of academic entrepreneurship international mobility programmes would be useful for young scientists to help them accumulate experiences abroad and build strong connections in centres of scientific excellence. These relationships could later serve the base of their cosmopolitan network after returning home. A complement of this initiative would be the creation of predictable academic career pathways as a further motivation for young scientists to come home and strengthen the Hungarian scientific base. This does not seem to be an unrealistic suggestion as empirical evidence suggests that the aim of young postdocs who leave their country temporary is the enhancement of their domestic career (Musselin 2004).

The results above reflect the situation at universities. An interesting future extension would be the analysis of the motivations, attitudes and outcomes among researchers employed at public research organizations like, e.g., the Hungarian Academy of Sciences. Further investigations are needed to identify the major obstacles that keep nonuniversity researchers with intrinsic motivations back from being involved in entrepreneurial activities.

Acknowledgements The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007–2013) under grant agreement n° 216813. We would like to express our special thanks to the useful comments and suggestions by Zoltán Bajmócy, János Barancsuk, Attila Buday-Sántha, Edward Bergman, Pablo D'Este, Javier Revilla-Diez, Harvey Goldstein, Simona Iammarino, Annamária Inzelt, Jan-Philipp Kramer, Francesco Lissoni, Gunther Maier, Gerd Schienstock, Sabine Sedlacek, Helen Lawton-Smith, Zoltán Szabó, László Szerb, Franz Tödtling, Michaela Trippl and Nick von Tunzelmann and also for the experts and consultants who offered their help by providing contacts to interviewees: Norbert Buzás, Kata Dobay, Arnold Fehér, Kinga Homolay, Zsolt Makra, Lenke Rónaszegi and Marcell Veidner and to all of the researchers who agreed to be interviewed. Comments and suggestions of the anonymous referee are gratefully acknowledged. Of course the usual disclaimers apply.

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