

A conceptual framework for studying a technology transfer from academia to new firms

Igor Prodan

Regional Technological Centre Zasavje
Grajska pot 10, 1430 Hrastnik, SI – Slovenia
igor.prodan@guest.arnes.si

prof. dr. Mateja Drnovsek

Faculty of Economics, University of Ljubljana
Kardeljeva ploscad 17, 1000 Ljubljana, SI - Slovenia
mateja.drnovsek@ef.uni-lj.si

prof. dr. Jan Ulijn

Faculty of Technology Management, Eindhoven University of Technology
P.O. Box 513, 5600 MB Eindhoven, The Netherlands
J.M.Ulijn@tm.tue.nl

Abstract

This paper summarizes results of an ongoing research of determinants of technology transfer from academia to new firms. Drawing from previous theoretical and empirical developments in the literature, a conceptual framework for studying technology transfer at the individual's level (entrepreneur's standpoint) is developed. The elements of the conceptual framework at the individual's level are (1) as dependent variables: Academic's entrepreneurial involvement or Academic's intention to become an entrepreneur and (2) as independent variables: Personal networks, Number of years spent at the academic institution, Nature of research, Motivational factors, Previous work with the industry, Scientific publications, Role models, Support from academic institution, Patents and Entrepreneurial self efficacy.

We believe that the proposed conceptual framework for studying technology transfer from academia to new firms will help researchers, policy makers and practitioners in designing policy measures and instruments to foster technology transfer from academia to new firms. In further stages of this research the model will be tested in three European regions (Slovenia, Eindhoven area and Cambridge area) for intercultural comparison.

1. Introduction

Global technological competition has made technology transfer from academia to firms an important public policy issue (Rahm 1994). Academia and individual academic institutions are a primary source of new knowledge production and innovation (Brennan and Pauric 2006 forthcoming). It is widely acknowledged that the commercialization of scientific and technological knowledge produced in public funded research institutions, including universities and research centres, to the marketplace have a fundamental role to play in wealth creation, supports economic growth and technological innovation, and plays a significant role in new venture creation, growth of existing firms and new job creation (Mansfield 1991, Harmon et al. 1997, Ndonzuau et al. 2002, Siegel et al. 2003b). Research by Acs et al. (1992), Jaffe (1989), Mansfield (1991, 1998) and others indicate that technological change in important segments of the economy has been based significant on knowledge that spun from academic research.

Academic spin-offs are an important means of technology transfer from an academic organization, an important mechanism for economic activity (Gregorio and Shane 2003, Roberts and Malone 1996, Nicolaou and Birley 2003a), a mechanism for creating jobs and new wealth (Steffensen et al. 1999, Walter et al. in press, Perez and Sanchez 2003), are being a key dimension in industry science links (Debackere and Veugelers 2005), are important means of regions' economic development (Mian 1997, Nicolaou and Birley 2003a) and are an important mechanism for introducing new commercial products to the marketplace (Association of University Technology Managers 2002). For example, spin-offs are the main mechanism for the rapid growth of technopolises like Silicon Valey, Route 128, Austin, Cambridge and others (Rogers et al. 2001). Carayanis et al. (1998) quote a Bank of Boston survey (1997) which observed that Massachusetts Institute of Technology had spun-off approximately 4,000 companies, employing 1.1 million people and generating an annual worldwide sale of 232 billion US dollars. Furthermore Mustar (1997) reported that 200 academic spin-off from France that he has studied, created 3500 jobs. Spin-offs are also found as a mechanism for emerging new industries in the long run (Roberts 1991).

Although many start-ups may fail within a few years as the technology itself fails to prove viable and financiers pull out, on occasion university based start-ups may grow into major industrial contenders. Several major employers in the San Francisco Bay area that were

spawned from university include Sun Microsystems, Cisco Systems, Chiron and Genentec. Most often, the results is somewhere in the middle: successful start-ups based on university technologies are acquired and absorbed by larger companies who seek out the technology or expertise developed by a start-up to complement their own R&D initiatives (Graft et al. 2002).

Politicians in European Union also recognized the importance of technology transfer from academia and establishment of spin-offs, therefore European Union funds projects such as PROTON (pan-European network of Technology Transfer Offices and companies affiliated to universities and other Public Research Organisations), PRIME (Policies for Research and Innovation in the Move towards the European Research Area) and INDICOM (Direct indicators for commercialisation of research and technology) that are examining issues concerning technology transfer from academia and establishment of academic spin-offs (Lockett et al. 2005).

Policymakers in many developed countries have responded to importance of academic spin-offs also by erecting infrastructures intended to facilitate the commercialization of scientific research output (Goldfarb and Henrekson 2003). For example, to stimulate the commercialization of university-based research and promote spin-offs, the UK government established the £50 million “University Challenge” which provides venture capital funding for university based spin-offs and based on a project “Science Enterprise Challenge” created 12 Government sponsored science enterprise centres at several UK universities which provide educational, training and financial services to would-be academic and graduate entrepreneurs (Wright et al. 2004, Lockett et al. 2005).

The aims of this theoretical and construct conceptualization paper are two fold: (a) to provide a discipline appropriate conceptualization of the constructs relevant for studying technology transfer processes, and (b) to develop an empirically testable model a technology transfer from academia to new firms.

2. Technology Transfer Process: Construct Conceptualizations

To avoid confusion resulting from various definitions of technology transfer and academic spin-off companies found in previous literature, it is necessary to know how we define these two terms in our research.

2.1 Technology transfer

Technology is information that is put into use in order to accomplish some task (Carayannis et al. 1998).

There is no widely accepted definition of technology transfer, but, generally speaking, technology transfer is the sharing of technology, technique or knowledge (Melkers et al. 1993, cited in Phillips 2002) and also know-how and organizational rationalities, which are the “soft” dimensions of technology (Storper 1995) among: individuals, industry, universities, public research institutions, federal, state and local governments and third party intermediaries. Walsh and Kirchoff (2002) explained that some form of technology transfer occurs in all organizations among and between departments in the organization, between manufactures and vendors, and between manufacturers and their customers. Walsh and Kirchoff (2002) additionally explained that any technology transfer model developed in the environment of conflicting objectives (which is based on the need for secrecy) must include a high degree of interaction and communication as a necessary ingredient. This is especially

true for disruptive technologies since the high level of uncertainty attached to new-to-the-world technologies requires trials in many different industries and many different products. There are several more narrowly definitions of technology transfer. For example Phillips (2002) for the purpose of research on technology business incubators, defined technology transfer as the licensing of technology from a university to an incubator client firm, Powers and McDougall (2005) defined university technology transfer as a process of transforming university research into marketable products etc.

Bozeman (2000) defined eight different transfer media or communication channels for technology transfer process: Literature, Patent, License, Absorption, Informal, Personnel Exchange, On-site Demonstration and Spin-off.

In this research **technology transfer is defined** as a transfer of knowledge, scientific or technical know-how, technology, technology-based ideas or research results, developed within an academic institution, from academic institution to industry, where an academic institution may or may not have the property rights for commercialization of such scientific or technical know-how, technology or research results.

2.2. Spin-off

There have been number of studies of spin-offs worldwide and various definitions are applicable. In one of the first studies on spin-offs Cooper (1971) used a term spin-off for a new company independent from parent organization which is often started by a group of founders from the same parent company. According to Cooper (1971) a spin-off company is technological based and emphasizes research and development or places major emphasise on exploiting new technical knowledge.

Garvin (1983) proposed that spin-offs are new firms created by individuals breaking off from existing ones to create compositing companies of their own. A spin-off normally occurs when a firm is formed by individuals leaving an existing firm in the same industry.

Smilor et al. (1990) defined university spin-off as a company that is founded (1) by a faculty member, staff member, or students who left the university to start a company or who started the company while still affiliated with the university; and/or (2) around a technology or technology-based idea developed within the university. Similar to this definition is a definition of Steffensen et al. (1999): a spin-off is a new company that is formed (1) by individuals who were former employees of a parent organization, and (2) around a core technology that is transferred from the parent organization. Another similar but different is a definition of spin-off from Nicolaou and Birley (2003a) which proposed a definition of university spin-offs as a company which involve (1) the transfer of a core technology from an academic institution into a new company and (2) the founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution. They additionally explicitly excluded companies established by current or former members of a university which do not involve the commercialization of intellectual property arising from academic research.

Carayannis et al. (1998) first defined a spin-off as a new company formed by individuals who were former employees of a parent organization, around a core technology that originated at a parent organization and that was transferred to the new company. In conclusions of their research they suggested that it is an oversimplification to define a spin-off as a new company

in which both the founder and the core technology are transferred from a parent organization, since only one or the other or both of these factors may be transferred.

Walter et al. (in press) defined an academic spin-off as business ventures that are founded by one or more academics who choose to work in the private sector (at least part-time) and that transfer a core technology from the parent organization.

Weatherston (1995) described the academic started venture or spin-off as a business venture which was initiated, or became commercially active, with the academic entrepreneur playing a key role in any or all of the planning, initial establishment, or subsequent management phases.

Rappert et al. (1999) in their research on academic–industrial relations and intellectual property defined university spin-offs as companies whose products or services develop out of technology-based ideas or scientific/technical know-how generated in a university setting by a member of faculty, staff or student who founded (or co-founded with others) the firm. The individual or individuals may either leave the university to start a company or start the company while still inside the university. It does not matter whether someone was a student or full-time academic and the time interval between the initial research and commercial exploitation is not an issue so long as their university research experience was essential in enabling the firm to provide particular products or services (rather than, for instance, the university experience merely providing background knowledge).

Pirnay et al. (2003) based on literature review proposed a definition of a university spin-off as a new firm created to exploit commercially some knowledge, technology or research results developed within a university. Similarly, but narrowly Druilhe and Garnsey (2004) defined spin-off as a new firm commercializing a proprietary leading-edge technology from a university department and backed by venture capital.

Grandi and Grimaldi (2005) proposed a generic definition of university spin-off, which includes cases in which university dependents (academic founders) start a company on the basis of either a university-assigned technology (license on a patented technology) or a more generic area of technological knowledge (non-university-assigned). They proposed, that a university spin-off also encompasses situations in which the university elects to provide the rights to the technology to an external, independent entrepreneur, non-university-dependent (non-academic founder), who initiates a new company.

Lockett and Wright (2005) narrowly defined university spin-offs as new ventures that are dependent upon licensing or assignment of the institution's intellectual property for initiation.

To avoid confusion resulting from various definitions of academic spin-off companies found in previous literature, it is necessary to define what we mean by an academic spin-off company in this research. We **define an academic spin-off** as a company that (1) is founded (or co-founded by non-academics) by one or more academics (not including students), (2) was created to exploit commercially some knowledge, scientific or technical know-how, technology, technology-based ideas or research results developed within an academic institution, (3) where an academic institution may or may not have the property rights for commercialization of such scientific or technical know-how, technology or research results and (4) where it is not necessary that such knowledge, scientific or technical know-how,

technology, technology-based ideas or research results developed within an academic institution is a core research focus of an academic institution.

3. Technology transfer from academia to industry

It is clear that there is more than one mechanism to the commercialization of academic intellectual property. Key mechanisms are formation of spin-off companies, patents, licenses and research joint-ventures (Lockett et al. 2005). Since Jensen and Thursby (2001) found that only 12% of university inventions were ready for commercial use at a time of licence (which points to the importance of incubation (Clarysse et al. 2005)) and manufacturing feasibility was known for only 8% and similarly Jensen et al. (2003) reported, that faculty involvement in further development is necessary for commercial success for 71% of the inventions licensed, we can be positive that whatever the route of technology transfer is, core to its success will be the role played by the creator of the intellectual property, the individual scientist or engineer (Jensen and Thursby 2001, Jensen et al. 2003, Goldfarb and Henrekson 2003, Wright et al. 2004, Markman et al. 2005b). Also, although an innovation may seem clearly applicable or marketable, it is common, that still no existing firm will risk taking on it (Graft et al. 2002), thus academic spin-offs are important mechanism for transferring technology from academia since the scientist is actively involved in its creation. In addition, spin-offs based on university technology (such as Lycos, Genentech, Cirrus Logic) tend to survive longer and are more likely to achieve Initial Public Offering (IPO) status (Shane and Stuart 2002).

Where in the past academic institutions have passively licensed their technologies to large established companies (Siegel et al. 2003a) today many academic institution actively search ways to channel proprietary technology to maximize rents to spawn new companies (Thursby et al. 2001, Wright et al. 2004, Chapple et al. 2005, Powers and McDougall 2005). Licensing, which is the most common mechanism to commercialize university technology (Radosevich 1995), has the advantage that the academic and the university are able to capitalize on the technology, and the academic is able to pursue his/her research without having to commit large amount of time to commercial matters (Lockett and Wright 2005). The downsides to this approach are (Franklin et al. 2001):

- the nature of the new technology may not be easily patented and transacted via a license agreement and,
- universities may not be able to capture the full value of their technology through a licensing agreement and therefore seek a more direct involvement in the commercialization of new technology through spin-off companies.

Despite the perceived importance of spin-offs and growth in the number of spin-offs from universities, there have been very few systematic studies that have examined this phenomenon. In fact, in most research, spin-offs have been one of a number of technology transfer mechanisms under study, including patenting and licensing with relatively little emphasis placed on detailed research into spin-off activity per se (Leitch and Harrison 2005).

4. A conceptual framework for studying a technology transfer process

Academic entrepreneurship arises from internal as well as external impetuses (Etzkowitz 2003). Both micro and macro level factors influence the decision to create a new company to exploit an academic invention. At the micro level, research has shown that motivational factors of academics' (Roberts 1991, Steffensen et al. 1999, Shane 2004b), the attributes of technological inventions themselves (Shane 2001a), inventors' career experience (Levin and Stephan 1991), their psychological make-up (Roberts 1991) and their research skills (Zucker

et al. 1998) influence this decision. At the macro level, research has shown, that technology regimes and characteristics of parent organization (Shane 2001b, Rogers et al. 2001, Powers and McDougall 2005), size of technology transfer office (O’Shea et al. 2005), age of technology transfer office (Roberts and Malone 1996, Powers and McDougall 2005) size of federal funding in science and engineering (Shane 2004b, Powers and McDougall 2005), level of industry R&D funding (Powers and McDougall 2005), availability of venture capital (Druilhe and Garnsey 2004, Powers and McDougall 2005) the strength of patent protection in a line of business (Shane 2002b), spin-off/parent conflict (Steffensen et al. 1999), the university rewards system, which is based mainly on publications and citations (Goldfarb and Henrekson 2003, Franklin et al. 2001) university quality (O’Shea et al. 2005), universities’ intellectual property (Goldfarb et al. 2001), official university policy towards spin-offs (Chiesa and Piccaluga 1998, Roberts and Malone 1996) and government policies (Liu and Jiang 2001, Shane 2004b) influence this decision.

Although both micro and macro level factors influence the tendency of academics to start a new company to exploit academic inventions, we discuss only factors from entrepreneur’s standpoint in this research. In developing the conceptual model of technology transfer from academia to new firms (Figure 1) we included the key facilitators as well as the key barriers to technology transfer previously identified in the literature (mainly literature about general entrepreneurship, about psychology of entrepreneurs, technology transfer, academic entrepreneurship and university-industry links) and also some additional facilitators as well as barriers to technology transfer, we identified during previous research. These factors that influence Academic’s entrepreneurial involvement or Academic’s intention to become an entrepreneur are: Personal networks, Number of years spent at the academic institution, Nature of research, Motivational factors, Previous work with the industry, Scientific publications, Role models, Support from academic institution, Patents and Entrepreneurial self efficacy.

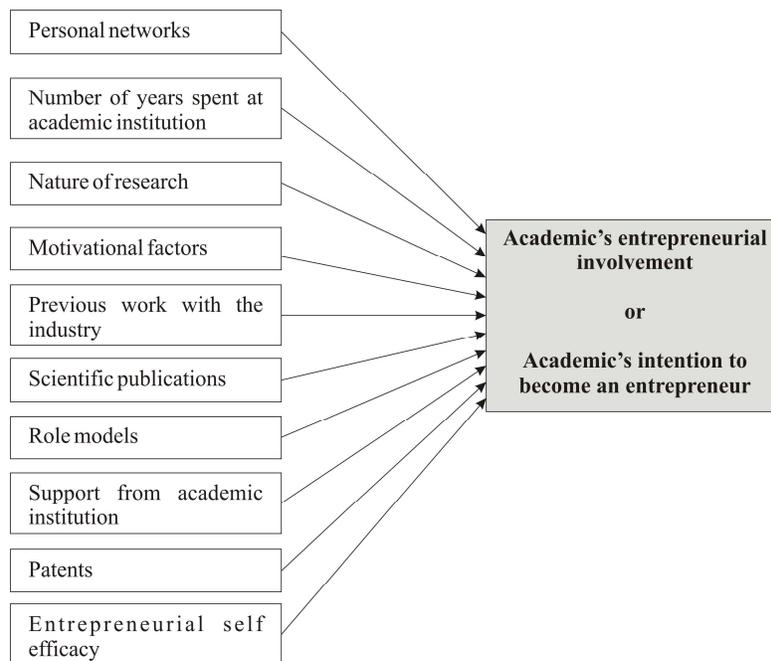


Figure 1: Conceptual framework for studying technology transfer from academia to new firms from the academic’s / academic’s entrepreneur point of view

Source: Authors development.

In what follows we in detail explain the conceptual model, together with both dependent variables and individual factors that influence Academic's entrepreneurial involvement or Academic's intention to become an entrepreneur. We also added measurement instruments for each variable.

4.1 Dependent variables

Academic's entrepreneurial involvement

The academic entrepreneur need to make choices in terms of committing full time to a spin-off or academic institution or working part-time at both. On the one hand, the academic may leave the academia to completely focus his or her energy in the firm; on the other hand, the inventor may decide to remain in the academia and may or may not accept a part time position in the company (Nicolaou and Birley 2003b). Harmon et al. (1997) found that few university inventors leave the university but rather generally help to commercialize the invention on a part-time basis. When academics establish a spin-off company this does not necessarily imply that they leave their academic position permanently, nor take a leave of absence (Goldfarb and Henrekson 2003). Richter (1986) estimated that 3.3 percent of scientists and engineers who are employed full time as professors in American four-year higher educational institutions also work as consultants for commercial companies of which they are owners or part owners. Similarly, Allen and Norling (1991) found out that among 912 faculty members in science, engineering, business and medicine 16.2 percent of academics are engaged in firm formation, but only 4.4 percent is engaged in firm formation on the basis of their academic research.

Most scholars have (1) tried to identify differences between entrepreneurs (academic entrepreneurs) and non-entrepreneurs (academics) for which they used dichotomous variable which coded entrepreneurs as 1 and non-entrepreneurs as 0 or (2) tried to determine a typology of academic entrepreneurs. Since academic entrepreneurs are specific and since there are clearly differences among those who have establish a spin-off we propose a new variable, called Academic's entrepreneurial involvement which measures the involvement of academic in his or her spin-off company. To our knowledge, so far there has been no scale variable that measured academic's entrepreneurial involvement.

This type of dependent variable can then be used in regression models as dependent variable and also in structural equation modelling.

Measure: Respondents will be asked to answer to the following four questions:

1. How many hours per week do you work for your company?
2. How many hours per week do you spend for consulting to your company?
3. How many hours per week do you work for academic institution?
4. What is the percentage of your employment at your company (in complement to employment at academic institution research)?

Intention to become an entrepreneur

Intentions are the single best predictor of any planned behaviour, including entrepreneurship (Krueger et al. 2000). Intentions correspond to a state of mind that directs the individual's attention, experience, and action toward the goal of founding a business (Bird 1988). Entrepreneurial intentions also embody an individual's commitment to start a new business (Krueger 1993).

Measure: We will use three items to measure entrepreneurial intention:

1. How interested are you in setting up your own business (5-point Likert scale ranging from 1 (not interested) to 5 (very interested)); Chen et al. (1998)
2. If you found commercial application for one or more of your inventions, you would seriously consider becoming an entrepreneur to commercialize the opportunity (5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree)); Kassicieh et al. (1997)
3. How probable is it that you will start your own business in the next 5 years (scale 0-100); Krueger et al. (2000)

4.2. Independent variables

Personal networks

Close relationships provide entrepreneurs with avenues for negotiation and persuasion, enabling them to gather a variety of resources (e.g. market information, ideas, problem solving, social support, venture funding and financial resources) held by other actors (Shan and Stuart 2002, Hoang and Antoncic 2003, Nicolaou and Birley 2003a, Nicolaou and Birley 2003b, Walter et al. in press). Nicolaou and Birley (2003a) more specifically based on the literature review defined business networks as those which can benefit in:

- opportunity identification - the academic inventor is in an advantageous position to better identify market niches and may adapt his invention accordingly,
- access to important information and resources that could not otherwise be obtained,
- timing, where through business contacts the academic acquires the market information early, which can be of catalytic importance in research and development,
- receiving positive recommendations and evaluation at the right place through referrals. For example, venture capitalists and business angels are more inclined to invest in spin-offs that they know or that have been referred to them by reliable resources, because this tends to alleviate informational asymmetry problems (Shane and Stuart 2002).

Measure: Respondents will be asked to answer to the following three questions:

1. How many hours per month do you spend developing contacts with persons with whom you can discuss business matters (e.g. commercialization, marketing, finance...)?
2. How many hours per month do you spend maintaining contacts with persons with whom you can discuss business matters (e.g. commercialization, marketing, finance...)?
3. With how many people did you discuss business matters (e.g. commercialization, marketing, finance...) in last month?

Number of years spent at the academic institution

Most members of the academic community have by a tenure professorship guaranteed their socio – economic status which thus does not depend on applicative research, which provides basis for spin-off creation. Their job stability and academic reputation normally are dependent upon teaching and publication. Without taking sufficient precautions, a faculty member may jeopardize his or her academic career by engaging in spin-off creation while shirking basic research responsibilities (Lee and Gaertner 1994). Thus, the number of years spent at the academic institution is a proxy for their scientific seniority, which should negatively affect the level of academic's entrepreneurial involvement and intention to become an entrepreneur.

Measure: The variable counts the sum of the number of years spent by academic founder at his or her academic institution.

Nature of research

In general, academic research is oriented more towards basic research, which is driven by a scientist's curiosity or interest in a scientific question, rather than applied research. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view (OECD 2002). Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective (OECD 2002) with market potential and thus more interesting for commercialization than basic research.

Measure: The variable refers to the nature of research carried out by academic or academic entrepreneur at the academic institution. It is measured with the following three questions:

1. How many hours per month are you involved in applied research?
2. How many hours per month are you involved in basic research?
3. What is the average percentage of research funds for your applied research (in complement to basic research)

Those who have already established a spin-off will be asked about their nature of research at the present time and about their nature of research before they established a spin-off.

Motivational factors impacting academic spin-off behaviour

In a recent exploratory study at MIT, Shane (2004b) uncovered motivational characteristics of academic entrepreneurs, such as (1) a desire to bring technology into practice (Samson and Gurdon 1993, Weatherston 1993, Corman et al. 1988, Shane (2004b)); (2) a desire for wealth (Roberts 1991, Shane (2004b)); (3) a desire for independence (Roberts 1991, Shane (2004b)), as key pull and push factors impacting academic spin-off behaviour. Besides those motivational characteristics of academic entrepreneurs that were discussed by Shane (2004b) there are some other motivational factors that apply for technical entrepreneurs and were discussed by other scholars (e.g. Roberts 1991): to do something others could not (challenge) and taking on and meeting broader responsibilities (challenge). Based on literature review and our knowledge of academic entrepreneurs, we additionally propose three other motivational factors that were not tested in the literature and that are impacting academic spin-off behaviour (1) desire to secure additional research funding, (2) dissatisfaction with the academic environment and (3) desire to pursue technological perfection - reverse.

Measure: Respondents will be asked to rate the extent to which they agree with following statements (on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree)):

- (1) I am dissatisfied with the academic environment; I have a desire (2) to bring technology into practice; (3) pursue technological perfection - reverse; (4) to disseminate my findings through the scientific literature - reverse; (5) for wealth; (6) for independence; (7) to do something others could not; (8) for taking on and meeting broader responsibilities and (9) to secure additional research funding.

Previous work with the industry

At the institutional level, previous research on university-industry relation indicates that institutions with closer ties to industry generate greater number of spin-offs and exhibit more entrepreneurial activity, such as faculty consulting with industry, faculty involvement in new

firms and faculty and university equity participation in start-up firms (Roberts and Malone 1996, Cohen et al. 1998 cited in Powers and McDoughall 2005).

Same applies also at the individual level. Blumenthal et al. (1996) surveyed 2052 academics at 50 universities in the life science field and found that industry funded academics are more commercially productive than those who are not industry funded. Similarly Mansfield's (1995) study of 66 firms as well as 200 academic researchers found that in early stage of research projects, academics receive more government versus industrial funding, while as a project matured, industry funding began to grow and academics become more involved as industry consultants. Corman et al. (1988) found that 90 percent of entrepreneurs interviewed (20 of 22) were deeply involved in technical consulting activity before and often after launching their own firms. The Kassiech's et al. (1996) study found significant differences between entrepreneurs and non-entrepreneurs in terms of situational variables such as the level of involvement in business activities outside the laboratory. Colyvas et al. (2002) found in their examination of 11 case studies from Columbia University and Stanford University, that in all but one case, the researchers involved in spin-off were members of a network of scientists that included industry professionals. In the single case in which there was no academic and industry scientist linkage, the technology was never transferred.

Measure: Respondents will be asked to answer to the following five questions:

1. How many hours per month are you involved in consulting to companies?
2. How many hours per month are you involved in projects related to industrial partners?
3. What is the average percentage of research funds from industry for your research projects?
4. In how many industry-related projects were you involved in last year?
5. In how many networks of scientists that include industry professionals are you involved?

Those who have already established a spin-off will be asked about their work with the industry at the present time and about their work with the industry before they established a spin-off.

Scientific publications

Academic institutions typically do not reward activities such as commercializing research and creating new spin-offs in their promotion and tenure decisions (Siegel et al. 2003a), thus academics are usually more interested in publishing their results, presenting them at conferences, and continuing in the academic research race (Graft et al. 2002), rather than being involved in patenting and commercialization of the research. The academic reward structure encourages the production of knowledge that is a useful input into other academics' research. Researchers wish to have their papers cited because this is a signal that they have established a reputation within the academic community (Goldfarb and Henrekson 2003), which is the primary motivation for university scientists (Siegel et al. 2003b). Different scholars have argued that publishing papers and striving for citations is a central objective of academic research, as citation measures are associated with higher income and prestige (e.g. Diamond 1986, Stern 2004) and also as a recognition from other scientists which may lead to election to a national academy and the ultimate accolade of the Nobel prize (Etzkowitz 1998).

The performance evaluation process and publishing-orientated research thus act as barriers to creation of new academic spin-offs (Ndonzau et al. 2002). There is little reason to believe that the goal of producing useful inputs into the research of other academics (which is done

through scientific publications) is congruent with the goal of producing commercially valuable knowledge. Hence, efforts directed at the production of commercially valuable knowledge will most likely come at the expense of the production of recognized reputation of academic's (Goldfarb and Henrekson 2003).

Importance of a reward system in academic institutions as barrier to creation of new academic spin-offs is also illustrated by Siegel's et al. (2004) study, which was based on 55 structured interviews of three types of university-industry technology transfer stakeholders (managers/entrepreneurs, technology transfer office directors/university administrators and university scientists). They found that from 80% (managers/entrepreneurs) to 85% (technology transfer office directors/university administrators and university scientists) of interviewers identified an importance of modifying the reward system in universities to reward technology transfer activities, in improving the university-industry technology transfer.

Measure: Respondents will be asked to answer to the following questions:

1. How many scientific papers did you publish in last three years?
2. How many citations did you receive in last three years?

Those who have already established a spin-off will be asked about the number of scientific papers and citations in last three years and also in last three years before they established a spin-off.

Role models

Role models' impact on entrepreneurial behaviour has been studied by many researchers and it has been found to correlate significantly with entrepreneurial behaviour and intentions (Roberts, 1991; Krueger, 2000). Once a university has established an entrepreneurial tradition, and a number of successful companies, fellow faculty members can offer material support, in addition to moral support to their colleagues who are trying to establish a company of their own (Etzkowitz 1998). Academics who have started their own firms can also become advisors to those newly embarking on a venture. The effort by pioneering faculty members to found companies can lead other faculty members to found companies as well, because it lead the followers to believe that firm formation was an easy and desirable activity (Feldman et al. 2000 cited in Shane 2004b). Similarly in a large sample study (although based on case studies), Audretsch et al. (2000) provides similar results, showing that science-based firm formation is in fact, influenced by a demonstration effect of prior start-up efforts by other scientists. Similarly conclusions were made also by Shane (2004b) and Etzkowitz (1998). Etzkowitz (1998) cited an aspiring academic entrepreneur that recalled that a department colleague who had formed a company, "gave me a lot of advice...he was the role model".

The availability of such role models makes it more likely that other academics will form a firm out of their research results, when the opportunity appears.

Measure: Respondents will be asked to answer to the following questions:

1. How many academic entrepreneurs do you know personally?
2. How many entrepreneurs do you know personally?
3. How many hours per month do you spend maintaining contacts with academic entrepreneurs?
4. How many hours per month do you spend maintaining contacts with entrepreneurs?

Support from academic institution

Locket and Wright (2005) argued that there is a positive relationship between incentives and rewards for establishing a university spin-offs and the creation of university spin-offs. Siegel et al. (2003b) found out that barriers for university-industry technology transfer are also university aggressiveness in exercising intellectual property rights and bureaucracy and inflexibility of university administrators. Additionally, Degroof and Roberts (2004) proposed that spin-off policies in academic institutions significantly affect the growth potential of spin-off companies. Thus, if academic perceive support from academic institution, he or she will more likely become an entrepreneur or will easier be more involved as entrepreneur.

Measure: Respondents will be asked to rate the extent to which they agree with following statements (on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree)):

1. Academic institution is too aggressive in exercising intellectual property rights – reverse (based on insights of Siegel et al. (2003b))
2. Bureaucracy and inflexibility of academic administrators impede the establishment of academic spin-offs – reverse (based on insights of Siegel et al. (2003b))
3. The marketing, technical and negotiating skills of the academic staff involved in commercialisation promote the establishment of spin-off companies (adapted from Locket and Wright (2005))
4. The availability of a clear process for establishing spin-off companies promote the establishment of spin-off companies (adapted from Locket and Wright (2005))
5. The availability of venture capital promotes the establishment of spin-off companies.
6. Academic institution provide facilities and access to research equipment to the spin-offs (based on insights of Steffensen et al. 1999)
7. There are good sources of assistance within the academic institution if one is interested in establishing a spin-off (adapted from Kassicieh et al. 1997)
8. Academic institution is supportive of academics who wish to commercialize their inventions (adapted from Kassicieh et al. 1997).

Patents

Patenting is a logical extension of the tendency toward increasing interest in commercially applicable results (Louis et al. 1989).

Measure: Respondents will be asked to answer to the following questions:

1. Number of patents you applied for in last three years?
2. Number of patents granted to you in last three years?

Those who have already established a spin-off will be asked about the number of patents they applied for and number of patents that were granted to them in last three years and also in last three years before they established a spin-off.

Entrepreneurial self efficacy

It is widely acknowledged that most scientist lack the business background needed to bring technology closer to the market (Druilhe and Garnsey 2004) and many established spin-off companies can be characterized by a lack of commercial awareness and may lead the company to become technology rather than market driven. Typically technology orientated entrepreneurs seeks to develop the absolute best “mousetrap” and constantly pursues perfection (Wilem 1991). Products never sell themselves: there is always the need for varying degrees of marketing and sales skills (Sljivic 1993). The ability to connect specific knowledge and a commercial opportunity requires a set of skills, aptitudes, insights and

circumstances that are neither uniformly nor widely distributed (Venkataraman 1997). Besides commercial knowledge new academic entrepreneurs also require administrations skills, since where previously all the administration was done by the university, spin-off company has to address these time consuming and distracting aspects themselves (Sljivic 1993).

The creation of a new venture by academics can be thus described as a process in which they are involved in both the invention and the commercialization exploitation phase (Grandi and Grimaldi 2005), thus they need both specific scientific knowledge and also business related skills or at least certainty in performing business related roles and tasks. The certainty in performing business related roles and tasks of entrepreneurs is entrepreneurial self efficacy, which is relatively more general than task self efficacy (Chen et al. 1998). Entrepreneurial self efficacy refers to the strength of an individual's belief that he or she is capable of successfully performing the roles and tasks of an entrepreneur (Boyd and Vozikis 1994).

Measure: Entrepreneurial self efficacy will be measured with 22 roles and tasks identified by Chen et al. (1998). Respondents will be asked to indicate their degree of certainty in performing each of the following roles/tasks on a 5-point Likert scale ranging from 1 (completely unsure) to 5 (completely sure):

1. Marketing related roles and tasks: set and meet market share goals, set and meet sales goals, set and attain profit goals, establish position in product market, conduct market analysis, expand business;
2. Innovation related roles and tasks: new venturing and new ideas, new products and services, new markets and geographic territories, new methods of production, marketing and management;
3. Management related roles and tasks: reduce risk and uncertainty, strategic planning and develop information system, manage time by setting goals, establish and achieve goals and objectives, define organizational roles, responsibilities and policies;
4. Risk-taking related roles and tasks: take calculated risks, make decisions under uncertainty and risk, take responsibility for ideas and decisions, work under pressure and conflict;
5. Financial control related roles and tasks: perform financial analysis, develop financial system and internal controls, and control costs.

In Chen's et al. (1998) study, Crombach alphas were 0.89 for Total entrepreneurial self efficacy, 0.86 for Marketing self efficacy, 0.74 for Innovation self efficacy, 0.75 for Management self efficacy, 0.65 for risk taking self efficacy and 0.77 for Finance self efficacy.

4.3. Controlled variables

Planned or spontaneously occurring spin-off

Steffensen et al. (1999) identify two types of spin-offs: (1) planned, when the new venture results from an organized effort by the parent organization, and (2) spontaneously occurring, when the new company is established by an entrepreneur who identifies a market opportunity and who founds the spin-off with little encouragement (and perhaps with discouragement) from the parent organization. Since in planned spin-off academics are much more influenced by parent organization (academic institution) we will control for this variable.

Other controlled variables

Gender, Age, Years since establishment of own company, Total years of employment, Percentage of equity in spin-off company of academic institution, Percentage of academic's equity in spin-off company, Whether an establish company arise from academic research, Number of entrepreneurs in establishing a spin-off and Highest professional degree attained at the academic institution (researcher, doctoral researcher, post- doctoral research associate, Assistant Professor, Associate Professor, Full Professor, other).

5. Propositions

To summarize our literature review, a conceptual framework for studying a technology transfer process and our understanding of technology transfer from academia to new firms, we propose the main research thesis and a set of 15 research propositions.

Main research thesis: Academic spin-off behaviour (entrepreneurial involvement and intention to become an entrepreneur) is from entrepreneur's standpoint influenced by availability of personal networks of academics or academics entrepreneurs, number of years spent at the academic institution, nature of research (basic versus applied research), personal motivational factors, previous work with the industry, publishing recognizable scientific papers, availability of role models, support from academic institution, patenting and entrepreneurial self efficacy.

Proposition 1: There is a positive relationship between academic spin-off behaviour (entrepreneurial involvement and intention to become an entrepreneur) and size and frequency of interaction with persons with whom academic entrepreneurs / academics can discuss business matters.

Proposition 2: There is a negative relationship between the number of years spent at the academic institution and academic spin-off behaviour (entrepreneurial involvement and intention to become an entrepreneur).

Proposition 3: There is a positive relationship between applied research and academic spin-off behaviour (entrepreneurial involvement and intention to become an entrepreneur).

Proposition 4: There is a positive relationship between different motivational factors and academic spin-off behaviour (entrepreneurial involvement and intention to become an entrepreneur).

Proposition 5: There is a positive relationship between work with the industry and academic spin-off behaviour (entrepreneurial involvement and intention to become an entrepreneur).

Proposition 6: There is a negative relationship between publishing recognizable scientific papers and academic's entrepreneurial involvement.

Proposition 7: There is a negative relationship between publishing recognizable scientific papers and academic's intention to become an entrepreneur.

Proposition 8: There is a positive relationship between availability of role models (academic entrepreneurs) and academic's entrepreneurial involvement.

Proposition 9: There is a positive relationship between availability of role models (academic entrepreneurs) and academic's intention to become an entrepreneur.

Proposition 10: There is a positive relationship between support from academic institution and academic's entrepreneurial involvement.

Proposition 11: There is a positive relationship between support from academic institution and academic's intention to become an entrepreneur.

- Proposition 12:** There is a positive relationship between number of patents (applied/granted) of academic and academic's entrepreneurial involvement.
- Proposition 13:** There is a positive relationship between number of patents (applied/granted) of academic and academic's intention to become an entrepreneur.
- Proposition 14:** Academic entrepreneurs with high entrepreneurial self efficacy are more likely to be more involved in spin-offs they have established.
- Proposition 15:** Academics with high entrepreneurial self efficacy are more likely to become entrepreneurs than those with low entrepreneurial self efficacy.

6. Conclusion

We believe that the proposed conceptual framework for studying technology transfer from academia to new firms will help researchers, policy makers and practitioners in designing policy measures and instruments to foster technology transfer from academia to new firms. In further stages of this research the model and constructs will be first pre-tested with approximately 20 academics and academic entrepreneurs in Slovenia and Eindhoven area and than tested in three European regions (Slovenia, Eindhoven area and Cambridge area) for intercultural comparison.

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