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Harvey Goldstein, Verena Peer, Sabine Sedlacek

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Harvey Goldstein*, Verena Peer**, and Sabine Sedlacek***

*Professor, MODUL University-Vienna: harvey.goldstein@modul.ac.at

** Senior Researcher, MODUL University-Vienna

*** Associate Professor, MODUL University-Vienna

Abstract

The generation of spin-off businesses from university scientific research projects is a potentially important way that universities can contribute to building regional knowledge-based economies. But while there is strong potential, the incidence of university spin-offs in most regions of Europe is disappointingly small, even in cases of the presence of highly ranked research universities. The literature on entrepreneurship generally indicates that the process of generating a successful, technology-based startup is complex and difficult, with different obstacles typically occurring at different phases of the start-up process. In order to understand better the reasons why the incidence of university spin-offs has been disappointingly low in the EU, we have conducted an empirical study of the perceived barriers for the region of Vienna, Austria. The results of the study for Vienna indicate that the most important barriers lie in the attitudes and experiences of individual faculty entrepreneurs, on the one hand, and the difficulty of securing funding and attracting investors from various sources, on the other. The results also show that there is general agreement in the perception of faculty entrepreneurs, university administrators, and experts about the entrepreneurship scene – about which barriers are most and least important. The empirical results suggest how the innovation ecosystem of Vienna can be strengthened to increase the incidence of university spin-offs. These suggestions include greater coordination and synergy among universities, private funding sources, and government policymakers. We also indicate fruitful directions for additional research.

Keywords: Spin-offs, universities, entrepreneurship, knowledge commercialization, technology transfer, innovation ecosystem, Vienna

1. Introduction

Research universities can contribute to economic development in multiple ways, including both human capital development (teaching) and basic research (Goldstein, Maier, Luger 1995). Indeed, the creation of human capital is often an underappreciated, but perhaps the most important, mechanism for HEIs to enhance regional economic development to the extent that graduates take jobs within their respective region (Goldstein and Renault, 2004). But since the Bayh-Dole Act of 1980 in the U.S., the emergence of the biotechnology industry and with it a U.S. Supreme Court decision that allowed the patenting of recombinant DNA, the *commercialization of knowledge* developed in universities took ‘center stage’ in many research universities in the U.S. This model of universities as loci for knowledge commercialization was soon replicated to the extent possible in Europe and parts of Asia (Liebeskind, 2001).

Knowledge commercialization activities come, however, in many flavors. They include joint university-industry research projects, the development and management of science parks and incubators, patenting and licensing, and the generation of academic spin-offs. Each offers potential benefits and risks. Universities often are engaged in a portfolio of knowledge commercialization activities whose mix largely depends upon local opportunities, the experience, expertise, and depth of university technology transfer professionals, and the set of laws, policies and regulations that govern the university.

The generation of university spin-offs is one of the strategic initiatives for universities to help create ‘knowledge regions’. Here, university spin-offs mean *the creation of new businesses whose scientific or technological bases grew out of university research projects* (in the next section of the paper we expand on our definition, noting the existence of a number of different definitions in the literature). Compared to patenting and licensing as the most commonly used mechanism of knowledge commercialization, the generation of university spin-offs have some distinct advantages from the perspective of regional economic development. Audretsch and Lehman (2005), for example, note that there is a very high likelihood the spin-off business will locate within the same economic region (at least for a while), while the licensing of technological innovations is often to existing businesses located outside the region. On the other hand, from the perspective of the university, patenting and licensing often ‘promises’ a higher return on investment; spin-offs pose relatively higher risk.

The European Union has recognized the generation of spin-offs as a key instrument for technology innovation and for the achievement of its Lisbon goal stated above (European Commission 1998, 2000), as has the OECD (2010). Yet, to-date, the incidence and subsequent growth of university spin-offs in Europe has been widely considered to be disappointing. There have been a variety of reasons offered, though there is no consensus.

In this chapter we examine the *barriers* to the generation of university spin-offs, using the region of Vienna, Austria as our case study. Specifically, we analyze which are the most salient obstacles from the point of view of different actors involved in the complex process of university spin-off generation. In section two we provide a brief review of the pertinent literature on university spin-off generation, including alternative definitions of university spin-offs, and the factors that have been considered important for understanding the variation in the incidence of university spin-off generation among universities and across regions. The third section of the chapter introduces the concept of the ‘innovation ecosystem’, a metaphor

borrowed from the biological sciences and which serves as a unifying framework for our empirical study. In the following section we describe the concepts, methods, and data used in this study. The fifth section is a description of some of the relevant institutions and conditions of the Vienna region affecting spin-off activity. In the sixth section we present our empirical findings of the case study, and in the last section we discuss some of the policy implications of our findings as well as provide suggestions for further research.

2. Literature Review

University spin-off definitions. Pirnay, Surlemont, and Nlemvo (2003) and Djokovic and Souitaris (2008) have conducted detailed literature reviews covering alternative definitions of university spin-offs. The definition is not a trivial matter since the measurement of the incidence of university spin-offs in any geographical area can vary considerably depending upon the definition adopted. Following Djokovic and Souitaris (2008), a valid and useful definition of a university spin-off needs to specify (i) the necessary outcome of the spinoff process, (ii) the actors that must be involved in the process, and (iii) what is it that is transferred during the process.

Just about all definitions agree that the outcome of a spin-off process is the formation of a firm (which did not previously exist). In practice it means that the new entity becomes officially and legally registered as a business. Note that this does not place conditions on the minimum length of time the firm stays in existence, its growth trajectory, or level of capitalization.

The involved parties include the parent organization; the technology originator(s) (who is mostly responsible for developing the technology from basic research to the stage at which technology transfer can occur); the entrepreneur who creates a new venture based upon the developed technology, and investors who provide funding for the new firm. It is clear that the *parent organization* is a university. There are good reasons, however, for including new firms that grew out of joint university-industry research projects, in which case there may be more than one 'parent', though a university must be one of the principals. The *technology originator* (or at least one of the principal ones if more than one) is an employee of the university, usually as a faculty member, but could be a non-faculty researcher or graduate student. The *entrepreneur* need *not* be the same as the technology originator, nor even an employee of the university. Who the *investors* in the new firm are does not matter; in principle they can be public or private, individual or institutional, local or foreign. The university itself could be an investor (or not), and other investors could be from private investment firms, banks, government organizations, or wealthy individuals (angels).

Cases of new firms that are created by a university graduate or a former university employee, *but the science or technology was not developed by the technology originator while that person was conducting research at the university*, should fall outside the definition of a university spin-off. Neither should we include cases of faculty members who decide to start a business while still employed at the university, but the basis of the business did not originate from their university research.

The elements transferred from the parent organization to the new firm might include the (1) core technology and (2) individuals who formerly worked at the parent organization that were involved in the development of the technology. Concerning the technology, DiGregorio and

Shane (2003) have stipulated that a spin-off is a new company founded to exploit some intellectual property developed within the academic institution. Similarly, Lockett et al. (2005) adopt the definition as “new ventures that are dependent upon licensing or assignment of the institution’s intellectual property for initiation,” (p. 1044). In our view, however, this is conceptually too narrow. It is often used, nevertheless, because it is consistent with, and allows the use of, the Association of University Technology Managers (AUTM) collection of spin-off data from member institutions in the U.S. We agree with Pirnay, Surlemont and Nlemvo (2003) that what is exploited by the new firm may be any knowledge, technology, or research results with commercial potential whether legally protected as intellectual property or not. Concerning the transfer of personnel from the university to the new firm, Smilor et al. (1990) posited that to qualify as a university spin-off, the firm founders must move their primary place of employment from the university to the new firm. A less restrictive condition is that the university employee must maintain an active role with the new firm. We agree with Nicoleau and Birley (2003) that neither the technology developer nor the entrepreneur need to be actively involved in the new firm, so long as the essential condition that the technology was developed at the university.

To summarize, what we believe the essential elements in a definition of a university spin-off are: (a) the technology as the basis for the new firm has had to have been developed at a university by a university researcher or team of researchers, referred to as technology developers; (b) the technology *may or may not* be in the form of intellectual property; and (c) the technology developer *may or may not* be the entrepreneur, and *may or may not* have a continuing relationship with the new firm. These criteria, we believe, are the most suitable to understanding and measuring the extent to which new knowledge generation in a university has led to new firm formation that otherwise would (probably) not have occurred.

Factors that condition the decision to create a university spin-off. The creation of a university spin-off is, above all, an *entrepreneurial act*. Entrepreneurship theorists concede, however, that the creation of a new firm is an incredibly complex and heterogeneous process. This has given rise to the multiplicity of theories regarding why, how, when, and what new firms get created, and by whom. Different theoretical frameworks focus on a particular aspect of the entrepreneurial act, a particular temporal stage of firm creation, a specific analytic level (micro-, meso-, or macro-), or a subset of the factors considered most important for new firm creation. The latter includes foci on the personal characteristics of academics who become entrepreneurs; on university policies, procedures, assets, other institutional characteristics of the parent organization; or on environmental factors and the knowledge infrastructure in the outside region or nation. To-date, there is no one theory that has emerged to be able to coherently address all the relevant interrogative issues above (Roberts, 1991; Rasmussen, 2011).

Many researchers have utilized new institutional theory when the chosen focus of study has been on university behavior in the creation of spin-offs (e.g., Etzkowitz, 1983). Here the emphasis has been on why and how university behavior has changed and adapted to emerging external pressures. For example in the context of the U.S., a number of studies have examined how university policies, investments, and norms were affected by the Bayh-Dole Act of 1980.

A somewhat related and common theoretical framework has been resource-dependency theories, sometimes referred to as the resource-based view (RBV) from the management science field (Wernerfelt, 1984, 1995). This has been used when the focus of action and

behavior is on the university – they search for new sources of funding when they perceive an actual or risk of loss of existing resources (e.g., O’Shea et al., 2005; Lockett and Wright, 2005). It has also been widely used to study how new start-ups act to gain the various resources needed to survive and grow to reach viability and sustainability in terms of attracting investors, management skills, markets, etc.

Evolutionary theory emphasizes the adaptive behavior of not only the university as an institution, but of individual actors, in the face of unpredictability in the external environment and availability of resources, path dependence, and serendipity (Nelson and Winter, 1982). Evolutionary theory is akin to the concept of innovation ecosystems discussed below. Renault (2006), in her review of the literature on academic entrepreneurship and using evolutionary theory, identified three sets, or layers, of influences on the decision to create a spinoff: (i) attributes and attitudes of the entrepreneur; (ii) institutional characteristics and policies of the parent organization, in our case the university and its constituent academic units, and (iii) the resources, opportunities, and cultural attitudes in the external environment, particularly the region in which the university is located.

In a well-known study to answer the question, “why do some universities generate more start-ups than others?”, DiGregario and Shane (2003) hypothesized four macro-level explanations for variation in the incidence of university start-up activity within the context of a sample of leading research universities in the U.S.: (i) the degree of ‘richness’ of venture capital in the region in which the university is located; (ii) the amount of industry-funded research within the university (more industry-funded research, more spin-offs); (iii) the intellectual status and prestige of the university (the higher the status, the more spin-offs), and (iv) adoption of university policies that provide incentives for faculty entrepreneurial activity. Their principal empirical results showed that the significant factors for increasing university spin-offs were the intellectual status of the university and university policies of making equity investments in spin-offs and maintaining a low inventor share of royalties. Most notably, *the only regional environmental factor in their study* – the proximity of sources of venture capital within the region -- was not a significant factor.

Using a quite different methodological approach, we test whether the factors identified by DiGregario and Shane hold for Vienna, as well as whether perceptions of the most important barriers vary across types of actors involved in the spin-off generation process.

3. The ‘Innovation Ecosystem’ as a Conceptual Framework

We view the creation of university spin-offs as a specific type of entrepreneurship. Our reading of the extant empirical literature indicates that the process is more complex and varied than any of the specific theories discussed in the previous section can account for. Rather, we view the metaphor of *innovative ecosystems* as a superior conceptual frame for understanding both the process of the creation of university spin-offs, for helping to explain regional variation in the incidence and rates of spin-offs, and for guiding policies to make the region more conducive to innovation generally and spin-off generation specifically.

Borrowed from biology, an innovation ecosystem has been defined as “dynamic, purposive communities with complex, interlocking relationships built on collaboration, trust, and co-creation of value and specializing in exploitation of a shared set of complementary technologies or competencies” (Gobble 2014). *Strong* innovation ecosystems, according to

Autio and Thomas (2014), are able to more effectively translate knowledge into increased value. At the same time, they show greater robustness and resistance to disruption than weaker innovative ecosystems. Building on the metaphor, the actors (organisms), in the innovation ecosystem include companies, higher education institutions, entrepreneurs, customers, regulatory and other government agencies, and intermediary organizations. Each of these types of actors is dependent upon the actions and well-being of the other types of actors within the system. The ecosystem changes over time by adaptive behavior in response to both external stimuli and events, and to endogenous behavioral change of particular internal actors. The complexity and highly non-linearity of such ecosystems, often lead to highly unpredictable outcomes and trajectories. This non-linear quality differentiates the concept of innovation ecosystems from the concept of networks, for example.

The concept of an innovation ecosystem developed out of the more general concept of a 'business ecosystem', defined by Moore (1996) as "an economic community supported by a foundation of interacting organizations and individuals – the 'organisms' of the business world." Here individual companies occupy particular niches, just as species do. The innovation ecosystem concept has been applied by Iansiti and Levien (2004), Kantor (2012), and Hwang and Horowitz (2012) and others to specifically understanding and assessing the conditions most favorable to business innovation. It has also spawned at least one enterprise for the measurement and ranking of regions in terms of how conducive they are for the generation and nurturing of high incidences of startup activity, for example, The Global Startup Ecosystem Ranking 2015 (Compass Co. 2015).

In our case of university spin-offs, a region's innovation ecosystem supplies (or not) many of the factors (assets) that stimulate interest and motivation for creating start-ups and then help to support and nurture start-ups so that they grow and become successful. The factors include a deep supply of scientific and entrepreneurial talent, access to funding sources at various stages of the start-up life-cycle, the market reach of the region, the degree of experience and tradition of generating tech-based start-ups, supportive public policies, cost-of-living and cost of workspaces, and positive cultural attitudes towards risk and innovation. Many of the individual factors are interactive with the others, so that improvement in one will often lead to improvement in others, or the obverse in situations of decline. In that sense together they work as a complex system. More fully developed and stronger regional innovation ecosystems *should* lead to higher incidences of start-up activity.

The potential scientific (and sometimes entrepreneurial) talent comes from the faculty and research staff of the university, while the potential funding sources include the university (especially at the very early stages) as well as outside public and private sources. The degree of experience and tradition includes the existence of faculty/entrepreneur role-models within the respective departments or institutes and the university overall, in addition to having this tradition within the region as a whole, and the supporting public policies include rules and incentives for faculty entrepreneurship of the university and its governing bodies, in addition to those of the local and national governments.

Within the conceptual framework of innovation ecosystems, our study aims (1) to identify which specific factors that comprise a healthy start-up ecosystem are considered to be either weak or missing in the case of Vienna, and (2) to inquire if the different types of actors that have key roles in supplying or utilizing these factors for the creation of university spin-offs have different perceptions of the strengths and the weaknesses, of Vienna's innovation

ecosystem. We operationalize the relative strengths and weaknesses in terms of the existence of barriers to university spin-off generation.

4. The Empirical Approach

In a well-known study to answer the question, “why do some universities generate more start-ups than others?”, DiGregario and Shane (2003) hypothesized four macro-level explanations for variation in the incidence of university start-up activity within the context of a sample of leading research universities in the U.S.: (i) the degree of ‘richness’ of venture capital in the region in which the university is located; (ii) the amount of industry-funded research within the university (more industry-funded research, more spin-offs); (iii) the intellectual status and prestige of the university (the higher the status, the more spin-offs), and (iv) adoption of university policies that provide incentives for faculty entrepreneurial activity. Their principal empirical results showed that the significant factors for increasing university spin-offs were the intellectual status of the university and university policies of making equity investments in spin-offs and maintaining a low inventor share of royalties. Most notably, *the only regional environmental factor in their study* – the proximity of sources of venture capital within the region -- was not a significant factor. Using a quite different methodological approach, we test whether the factors identified by DiGregario and Shane hold for Vienna, as well as whether perceptions of the most important barriers vary across types of actors involved in the spin-off generation process.

Both qualitative and quantitative data collection and analysis techniques have been used for the Vienna case study. In this chapter we focus on the presentation of the quantitative analysis of data generated from a closed-end questionnaire, although our interpretation of the results are also informed by the results of the information gained from our interviews of key actors.

The use of a single case study design has both advantages and disadvantages. The disadvantages are that we do not have variation on regional factors and a reduced amount of variation on institutional conditions since all universities in Austria are under the same regulations and laws from the federal ministries and parliament (though there is now greater university autonomy compared to ten years ago). The principal advantage is that we are able to generate primary data directly from actors involved in the spin-off generation process that would not be feasible for a multi-regional, large sample study.

Data were collected from individual actors using structured questionnaires and face-to-face interviews. Individuals were chosen for interviews and/or to receive the questionnaires from among five groups of actors: (1) faculty entrepreneurs, (2) university administration officials (vice rectors for research and TTO directors), (3) policy officials of funding and entrepreneurship support organizations, (4) federal and city government officials, and (5) ‘experts’ on academic entrepreneurship, and/or the Vienna regional economy. In the case of faculty entrepreneurs, the particular individuals were selected so as to obtain a cross-section across the two principal technology areas of the life sciences and ICT, and also across the five main research universities in the Vienna region.

The questionnaire consisted of a list of potential barriers, or obstacles to the generation of university spin-offs and respondents were asked to indicate their relative importance based upon their knowledge and experience. Response categories in the questionnaire were on a

five-point Likert-scale ranging from ‘very important’ to ‘not important at all’. The responses to the questionnaire were analyzed quantitatively to identify the most important obstacles (based upon the mean response) as well as to examine variation in perception of obstacles among types of actors.

The potential barriers. The empirical literature posits a number of *potential* barriers to the generation of university spin-offs. Here we align a set of potential barriers with those suggested by the ecological framework of individual, institutional, and regional environmental factors influencing spin-off creation described above.

Barriers related to individual attributes (of the faculty entrepreneur) are likely to be most important early in the process of spin-off generation, when the faculty researcher realizes his/her research has led to an idea for an invention that has commercialization potential. First, the faculty researcher may have no or little *awareness* of commercialization potential of the research; even if there is such awareness, there may be no or little *interest* in pursuing commercialization opportunities. Lack of interest seems to be more likely than lack of awareness, and there are a variety of reasons for a lack of interest, including: a personal commitment to pursuing basic science; a perception that prestige and status within his/her discipline are more likely achieved through a focus on basic science than in pursuing commercialization opportunities; and a low tolerance for financial risk or avoidance of the stigma of failure in their professional careers. Even when there may be an interest or curiosity about pursuing a commercialization opportunity, the faculty researcher may feel he/she lacks the business and entrepreneurial know-how; or perceives that gaining the necessary support and assistance from the university (department) and other potential resource providers in the external environment would be too difficult to obtain.

If there is sufficient interest on the part of the faculty researcher, then a number of institutional factors within the university as well as the lack of availability or cost of acquiring, particular resources from the external environment play more important roles as potential obstacles to the creation of university spin-offs. Institutional barriers can include a lack of support and knowledge about the process of creating a spin-off company including entrepreneurship training, applying for patents or other forms of intellectual property protection; a lack of physical space and/or equipment for the housing of a fledgling spin-off within university facilities; university policies that restrict the use of facilities, equipment, or staff for private business use, to avoid or manage conflict-of-interest risks; the lack of university incentives or rewards for commercialization activities; the lack of seed funding from the university to support the next stages of development of the idea or product; and a culture in the department or university at-large that is ‘hostile’ to commercialization activity. Again, some of these institutional factors can be viewed in the dialectical variant of process theory as posing a conflict between the individual motivations and aspirations of the faculty entrepreneur and the norms and rules of the university. Others can be seen as an imposition of resource constraints that requires the faculty entrepreneur to take the initiative of seeking other sources of funding and support outside the university, highlighted in the teleological variant of process theory.

The regional environment in which the university is located serves as an important source of particular resources that the university often is unable to provide. These may include investors, specialized business or legal services and know-how, a recruitment base for additional members of the ‘team’, role models, potential partners, potential markets, a culture of risk-taking, and networks and a set of intermediary organizations that help individual

entrepreneurs connect with potential resource providers. An inadequate level or absence of any of these may constitute a barrier to spin-off generation despite favorable individual attributes and institutional factors. Local, regional, and national government policies and programs can serve as providers of these resources when the private market is not effective or sufficient, but there is wide variation among cities and regions in the provision and effectiveness of such policies and programs.

Finally, global and/or nationally-specific macroeconomic conditions, such as interest rates on borrowing, demand and consumer spending, and corporate attitudes towards risk may constitute obstacles to university spin-off generation. National laws, policies, and regulations, such as what can and cannot be done within public universities, as well as supra-national regulations concerning requirements for safety testing, including clinical trials, are also potential obstacles to university spin-offs.

5. The Knowledge Assets and Institutional Conditions of Vienna

The City of Vienna, in its position as Austria's capital, has a population of about 1.7 million as highlighted in Table 1. From 2001 to 2010 its population grew 10.6 percent and its GDP per capita of 42,600 Euro is well above Austria's and comparable to or higher than a number of other major European cities (Eurostat 2009: Munich 45,785 Euro; Stockholm 45,200 Euro; Berlin: 26,500 Euro). The entire metropolitan region of Vienna comprises 2.3 million inhabitants and has a somewhat lower GDP per capita of 39,552 (see Table 1).

Table 1: Some Basic Data for Vienna

	Population (millions)	Population growth	GDP (EUR) per capita	Area (km ²)
City of Vienna	1.7	+10.6%	42,600	415
Vienna region	2.3	+8.6%	39,552	8,415
Austria	8.5	+4.0%	32,900	83,879

Source: Statistics Austria 2012, Stadt Wien 2012, Eurostat 2009

Vienna is clearly Austria's research hub in which 38 percent of the Austrian scientific personnel are employed and 38% of Austria's R&D expenditures are invested (Stadt Wien, 2011). The shares of expenditures in different research categories show that experimental research (44 percent) and applied research (36 percent) are funded at a higher level than basic

research (20 percent). But within the higher education (HEI) sector¹, basic research is still the most important (48 percent of total R&D expenditures) with 44 percent for applied research, 8 percent devoted to experimental research). The HEI sector, however, employs only 35 percent of total R&D employment in Vienna, with private industry employing 56 percent. A large portion of the funding for R&D – 40 percent -- is sourced in the public sector and the majority of publicly funded R&D (72 percent) is awarded to the HEI sector. Private industry is the second largest source for funding R&D expenditures (36 percent), and then followed by foreign investment (21 percent).

Vienna hosts nine of the 22 Austrian public universities. Six of these universities are research universities, i.e., they award doctorate degrees, and together had 777 million Euro in research expenditures in 2007 (Stadt Wien, 2011). This equates to 30 percent of the total R&D expenditures in Vienna. The areas of R&D spending by universities in Vienna are distributed among 30 percent natural sciences, 26 percent medical/life sciences, 14 percent engineering and technology, 13 percent social sciences, 9 percent humanities, and 8 percent agriculture, forestry, and veterinary medicine (Stadt Wien, 2011).

Research foci and specializations in Vienna

Life sciences. Vienna has a long tradition in excellent scientific and medical research. This provides a strong base for specializing in biotechnology as is the case today. Currently more than 400 life science companies with revenue of about 1,718 million Euro are located in Vienna. These companies employ together more than 9,000 persons (LISA Vienna, 2011). The research cluster is shaped by 22 research institutions, including the five research universities that have a specialization in the life sciences, two applied universities, and fifteen other research institutions. The sector is distinguished by several ‘hot spots’ where R&D in the life sciences are concentrated, such as LIFE Science Vienna Muthgasse, the Medical University of Vienna campus, the University of Veterinary Medicine campus, and the Campus Vienna Biocenter (LISA Vienna, 2011). The total life science budget was estimated in 2010 to be about 700 million Euro. Third party funds in life science research have been reported to be about 200 million Euro (LISA Vienna, 2011, p. 16). The organizations with the largest research expenditures are universities followed by non-profit research institutions.

Information and communication technologies (ICT). The ICT research sector in Vienna is comprised of three universities (University of Vienna, TU Vienna, Medical University Vienna), two applied universities, six research institutions, and a large number of private companies. Austria has developed its own ICT research strategy (Rundfunk- und Telekom Regulierungs-GmbH (2008) since the ICT sector has performed extremely well starting around 2005. Vienna is the largest ICT hub in Austria with an economic performance of 20 billion Euro (i.e. 15 percent of the regional GDP) and where 65,000 people are employed in this sector (ZIT, 2010). The ZIT (2010) reported that 40 percent of the ICT companies in Vienna are involved in research. The development of the ICT strategy has identified a huge innovation potential in seven areas of ICT development. In terms of its innovation performance Austria as a whole is ranked as an innovation follower in the European

¹ The HEI sector in Vienna covers public universities, medical clinics, universities of arts, academy of science, applied universities, private universities, and pedagogical colleges.

Innovation Scoreboard (EC, 2013a). The Vienna region, however, is classified as an innovation leader within Austria in the Regional Innovation Scoreboard 2012 (EC, 2013b).

6. Empirical Results: Identification of the Perceived Barriers to the Generation of University Spin-offs

We provide a summary of key insights gained from the interviews grouped by type of actor before reporting on the analysis of the questionnaire responses.

Technology transfer office directors (TTOs)

From the perspective of the TTOs, the main barriers at the level of individual researchers are seen in their risk-avoidance and need for security: the foundation of a spin-off often requires long-term financing as well as giving up, or at least, reducing, the time devoted to an academic career. Most of the scientists are described by the TTO officials as focused on their profession with no or little entrepreneurial know-how. Barriers related to individual attributes of the scientists are emphasized with regard to the different universities: due to their education and career models, researchers at the Medical University are between the ages of 40 and 50 when it comes to founding a spin-off. They look back on a successful academic career and have also personal restrictions which hinder them to go for the riskier option of founding a company. By comparison, the situation at the TU Vienna is different. There the scientists have the option to found a business on the Ph.D. or Post-Doc level between the ages of 25 and 30, and tend to be less risk averse, more open, and more flexible.

There is general agreement among the TTO officials that the universities are not interested in actively supporting the foundation of spin-offs. Reasons for this are seen in the perceived lack of added value for the university (no financial value creation, no marketing effects) as well as the fact that commercialization is not seen as a principal part of the mission of the university. The institution's main interests lie within the realm of if and how the professor or post-doc involved in the spin-off continues with the research and the teaching for the University and if the know-how generated within the spin-off company is also used for teaching PhDs and Post Docs. Some TTOs mention, as a further institutional barrier, the posing of conflicts of interest to describe the lack of a 'clean' separation by researchers/entrepreneurs between their work at the university and in the company. This can lead, for example, to a misuse of university infrastructure and facilities, such as lab space.

Vice-Rectors for Research

The vice-rectors of the five main research universities identified several obstacles and problems that became evident after universities gained autonomy in Austria effective in 2004. One of the most important impacts of universities gaining autonomy was in the budgetary process. The Ministry of Science now allocates a global (total) budget for each university universities (see Table 1 in section 3.3) on the basis of negotiated performance agreements. On average, almost two-thirds of the global budget of universities is used for personnel costs in order to fulfill teaching and basic research goals. The remaining one-third is available for funding activities to meet all other goals, including technology development. This has been identified as a major obstacle by the vice rectors for research. The result has been underfunding of TTOs, general support of IP activities, as well as a lack of financial resources to support the generation and nurturing of spin-offs in their seed and early stages. For

example, most vice rectors have cited the inability of their universities to offer faculty space and facilities for new spin-off businesses.

Besides these pure pecuniary limitations the vice-rectors cited organizational barriers which occur because of two co-existing systems of employee contracts, the 'old' public contracts ('Beamtenverträge' and the 'new' private contracts ('ASVG')). This has led to a 'generation gap' due to the fact that staff members in the two different systems have different career horizons, different salaries, and different obligations that partly affect the individuals' attitudes towards entrepreneurial activities. The paucity of role models as well as the absence of entrepreneurial skills of the faculty hinder the generation of spin-off businesses.

With regard to the regional environment, vice-rectors agree with other actors that there is an inadequate amount of public funding for the foundation of spin-offs. Furthermore, Vienna is characterized as having 'structural weaknesses' for technology-based entrepreneurship and innovation generally, indicated by a lack of critical mass in R&D, a lack of culture for risk taking, and a lack of implementation ("defensive strategies" only on the paper).

Faculty entrepreneurs

The most important barrier perceived by faculty entrepreneurs related to individual attributes is the lack of entrepreneurial skills. For most of the interviewed faculty entrepreneurs it was not until an *entrepreneurially skilled* person was involved, that the foundation of the spin-off was realized. The intention towards founding differs significantly across the faculty entrepreneurs and ranges from "always considered" to "a rather spontaneous decision". For several entrepreneurs role models were missing at the institute or department. The loss of prestige, in the sense of a lack of collegial appreciation of entrepreneurial activities, is mentioned as an initial barrier. Those who have not yet founded a company mention as an inhibitor the fear of being overruled by some investor as well as not having an entrepreneurial role model at the university. Also mentioned are the very different 'mind-sets' of being a researcher and being a founder of a company.

Concerning the institutional obstacles, the one unanimously mentioned is lack of training and education in entrepreneurship in the Austrian higher education sector. The support from the university is described as low and the institution's mindset as focused on "pure, basic and ground-breaking research" with no acknowledgement for the importance of research conducted for, and with, industry. In addition to this, the strict university policies make the foundation process of spin-offs even more challenging. Other institutional barriers are seen in the organization and structure of the TTOs; they are described as "underfunded, small and not that experienced". Those who have not yet founded a company see the main barrier in the lack of support by the department as well as the university. One of the main obstacles within the regional environment is the lack of affordable space for the location of the company, which is drawn back on the private ownership of those facilities. Also incubators that provide laboratories, manufacturing facilities etc. as well as qualified labor forces are lacking in the Vienna region. Additionally, difficulties in finding venture money are observed: the venture capital scene is not developed as well as in other cities (e.g. Munich). The general attitude in Austria towards innovative developments is perceived as rather restrictive, an outcome of a culture related to risk avoidance and demand for security. These observations are also applicable to the financial support programs, considered by faculty entrepreneurs as too risk averse. For those who have not yet founded a company, the lack of support from national or Viennese funding organizations is one of the main obstacles.

External experts

Knowledgeable experts and officials in funding, policy and intermediary organizations whom we interviewed tend to have a broader and more ‘holistic’ view of the obstacles and barriers to spin-off generation compared to university officials and faculty entrepreneurs. From the point of view of some experts, Austria has not a long tradition of university spin-off activities due to the fact that it was not until 2002 that federal law gave universities considerable autonomy. Most experts interviewed acknowledge that there has been movement within the last 15 years or so favoring a more entrepreneurial environment in Vienna and Austria as a whole. Yet the entrepreneurial environment not only in Austria but in almost all of Europe is still considered by many experts to be much lower when compared to the U.S. In general, researchers seem to be more risk averse in Europe within societies having a low tolerance for failure. Interest by academics in acquiring business and entrepreneurial skills has been increasing, however, and there is now greater opportunity for faculty and graduate students in several of the universities to take short courses to acquire business and entrepreneurial skills.

It is generally understood that scholarly publications and then patenting are assessed as more valuable, or worthy, activities by university researchers compared to generating spin-offs. Publications, however, by far matter the most in terms of reward and prestige in almost all disciplines. Within the domain of commercialization of research, patents have gained in value for advancing scientific careers but the creation of spin-offs is still seen as having little value within research communities. Another point that has been mentioned is that academic CVs are evaluated differently in Europe compared to the U.S. In the latter, professors have greater freedom and mobility to move back and forth between the university and industry without harming their careers. That mobility has helped to embed an entrepreneurial attitude within departments in universities in terms of the types of questions investigated and the rewards given for different forms of research output. In Europe, including Austria, faculty careers would be harmed by spending periods working in industry since their work is evaluated almost entirely by publications in highly ranked scholarly journals.

Experts have also identified that expectations of academics in terms of commercialization are often unrealistic. They tend to underestimate the time, costs, and skills required for their businesses to become successful. Scientists who want to become entrepreneurs need sufficient knowledge about the potential market (‘researching the market’).

In terms of financial issues, there is a consensus among our expert respondents that Austria suffers from a lack of private venture capital. This has been identified as a European-wide phenomenon which has improved somewhat over the last ten years or so, but is still a major problem. There is general agreement that ample opportunities exist for spin-offs to receive public pre-seed and seed funds, but experts agree that private equity is needed for late-stage funding, often covering a horizon of ten years. The dearth of private equity investors has been identified as one of the most important obstacles.

Another factor that prevents a higher incidence of university spin-offs is the lack of inter-university cooperation. Universities in Austria are basically separate entities with specific experience and expertise, but often lack certain know-how necessary for successful commercialization. Pooling and sharing know-how and expertise across universities may be a way to provide more support for faculty entrepreneurs in an environment of scarce resources for higher education institutions.

The most and least important perceived barriers: questionnaire results

The questionnaire asks about the perceived relative importance of various hypothetical barriers to the generation of university spin-offs. The total number of respondents was 30, of whom twelve were faculty entrepreneurs, nine were university administrators (Vice-Rectors for Research and TTO directors) and nine were external experts on university entrepreneurship in the Vienna region. The results are shown in Table 1 (more complete descriptive statistics are provided in Appendix B). The two types of barriers that stand-out as most important are: (1) individual faculty researcher attitudes, experience, and know-how regarding entrepreneurship and commercialization, and (2) the difficulty of obtaining funding and investment in various stages of the innovation and business development process.

On the level of the individual attributes, the first and foremost barrier is the lack of business and entrepreneurial skills of the researchers and their low tolerance for risk. This is followed, however, with not having an orientation to commercialization opportunities, stemming either from a lack of interest – they would rather engage in basic science – a lack of rewards and incentives, and/or a lack of awareness of there even being commercialization potential to their research.

Among institutional (university) factors, the lack of opportunities provided by their universities for ‘would-be’ faculty entrepreneurs to receive training in ‘how to start a business’ is the highest ranked. It is consistent with the highest ranked barrier mentioned above. The other two highly ranked factors concerning university barrier are the lack of rewards or incentives from universities for faculty researchers to engage in commercialization activities, and the lack of seed capital provided by their universities for individual faculty to push their research closer to the stage where commercialization can be pursued. Both of these are also consistent with the individual attitudes faculty researchers have as disincentives to engage in commercialization.

The most prominent inhibiting factor lying with the regional economic fabric of Vienna is the paucity of private funding sources and investors inside the Vienna region. Angel investors and venture capitalists do not have a strong presence in Vienna, not unlike much of the rest of Europe outside of the UK. The situation has been improving in terms of Vienna entrepreneurs being on the ‘radar screen’ of private investors located outside Vienna, but the small presence and interest of private investors within Vienna, given its strong scientific base, is perceived as a hindrance across all groups of actors. Although not considered as important, the lack of entrepreneurial role models and mentors, and the general culture of risk avoidance in Vienna as a cultural milieu are considered additional barriers.

For the most part, national government policies, programs, and laws/regulations do not constitute major barriers. Neither do those of the European Union/European Commission.

When we examine the mean values placed on importance of potential barriers by different types of actors, there is very little cognitive dissonance. That is, the perceptions of what factors are important as barriers to university spin-off generation and which are not as barriers are remarkably similar for faculty entrepreneurs, university administrators, and outside experts alike. There is only one factor – insufficient reward from universities to faculty researchers for commercialization activity – for which there are statistically significant differences in perceived importance across type of actors. As we would perhaps intuitively expect, university administrators and TTO officials do not perceive this to be as an important barrier as either individual faculty entrepreneurs or external experts.

Only regarding the factor of lack of sufficient rewarding by their universities for work that leads to commercialization is there a difference between the means of responses among the different actors (significant at 5%, $F = 4.13$, $Pr = 0.027$). While the university officials do not perceive this factor as relatively important in inhibiting the generation of spin-offs (mean = 2.7, the set of faculty entrepreneurs (mean = 3.8) and the external experts (mean = 4.2) do perceive it to be important.

In addition to the ANOVA tests, we also performed Spearman rank-order correlation tests to identify if there were overall differences in ranking of importance among the three main groups of actors. The correlations in the rankings between each pair of groups of actors (faculty entrepreneurs and university administrators, faculty entrepreneurs and experts, university administrators and experts) were all positive and significant at 1%, with all rho values above 0.60 of successful entrepreneurs. Also on the national and EU level the various actors identify the same factors inhibiting university spin-off generation: the lack of seed capital from the national government and programs as well as the lack of early or late stage funding from federal government programs for start-ups.

Table 2: Rank order of perceived importance of barriers to spin-off generation

<u>Rank</u>	<u>Barrier</u>	<u>Type*</u>	<u>Mean</u>
1	Lack of business or entrepreneurial skills	I	4.15
2	Lack of angel investors in the Vienna region	R	3.82
3	Lack of potential early-stage investors in the Vienna region	R	3.78
3	Lack of business training opportunities for faculty researchers	U	3.78
5	Low awareness of commercialization potential of research	I	3.75
6	Universities do not provide sufficient seed-capital	U	3.72
7	Little reward for research that leads to commercialization	U	3.65
8	Prestige within discipline does not come from commercialization	I	3.62
9	Interest in basic science outweighs interest in commercialization	I	3.57
10	Early- and late-stage funding from national government is lacking	N	3.55
11	Lack of mentors and entrepreneurial role models in Vienna region	R	3.50
12	Low tolerance for risk in one's professional career	I	3.41
13	Lack of suitable facilities for new spin-off businesses	U	3.36
14	Inadequate national government programs to supply seed capital	N	3.26
15	Lack of private late-stage investors in Vienna region	R	3.24
16	Weak culture of entrepreneurship in Vienna region	R	3.16
17	University policies restrict spin-offs from using university infrastructure	U	3.07
18	Lack of research conducted that has commercialization potential	I	3.04
19	Insufficient help to identify commercialization potential of research	U	3.03
20	Inadequate networks/orgs for support of tech-based start-ups in Vienna	R	2.93
21	Low amount of industry R&D activity in Vienna region	R	2.88
22	Generation of university spin-offs not encouraged by local government	R	2.81

23	EU policies/programs provide insufficient support for spin-off generation	N	2.58
23	National government does not provide sufficient autonomy to universities	N	2.58
25	Universities do not provide faculty with external contacts for support/advice	U	2.35
26	Conflict-of-interest laws make it too expensive to use university infrastructure	N	2.22
27	Universities do not provide adequate support for submitting patent applications	U	2.03
28	Austria does not have adequate intellectual property protection	N	1.55

N= 30

**I indicates an individual faculty researcher attribute; U indicates a university factor; R represents a regional factor; N is a national or supranational policy factor*

The paucity of ‘angel investors’ and other sources of venture capital in the Vienna region is seen by all of the groups of actors as a major barrier to generating a higher number of spin-offs. At the same time they share the perception that the Austrians intellectual property protection as well as national laws and conflict of interests regarding the utilization of university infrastructure are no major barriers. All of the types of actors agreed on the lack of business and entrepreneurial skills of the researcher as one of the main factors in preventing a greater incidence of university spin-offs in the Vienna region.

7. Conclusions and Suggestions for Policy and Further Research

The innovation ecosystem theoretical frame posits that there are certain environments more conducive to the generation of technology-based spinoffs than others. Strong ecosystems are built on synergistic relationships among a wide variety of actors and institutions. Strong innovation ecosystems should lead to more vital, dynamic, robust and resilient regional economies. By and large, the empirical literature on entrepreneurship generally and university spin-offs specifically are consistent with this theory. Vienna is a case where university spin-offs (and entrepreneurship more generally) have lagged. Our study has sought to identify the weaknesses within the innovation ecosystem of Vienna by asking key actors about their perception of what are the barriers to the creation of university spin-offs. At the same time we have sought to identify if the perceptions vary among different types of actors.

Our empirical results for the case of Vienna confirm that there is a variety of factors that inhibit the formation of university spin-offs, and that university spin-offs face an even more daunting set of barriers than technology-based start-ups in general. Specifically, the set of institutional (universities) norms and practices are often not compatible with the ambitions of faculty entrepreneurs and hence represent an additional layer of obstacles to be overcome by faculty entrepreneurs at early stages of their efforts.

Overall, our study indicates that the perceived barriers to the generation of university spin-offs are not concentrated *solely* or even *primarily* in the individual attributes of faculty entrepreneurs, the institutional environment of their universities, or the wider regional and national environments. Indeed, the six most important factors (specified as obstacles) cited by our respondents revolve around (i) lack of business and entrepreneurial skills and training opportunities, (ii) lack of seed funding from universities and difficulty of attracting private investors from the region at later stages, and (iii) lack of awareness by university researchers

of commercialization potential of their research. Conversely, federal government regulations and laws, insufficient university autonomy, restrictive university policies, or inadequate intellectual property protection, are *not* considered important obstacles to the generation of university spin-offs. Within universities, it is the lack of a supportive culture for spin-off generation and faculty entrepreneurship more broadly that hold sway, rather than any formal institutional barriers, with the exception of the short-term effect of having a dual system of employee contracts as a legacy of the universities being granted autonomy. To state this slightly differently, we can say that universities are *not* antipathetic to spin-offs, but neither are they giving priority or active support to the generation of spin-offs in the form of incentives or rewards.

There is a high degree of consensus among the types of actors about which factors are most and least important. Only on one factor – the lack of rewards and incentives from universities as an inhibiting factor -- is there a significant disagreement between university administrators, on the one hand, and faculty entrepreneurs and external experts on the other.

DiGregario and Shane (2003) found that of their four hypothesized macro-level factors for explaining variation in the number of university spin-offs among universities, the status and prestige of the university and university policies regarding academic entrepreneurship were significant while the degree of availability of venture capital in the region and the degree to which university had a more commercial orientation to university research were not significant. Within our single case study of Vienna we have no variation in the availability of venture capital in the region, and only limited variation in university policies. That we found, however, general agreement among the variety of actors that there is a paucity of private angel investors and venture capitalists in the Vienna region and that these were important barriers calls into question the generality of DiGregario and Shane's results.

Our empirical results suggest that the Vienna innovation ecosystem has both strengths and weaknesses. The areas of strength include the amount and degree of scientific talent, and market reach. There are, however, several notable weaknesses. The first of these is an inadequate level of *coordination* and *synergy* among many of the key actors, namely the universities, actual and potential private funding sources, and government policymakers and funding sources. If, to use a biological analogy, compared to the social organization of an ant colony that represents the ideal, then Vienna ranks rather low in this aspect of its ecosystem. A second notable deficit is a relatively small number of successful entrepreneurs and other employees with startup experience and personal equity. This has indirectly led to a paucity of role models for would-be academic entrepreneurs and to Vienna not being located on the mental maps of many investors and entrepreneurs as a place to start new companies.

Our research results suggest a range of possible actions and changes that, if implemented, could and should increase the incidence of university spin-offs. They would include, for example, instituting entrepreneurship training for graduate students as part of their study programs, and making it easier for faculty and industry researchers to swap jobs for, say, one or two year periods. These actions would focus on changing the prevailing culture within universities and within the society, but cultures change slowly, and it would likely take a number of years before being able to observe effects of such actions.

Of course, there are insufficient resources to enact everything that could increase spin-off generation. There are tradeoffs between being able to better meet educational needs – teaching – and the support of commercialization. There are also tradeoffs of investing resources for a strategy aimed at increasing academic entrepreneurship and other strategies to

create economically sustainable economies. How these tradeoffs should be considered is beyond the scope of this paper.

Further research

To more rigorously test the effect of the various factors on the incidence of spin-off generation as well as to increase the external validity of the results reported here for Vienna, replication of the study to other European regions should be performed. Other regions would be selected in order to have variation in our hypothesized conditions that make it easier, or harder, for university spin-offs to be generated. These would include: the regional economic and industrial structure; the regional cultural milieu with regard to entrepreneurship and risk-taking; university incentives and rewards towards entrepreneurship, the status and prestige of the university, and regional/national policies and programs to support university spin-off generation. A modest expansion of the number of regions would allow the use of a comparative case study design, while a more ambitious increase in the number of cases might allow the use of a hierarchical (multi-level) modelling framework by pooling the data from the questionnaires across regions. In replication it would, of course, be important to use the same definition of university spin-off and the same questionnaire/interview instrument

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Appendix A

Barriers to Generating University Spin-off Companies in the Vienna Region

Faculty Entrepreneurs

Name _____

Title _____

University _____

Please complete the questionnaire and return it via e-mail to harvey.goldstein@modul.ac.at or verena.peer@boku.ac.at, or by fax to Prof. Harvey Goldstein: (+ 43) 1 320 3555 903

In several of the questions below, we refer to seed capital, angel investors, early stage investment, and late stage investment. We define these terms as follows:

Seed capital here refers to funding to support further R&D leading to an invention or prototype, but before the new business is actually formed. **Angel investors** are individuals who may be one source of seed capital.

Early stage investment refers to sources of capital needed for product development *after* a new business is formed.

Late-stage investment refers to sources capital needed for production to finance the operations of the business up to the point of selling publicly-traded stock in the business.

Based upon your own *personal and professional experience*, as well as *knowledge of other colleagues* who have attempted to start up a business based upon their university research, what is the relative importance of the following factors in *preventing* a greater incidence of university spin-offs in the Vienna region, on a scale of 1-5, where 5 means a very important factor, and 1 means not a factor at all (please highlight).

Individual faculty/researcher attributes	Importance				
	High				Low
University researchers are not conducting enough research that has commercialization potential.	5	4	3	2	1
University researchers are much more interested in basic science and not interested in research that leads to commercialization.	5	4	3	2	1
University researchers are not rewarded sufficiently by their universities for work that leads to commercialization.	5	4	3	2	1
University researchers are not aware of the commercialization	5	4	3	2	1

potential of their research.

University researchers may be interested in research that leads to commercialization, but lack business or entrepreneurial skills.	5	4	3	2	1
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University researchers have low tolerance for risk in their professional work and their careers.	5	4	3	2	1
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Prestige and status within their disciplines do not come from research that leads to commercialization.	5	4	3	2	1
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University Policies and Services

Universities do not provide sufficient rewards or incentives to faculty researchers to develop spin-off businesses.	5	4	3	2	1
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Universities do not provide researchers with training to learn the business skills needed to start a business.	5	4	3	2	1
--	---	---	---	---	---

Universities do not provide sufficient 'seed capital'	5	4	3	2	1
---	---	---	---	---	---

Universities do not provide adequate physical facilities for the location of new spin-off businesses.	5	4	3	2	1
---	---	---	---	---	---

University policies restrict start-up businesses from freely using university infrastructure, such as laboratory equipment.	5	4	3	2	1
---	---	---	---	---	---

Universities do not provide sufficient help to identify if faculty research has commercialization potential.	5	4	3	2	1
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Universities do not provide enough assistance in submitting patent applications.	5	4	3	2	1
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Universities do not supply researchers with names and contacts of external resources for assistance or advice.	5	4	3	2	1
--	---	---	---	---	---

External Regional Environment Factors

The region of Vienna does not have a 'culture' of entrepreneurship.	5	4	3	2	1
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There is an inadequate concentration of private industry R&D activity within key technology areas in the Vienna region.	5	4	3	2	1
---	---	---	---	---	---

There are a lack of 'angel investors' for spin-off businesses in the Vienna region.	5	4	3	2	1
---	---	---	---	---	---

There is a lack of potential private early stage investors in the Vienna region.	5	4	3	2	1
--	---	---	---	---	---

There is a lack of potential private late stage investors in	5	4	3	2	1
--	---	---	---	---	---

the Vienna region.

There is an inadequate number of mentors and role models of successful entrepreneurs in the Vienna region.	5	4	3	2	1
--	---	---	---	---	---

A network of actors and organizations for the support of new technology-based businesses in Vienna is not well developed.	5	4	3	2	1
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City and Länder government policies do not support and encourage the generation of university spin-offs.	5	4	3	2	1
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National and EU Policy Environments

National government policies and programs do not provide enough seed capital for university researchers to seek commercialization possibilities	5	4	3	2	1
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National policies and programs do not provide enough early stage and/or late stage funding for start-ups to survive	5	4	3	2	1
---	---	---	---	---	---

Austria does not have adequate intellectual property protection.	5	4	3	2	1
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National laws on conflict of interest make it too expensive for spin-off businesses to utilize university infrastructure.	5	4	3	2	1
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The federal government does not provide sufficient autonomy and flexibility to individual public universities for supporting or encouraging spin-off activity.	5	4	3	2	1
--	---	---	---	---	---

EU policies and funding programs do not adequately support or encourage commercialization of university research	5	4	3	2	1
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Additional comments or observations you might have:

Appendix B

Questionnaire Results

Factor		University (n=9) mean <i>standard deviation</i>	Entrepreneur (n=12) mean <i>standard deviation</i>	Expert (n=9) mean <i>standard deviation</i>
Individual researcher / faculty attributes	University researchers are not conducting enough research that has commercialization potential.	2,67 <i>1,00</i>	3,00 <i>1,35</i>	3,44 <i>0,88</i>
	University researchers are much more interested in basic science and not interested in research that leads to commercialization.	3,56 <i>1,24</i>	2,92 <i>1,56</i>	4,22 <i>0,83</i>
	University researchers are not rewarded sufficiently by their universities for work that leads to commercialization.	2,67 <i>1,22</i>	3,75 <i>1,42</i>	4,22 <i>0,67</i>
	University researchers are not aware of the commercialization potential of their research.	3,44 <i>1,01</i>	3,92 <i>0,90</i>	3,89 <i>0,78</i>
	University researchers may be interested in research that leads to commercialization, but lack business or entrepreneurial skills.	3,89 <i>0,93</i>	4,33 <i>1,23</i>	4,22 <i>1,09</i>
	University researchers have low tolerance for risk in their professional work and their careers.	3,56 <i>1,24</i>	3,33 <i>1,50</i>	3,33 <i>0,87</i>
	Prestige and status within their disciplines do not come from research that leads to commercialization.	3,44 <i>1,81</i>	3,42 <i>1,44</i>	4,00 <i>1,12</i>
University Policies and Services	Universities do not provide sufficient rewards or incentives to faculty researchers to develop spin-off businesses.	3,11 <i>1,17</i>	4,17 <i>1,11</i>	3,67 <i>1,00</i>
	Universities do not provide researchers with training to learn the business skills needed to start a business.	3,33 <i>1,00</i>	4,00 <i>0,95</i>	4,00 <i>1,00</i>
	Universities do not provide sufficient 'seed capital'	3,56 <i>1,59</i>	4,17 <i>1,53</i>	3,44 <i>1,59</i>
	Universities do not provide adequate physical facilities for the location of new spin-off businesses.	3,44 <i>1,51</i>	3,75 <i>1,60</i>	2,89 <i>0,78</i>
	University policies restrict start-up businesses	2,78	3,42	3,00

	from freely using university infrastructure, such as laboratory equipment.	1,64	1,00	1,12
	Universities do not provide sufficient help to identify if faculty research has commercialization potential.	2,67	3,42	3,00
		1,00	1,24	1,66
	Universities do not provide enough assistance in submitting patent applications.	1,44	2,33	2,33
External Regional Environment Factors		0,73	1,37	1,12
	Universities do not supply researchers with names and contacts of external resources for assistance or advice.	1,56	2,83	2,67
		1,01	1,40	1,12
	The region of Vienna does not have a 'culture' of entrepreneurship.	3,00	3,25	3,22
		1,12	1,22	1,30
	There is an inadequate concentration of private industry R&D activity within key technology areas in the Vienna region.	2,89	2,75	3,00
		0,78	1,54	1,41
	There are a lack of 'angel investors' for spin-off businesses in the Vienna region.	3,89	3,58	4,00
		0,78	1,56	0,87
	There is a lack of potential private early stage investors in the Vienna region.	3,89	3,67	3,78
		1,62	1,92	0,97
	There is a lack of potential private late stage investors in the Vienna region.	3,44	3,17	3,11
National and EU Policy Environments		1,59	2,12	0,93
	There is an inadequate number of mentors and role models of successful entrepreneurs in the Vienna region.	3,44	3,83	3,22
		1,01	1,27	1,20
	A network of actors and organizations for the support of new technology-based businesses in Vienna is not well developed.	2,78	3,33	2,67
		0,67	1,15	1,12
	City and Länder government policies do not support and encourage the generation of university spin-offs.	2,67	3,08	2,67
		1,32	1,31	1,12
	National government policies and programs do not provide enough seed capital for university researchers to seek commercialization possibilities	3,78	3,00	3,00
		1,48	1,54	1,22
	National policies and programs do not provide enough early stage and/or late stage funding for start-ups to survive	3,89	3,75	3,00
		1,05	1,48	1,22

	Austria does not have adequate intellectual property protection.	1,44	1,33	1,89
		0,73	0,49	1,17
	National laws on conflict of interest make it too expensive for spin-off businesses to utilize university infrastructure.	2,11	2,33	2,22
		1,05	1,50	0,83
	The federal government does not provide sufficient autonomy and flexibility to individual public universities for supporting or encouraging spin-off activity.	2,22	2,42	3,11
		1,56	1,73	1,05
	EU policies and funding programs do not adequately support or encourage commercialization of university research	2,67	2,75	2,33
		1,00	1,36	1,32