INSTITUTIONAL ORIGIN AND RESOURCE ENDOWMENTS TO SCIENCE-BASED ENTREPRENEURIAL FIRMS: A EUROPEAN EXPLORATION

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ABSTRACT

This paper addresses theoretical and empirical gaps in the relationships between the nature of institutional origin, firm resources and growth in the context of spinning off ventures from public research organisations (PROs). Institutional origin is considered a two dimensional construct consisting of the formality of technology transfer and the research specificity of a PRO. In this perspective, these variables are hypothesised to predict the resource endowments of science-based entrepreneurial firms. Additionally, given the widespread attention from academics and policy makers to IP based science-based entrepreneurial firms, the formality of technology transfer is expected to be associated with growth.

Empirical tests of hypotheses derived from this view are based on data from 184 science-based entrepreneurial firms, representing 48 public research organisations. Multivariate analysis of variance shows that institutional origin predicts firm resources, showing significance levels for start capital. An ordinal interaction effect shows that companies established with a formal transfer of technology start with higher resource levels, and even more so when started from a PRO with a specific research base. This suggests that specific PROs are more selective in the projects they consider eligible for spin off incubation and creation. Next to this, two-stage regression analysis indicates that the formality of technology transfer has a single direct effect on growth in employees and capital, independent of the start capital of the firm, pointing to the intrinsic advantage of having protected intellectual property formally transferred to the science-based entrepreneurial firm at the onset of the business activities.

1. INTRODUCTION

The insights that resource based theories and the new institutionalism in organisation studies have contributed to our understanding of firm founding and survival suggest that these distinct perspectives are in fact complementary. Resource based theories suggest that firms make economically rational choices that are shaped by the economic context of the firm. According to institutional theory, firms make normatively rational choices that are shaped by the social context of the firm. Although Oliver (1997) already suggested that resource based and institutional views actually converge, very few have investigated how combining elements from these perspectives in an empirical analysis can explain firm similarities and differences.

The purpose of this paper is to investigate the extent to which institutional origin has an impact on the resource endowments of science-based entrepreneurial firms, which are founded from the research base developed at public research organisations. We define institutional origin as the nature of the relationship between the science-based entrepreneurial firm and the PRO. More specifically, we consider institutional origin as a two-dimensional construct consisting of the formality of technology transfer (formal or informal) and the research specificity of the PRO (generic or specific) from which the venture emerges. We also assess the extent to which institutional origin affects the growth of science-based entrepreneurial firms.

Investigation of the potential explanatory capacity of the nature of institutional origin on the resource endowments of science-based entrepreneurial firms at time of founding is potentially important for different reasons. First, public research organisations are increasingly argued to play a key role in knowledge creation, knowledge dissemination and economic growth (OECD, 1998; 2003) and the US was the first country to set the stage. The successes of Route 128 and Silicon Valley led to wider endorsement about the US model and the central role of public research organisations in such regional successes (Saxenian, 1994). In this perspective it has been recognised that the economic sectors with the most rapid growth are those closest associated with the 'science base': microelectronics, software, biotechnology and new materials (Van Looy et al. 2004). As a result, policies have been put in place to stimulate the commercialisation of research and, more specifically, the creation of science-based entrepreneurial firms. New regulations gave PROs ownership of IP arising from their research base and the right to commercialise the results obtained.

Second, both the early neo-institutional framework and resource based view have been criticised: the institutional framework for its focus on homogeneity and persistence of organisational forms (Dacin et al, 2002); the resource based view for not taking into account the context of resource acquisition (Oliver, 1997). Thus, combining elements from both an institutional and resource-based perspective in a conceptual model of firm heterogeneity and similarity may shed light on how institutional origin of science-based entrepreneurial firms explains the resource conditions of these companies. Integrating both perspectives in an empirical analysis helps addressing the seemingly paradoxical challenges new science-based entrepreneurial firms face: although they rely a lot on the entrepreneurs' initiative to attract the necessary resources, we expect them to be also partly determined by their institutional origin at time of founding. To our knowledge, this study is one of the few attempts focusing on the investigation of the specific institutional relations that science-based entrepreneurial firms have at time of founding and the predictive capacity of this linkage on firm resources and growth.

Finally, this study is also important because it typically focuses on the founding conditions of companies. More specifically, the question of initial resource endowments has been argued to be of significant interest in organisational ecology, evolutionary theory and entrepreneurship research (Shane and Stuart, 2002). At the organisational level, Stinchcombe (1965) was the first to stress the "imprinting effect" of initial conditions at founding, including the institutional environment. Later research has confirmed this view. Population ecologists as well as institutional theorists, for example, have confirmed that the main organisational characteristics when an organisation is established tend to become institutionalised (Hannan and Freeman 1977; Meyer and Rowan, 1977; Boeker, 1989). Over the years, a general consensus has been growing about the fact that initial (founding) conditions are likely to have an effect on firm survival and growth.

The remainder of the paper is organised as follows. First, we describe the context in which the phenomenon of science-based entrepreneurial firms has increasingly gained momentum. Second, we develop the conceptual model combining elements from both institutional and resource based perspectives, hypothesising that institutional origin explains firm resources and growth. Third, we discuss the data and methods employed. Fourth, we present the analyses and the results, developing the main findings of this research. We conclude with a discussion section pointing to the main implications of this study.

2. SCIENCE-BASED ENTREPRENEURIAL FIRMS, INSTITUTIONAL ORIGIN AND RESOURCES

Background: Science-based entrepreneurial firms in Europe

Science-based entrepreneurship looms large in the public arena (Henrekson and Rosenberg, 2001). There is a large tendency among public research organisations to add ‘entrepreneurial’ objectives to their mission, including a spectrum of evolutions such as more involvement in social and economic development, more intense commercialisation of research results, patent and licensing activities, the institutionalisation of spin off activities and managerial and attitudinal changes among academics regarding collaborative projects with industrial partners (OECD, 1998; Van Looy et al. 2004). A marked increase in the number of companies created from PROs has been observed in North America as well in Europe since the early nineties. The creation of new companies from PROs has become central to research and innovation policy and policies have been put in place to promote the development of these ventures (Chiesa and Piccaluga, 2000; Mustar, 1997). Regulatory constraints have been removed or loosened so as there are now more possibilities for an academic to create a company. However, different studies in different countries use a variety of definitions of what exactly constitutes a spin off company. Terms used include (academic) spin-outs, university based start-ups, (academic) spin-offs, firms created by researchers, research-based spin offs, … A common definition has been developed by authors such as Roberts and Malone (1996), Smilor et al. (1990) and Steffenson et al. (1999):

> A spin-off is a new company that is formed by a faculty member, staff member, or doctoral student who left university (research organisation) to found the company or started the company while still affiliated with the university, and/or a core technology (or idea) that is transferred from the parent organisation.

This definition leaves room for inclusion of a variety of firms and a lot of researchers to date have adhered to this definition, albeit using it in diverse ways. The heterogeneity in the interpretation of this definition partly reflects the fact that researchers have indeed observed that research-based spin offs are not a homogeneous group of companies (Stankiewicz, 1994; Mustar, 1997; Druihle and Garsney, 2003), urging them to make empirical choices as to whether or not firms are to be included in sample frames. As a result, in Europe, spin offs often comprise all the ventures that are "listed" or "identified" by researchers and / or technology transfer officers as having emerged from PROs (Moray and Clarysse, 2004).

The remainder of this paper will use the term "science-based entrepreneurial firm" (SBEF), following authors such as Henrekson and Rosenberg (2001) and Murray (2004). We choose this term to denote an inclusive concept for the companies that have been identified by researchers or technology transfer officers as having emerged from the research performed in public research organisations. This paper develops hypotheses about the effect of institutional origin on resource endowments at time of founding and venture growth. The basis assumption is that institutional origin at time of founding has potential explanatory capacity for the heterogeneity that is observed among science-based entrepreneurial firms, both in terms of resources at time of founding and growth.

In the remainder of this section we combine elements of institutional and resource based perspectives to the study of science-based entrepreneurial firms. The basic, rather intuitive value of combining the 'material' with the 'institutional' lies in the observation that science-based entrepreneurial firms emerge from within diverse public research organisations, and that new firms typically need to attract the necessary resources to start and develop their activities. We develop hypotheses taking into account both aspects of this reality.

Institutional origin and science-based entrepreneurial firms

Researchers have stressed the importance of institutional characteristics in the commercialisation of innovation (e.g. Lynn et al, 1996). In the context of science-based entrepreneurial firms, this is particularly apparent because these companies display different types of links with the institutional parent at the moment the venture is set up.

One of the common features of PROs is that they have in varying degrees commercial ideas in their research portfolio but they differ substantially in the extent to which they actively search for these business opportunities as well as in the extent to which the trajectory of business development is guided and supported, if at all. Previous researchers have studied the differences in technology transfer activities in a range of European public research organisations and have come to useful classifications. Clarysse et al. (Forthcoming), for example, have developed a typology of interface services based on the resources they employ and the activities they actually engage in for supporting new businesses. Together with other authors (Siegel et al. 2003), they also come to the conclusion that technology transfer activities are difficult to measure, especially as it is an intrinsically evolutionary phenomenon: public research organisations can be in transition, evolving of one 'incubation' model to another. In spite of a general convergence, the practical implementation of these models and the regional / national regulatory details are very diverse and make it difficult to judge whether and under which circumstances such models are effective.

Therefore, we decided to focus on one particular element that may signal technology transfer activities in the PRO: *institutional origin with the science based entrepreneurial firm at time of founding*. Baum et al. (1991) already pointed to the importance of institutional origin when they studied the impact of institutional origin on mortality rates of service organisations. Focusing our analysis on institutional origin at time of founding has at least two advantages. First, it empirically overcomes the intrinsic evolutionary nature of technology transfer activities as they are practiced in the PROs. These evolutions have been quickened since the mid nineties and a lot of European PROs have not reached equilibrium. Second, taking into account "institutional origin" will prove to be helpful to categorise science-based entrepreneurial firms, potentially leading to a better understanding of the characteristics and the relative role of different types of science-based entrepreneurial firms.

In this research, institutional origin is considered a two dimensional construct, consisting of *formality of technology transfer to the science-based entrepreneurial firm* and the *research specificity of the parent research organisation* from which the venture emerges. The *formality of technology transfer* refers to the extent in which a company is formed based on a formal transfer of intellectual property. Roberts (1991, 103-107) already noted the variety of linkages of science-based entrepreneurial firms with MIT. Therefore, he questioned the entrepreneurs about the link of the firm with the research organisation and more specifically, about the importance of technology transferred to the new firm. He asked the respondents to rate the degree of dependence on source technologies: direct, partial and vague. In these categories learned technology is unquestionably important; the difference is only in degree. Where technology is transferred directly, the company would not have been started without the formal transfer of Intellectual Property Rights (by means of a license agreements or transfer of a patent). “Partial” means that the company was founded based on the formal transfer of Intellectual Property rights; however, this know-how needed to be expanded with some other source of know-how (i.e. IP coming form another institute then the parent institute). We label the companies that received a partial or direct transfer of technology as the IP based spin offs. The category “vague” represents those companies that are categorised as a SBEF by the parent institute for other reasons than formally transferred technology, for example because academic staff co-founded the company based on know how they acquired at the parent organisation or because the PRO provided some start-up capital.
The Association of University Technology Managers[3] has made an explicit distinction between “start-ups” and “spin offs”. The first group of companies are based on know how developed at the PRO without formal transfer of technology. It is possible however, that the PRO has an equity stake through the provision of capital. The start-ups clearly use source learned (but often non-protected and non-formally transferable) knowledge and/or technologies. Conversely, “spin offs” received a formal transfer of technology by means of a license agreement in return for royalties or IP in return for

[3] www.autm.org

equity (i.e. they were directly or partially dependent on source technologies at time of founding).

Next to the formality of technology transfer we define institutional origin by an intrinsic characteristic regarding the research base developed at the PRO. Some PROs have a specific technology focus while others perform research in a variety of technological domains and the humanities. In Europe, the majority of the research that is publicly financed is organised in universities or research institutes. In practice we observe that research institutes are more likely to have a specific technology focus, whereas the universities can have either a generic research portfolio or be quite specific in a few domains. Chalmers institute of Technology for example has five explicit strategic research streams: biotechnology, information technology, the environment and micro- and nanotechnology. Intuitively, one can expect PROs with a specific research base to be able to specialise in the commercialisation of these research results, which have a rather delineated scope. Since these PROs often have contract research with industry as core competence, these PROs are expected to be more involved in intellectual property issues and technology transfer activities, since they seem to operate much closer to industrial partners. As the propensity of research and technology transfer can be captured in a number of indicators, (Siegel et al, 2003), we use these indicators for empirically validating this conceptual distinction (see section 3.2 for specification of the variables). Since the specific – generic distinction regarding the research base of PRO has not been validated and generally acknowledged to date, in contrast with the 'formality of technology transfer' dimension (AUTM), our first hypothesis addresses this issue:

Hypothesis 1: A public research organisation with a specific research focus (one or a number of clearly delineated technological domains) will be more actively engaged in technology transfer related activities than a generic PRO.

Resources and science-based entrepreneurial firms

Emerging science-based entrepreneurial firms need to extract resources from the environment. In order to do so, these firms will act in self-interest, trying to gain access to, and ultimately control over, needed resources (Pfeffer and Salancik, 1978). It has also been argued that ventures originating from public research organisations display a variety of resource configurations (Druihle and Garsney, 2004). Researchers studying the diversity of science-based entrepreneurial firms often focused on internal characteristics associated to the business model of the company. Bullock (1983) already identified two categories: "soft companies", the technical consultants solving customised problems, and "hard companies" that sell standardised products to a general market. In parallel, Stankiewicz (1994) classifies science-based entrepreneurial firms according to the way they operate. He identifies three different operation modes: consultant and R&D boutique mode, product-oriented mode, and technological-asset mode. Still others have suggested defining science-based entrepreneurial firms according to specific types of resource transfer from their environment (Carayannis et al., 1998). Although these studies have significantly contributed to our understanding of the diversity of science-based entrepreneurial firms, most studies have not extended their approaches to looking for potential predictors "external" to the firm as an organisational entity that can help explain the diversity in resource configuration. Additionally, most of the categories described above are intrinsically developmental and overlapping, so that it is hard to integrate them in an empirical research design. This research hypothesises that the nature of institutional origin will affect the resource endowments of a science-based entrepreneurial firm at time of founding.

Hypothesis 2: The nature of institutional origin affects the resource endowments of a science-based entrepreneurial firm at time of founding

Following resource based scholars we focus on the financial and the human resources (Barney, 1996). More specifically, we expect ventures that are established with a *formal transfer of technology* (the 'spin offs') to start with higher capital levels and more employees. We hypothesise that starting business activities with a formally transferred technology is intrinsically more capital intensive since the technology needs to be valued as part of the transfer agreement between the PRO and he new venture. As a result of the higher start capital we expect ventures starting with a formal transfer of technology also to have more researchers working in the firm. The human resources in a science-based entrepreneurial firm are intrinsically tied to the research and technology they bring into the company. When one employs researchers, it is the researcher's labour and scientific and technical human capital that is actually brought into the company: the formal educational endowments, but also the skills, know-how and "tacit knowledge," embodied in individual scientists and engineers (Bozeman and Mangematin, 2004). The relation between the resources however, cannot be clearly stipulated. For example, an argument can be made that more capital is needed in “spin offs” because they need more researchers / employees to further develop and maintain the technology (platform) on which the firm is built. Although there is an increasing awareness that resources are interrelated with one another, the direction and order of these interrelations have not been examined extensively. Therefore, when formulating our hypotheses, we put the resource variables at one level.

H2a: When know how is transferred formally to a science-based entrepreneurial firm, the firm will display higher capital levels and a higher number of employees as compared to ventures that start activities without formal transfer of technology.

Similarly, we expect ventures emerging from specific PROs to start with a greater resource base as compared to companies that emerged from a generic PRO. The reason for this is twofold. First, building on the results of hypothesis 1, we infer that specific PROs seem to have the commercialisation of research and technology more central to their activities as compared with generic PROs. As a result, one can expect that the ventures set up from these institutes will have more often transferred protected technology at time of founding as compared to ventures coming from generic PROs. Since we do not have complete data sets of the full population of ventures emerging from the PROs in the sample, we could not test this intuition in the context of this paper. However, Moray (2004, IN: Clarysse, 2004) has shown this for the full population of science-based entrepreneurial firms in Flanders (Belgium): generic PROs set up significantly more science-based entrepreneurial firms without formal transfer of technology (“start-ups” according to AUTM) as compared with the specific PROs which seem to have the establishment of IP based science-based entrepreneurial firms as core strategy (“spin offs” according to AUTM). Second, PROs that put the commercialisation of research and technology to the core of their mission are expected to have more developed systems and trajectories to guide and support these types of ventures. This potentially increases the legitimacy of these companies and subsequently the amount and the nature of the financial and human resources they attract at time of founding (Pfeffer and Salancik, 1978; Suchman, 1995). These observations lead to the formulation of the following hypothesis:

H2b: A science-based entrepreneurial firm originating from a PRO with a specific research portfolio will display higher capital levels and have a higher amount of employees as compared to ventures that start from a PRO with a generic research base.

Growth of science-based entrepreneurial firms

While science-based entrepreneurial firms are argued to be a key feature of the modern economy, our insights into their growth and productivity remain limited (Murray, 2004). Growth of start-up companies in general is a complex and multidimensional phenomenon and factors such as firm age and industry affiliation have been argued to be important characteristics predicting growth (Delmar, 2003). It is likely that the conditions at time of founding are related to growth of these science-based entrepreneurial firms. Since policy makers have been emphasising the commercialisation of intellectual property through setting up science-based entrepreneurial firms as an important engine for economic growth (OECD, 2003), we hypothesise that the formality of technology transfer will affect the average growth of the company. We argue that the research specificity of a PRO is of much less importance in predicting the potential economic contribution of a science-based entrepreneurial firm, given the time lag between founding the company and assessing growth. More specifically, we expect “spin offs” to display higher average growth as compared to “start-ups”, given policy makers’ substantial focus on IP based science-based entrepreneurial firms. The following hypothesis summarises this:

Hypothesis 3: A science-based entrepreneurial firm receiving a formal transfer of technology will display higher average growth in capital and employees as compared to a science-based entrepreneurial firm that is established with intangible know-how.

3. METHOD

The following section elaborates on the construction of the European sample, the data collection procedures and the variables included for both univariate and multivariate analyses.

Sample and data collection

One of the main problems in performing studies on science-based entrepreneurial firms from PROs is the difficulty to randomly sample either a number of PROs or science-based entrepreneurial firms across Europe. This would require a large up-front knowledge base about the composition and the nature of the population of PROs as well as science-based entrepreneurial firms in the respective countries. This is not the case at both levels. For the PROs, because each country has its own specific context of organising and financing research and development activities in public research organisations. Estimating the population of PROs that rightfully represents the majority of publicly financed research in a region or country in a comparable international dataset is a research project in itself. For the firms, because researchers involved in the domain of science-based entrepreneurial firms have only very recently launched initiatives to integrate data sets from respective countries. Moreover, at the micro-institutional level, PROs often are not knowledgeable about the full population of science-based entrepreneurial firms that are set up from their research base. This is especially true for the firms that start without formal transfer of technology[4] and in countries with a strong decentralised system for different types of technology transfer related activities such as Germany and Sweden.

[4] In this perspective, some researchers are strong advocates to only include science-based entrepreneurial firms in empirical analyses that start with a formal transfer of technology (focusing on ‘spin offs’ only). Although empirically, this is probably the ‘purest’, it intrinsically denies the issue that in a lot of countries samples are constructed as a mix of different types of firms having a link with the parent institute. This does not only make research results hard to compare internationally, it also takes not into account that whether or not technology transfer happens, is an evolutionary phenomenon: some firms that were started in the early nineties as ‘start-ups’, would today be established as ‘spin offs’, given the upsurge of the phenomenon. We explicitly argue that sample frames should be all-inclusive, representing particular regional contexts, BUT that the science-based entrepreneurial firms should be coded as to the nature of institutional origin at time of founding to better understand the heterogeneity among these firms and their relative importance, both at the firm, the micro-institutional and the regional/national level.

To date it has been very difficult to construct comparative European sample frames and this has urged researchers to construct theoretically sampled data sets to address particular questions of interest (see for example Clarysse et al. forthcoming). It has been argued that theoretical sampling is a valid alternative to random sampling as long as the research design is determinate and if the conditions of unit homogeneity and conditional independence are met (King et al., 1994), issues contributing to making scientifically sound inferences.

This research is performed in the context of a European collaborative effort between researchers from 7 European countries: Belgium (Flanders), France, the United Kingdom, Germany, Sweden, Italy and Hungary. Theoretically sampling a number of PROs we arrive at a research design ensuring maximum variety regarding the organisation of R&D in PROs. A three-step approach was utilised for sampling and data collection at the PROs and the science-based entrepreneurial firms in the respective countries.

First, for each country an analysis was performed looking at the broader context of the national innovation systems and start-up activity. How is research organised and financed? What is the R&D expenditure and patent activity? Table 1 shows that the countries included vary significantly in their share in R&D activities and patent activities. Most of the countries studied are in the top 10 in their share of triadic patent families (except Belgium and Hungary). Since we analyse institutional origin and its potential impact on resource endowments, this variety of contextual constellations improves external validity of the findings, i.e. improves the probability that the hypotheses at the level of the public research organisation and the firms hold true across national contexts.

INSERT TABLE 1 ABOUT HERE

Given these contexts, we discussed with the national experts / researchers what is the best way to sample public research organisations and the science-based entrepreneurial firms that emerged from their knowledge base ensuring ‘real life’ but ‘controlled’ diversity so as to maximise comparison and external validity. There was a general consensus that the common denominator for public research activities across

Europe, is that the majority is organised in universities or research institutes. In relatively small samples – as compared to the total population – this controlled diversity is key in making scientifically sound inferences. Thus, the second step involved the selection of a small number of PROs in each country that is representative for the way research is organised. Moreover, the technology transfer office needed to be at least three years old and the PRO needed to have a significant track record in setting up science-based entrepreneurial ventures since the mid nineties. Data on each PRO was collected through personal interviews with technology transfer managers. Each public research organisation in the sample was interviewed using the UNICO-NUBS questionnaire specifically designed for collecting quantitative indicators from Technology Transfer Offices of Public Research Organisations (UNICO-NUBS, 2003). Sampling the PROs first was crucial since we are typically interested in micro institutional origin with the research base at time of founding the science-based entrepreneurial firm. The data on the PROs is used to test hypothesis 1.

Third, for each PRO about 4-5 science-based entrepreneurial firms were sampled. Companies established since 1991 were included. In some cases the national experts / researchers were able to identify the full population of science-based entrepreneurial ventures and sampled the firms as such that they can be seen as representative examples of companies set up from the research base of the particular parent. In most cases, populations were unknown and firms were included based on the ‘known’ science-based entrepreneurial firms and the willingness to participate in the study. Given our research questions, which want to explore the impact of institutional origin on resource endowments and growth, this is appropriate, as we do not expect the willingness of founders/CEOs to cooperate or the (lack of) knowledge of the population of firms to influence both independent variables representing institutional origin. We developed a standardised survey instrument that was used as a road map during face-to-face interviews with the founders and/or CEOs of the companies. During these 1 - 1,5 hour interviews, we questioned the respondents about the start-up history of the firm in terms of technology transfer from the PRO, the inventors involved, how (much) resources were attracted at time of founding and how the company evolved since then. Special attention was given to the resource endowments:

the human, financial and technology resources. Our final sample consists of 48 PROs and 184 science-based entrepreneurial firms that emerged from these institutions.

Measures

To address the hypotheses outlined above we selected or developed measures regarding institutional origin, firm resources and growth.

Institutional origin

As aforementioned, we measure institutional origin by two categorical (independent) variables, which are both coded at the company level: research specificity of the parent organisation and the formality of technology transfer at time of founding. Since the validity of the distinction between formal technology transfer and the informal transfer of research / know how has been launched and generally acknowledged by the Association of University Technology Managers, hypothesis 1 specifically addresses the empirical validation of the conceptual distinction between generic and specific PROs, using univariate Mann Whitney U tests. Siegel et al. (2003) identified a number of input indicators related to university – industry technology transfer, internal to the research organisation: invention disclosures (a proxy for the set of available technologies), labour employed by the Technology Transfer Office (TTO), and the legal fees incurred to protect the intellectual property of the PRO. We complemented these measures with research expenditure, license income, patents filed and the number of science-based entrepreneurial firms set up in 2002 to get an idea of the nature of commercialisation activities at each of the groups of PROs. We compare the generic and specific PROs in the sample on this set of indicators.

Resource measures

Several researchers have traditionally pointed to the financial (Manigart et al., 2002), and human resources (Shane and Stuart, 2002) as significant assets in young firms and science-based entrepreneurial firms in particular. The entrepreneurship literature Roberts (1991) argued that the human and financial resources are instrumental in the development of an initial resource base.

For each group of resources we selected one variable argued to be crucial for founding science-based based entrepreneurial firms (Heirman and Clarysse, 2004) and that rightfully represent the resource categories of interest. Choosing one variable for each resource category is appropriate given the relatively small sample and since there is a high inter item reliability[5]. For the financial resources we included the *start capital* of the company, i.e. the total capital represented in the company during the first year of activities, including capital from entrepreneurs equity investors and debtors. Including the total capital is important, because for some firms the (high) valuation of the technology on behalf of the PRO need to be taken into account. Finally, we measure the human resources by looking at the size of the team that started working in the newly founded business, providing a crude indicator of firm size. We count the number of active persons working in the firm, including the *employees, active founders and managers.*

Growth measures

When measuring growth of high tech companies in general, authors have used a variety of indicators (Heirman and Clarysse, 2004b) such as sales growth (e.g. Lee et al., 2001), employment growth (e.g. Westhead and Birley, 1994), first product shipment (e.g. Schoonhoven et al., 1990) or some composite performance indicator. Delmar et al. (2003) argue that there is no “one best way” of measuring firm growth because it is intrinsically multidimensional. Although different measures of growth have been proposed in the entrepreneurship literature, the following growth indicators seem to be listed most often: (return-on) assets, employment, market share, physical output, profits, and sales. However, several scholars argue that traditional accounting-based indicators of profitability and assets are inappropriate for relatively young companies in high technology sectors (e.g. Shane and Stuart, 2002). However, for science-based entrepreneurial firms, it is possible that capital levels and employment will grow before any substantial sales and revenues are generated or profitability is obtained, displaying the investment intensity that often entails these types of companies. Therefore, we measure growth in terms of average growth in employees and capital. Both growth measures seem to be suitable indicators if the specific

[5] For the financial resources we evaluated inter item reliability between total capital at founding and the amount of external capital (Cronbach Alpha = 0,99). For the human resources, we are focusing on the amount of people actively involved in the firm, which is captured in one measure.

interest is assessing policy implications. Growth in capital is informative about the propensity of the venture to attract investors for science-based entrepreneurial firms, which are established from largely publicly funded research. Growth in employees helps us understand the relative role of spin offs and start-ups in their contribution to job creation. Moreover, resource-based scholars value employment based measures as a highly suitable indicator of firm growth (e.g. Kogut and Zander, 1992). Thus, both growth measures provide insight in the relative contribution of spin offs and start-ups in regional development objectives: employment creation and attracting (foreign) capital. We do not use relative growth measures (%) since the smallest venture naturally ends up with highest relative growth even if in absolute terms its growth is negligible compared to the absolute growth of its larger counterparts. Instead we choose to include absolute average growth in our analyses (value today minus value during first year of operations, divided by the age of the firm).

The next section discusses the analyses performed for assessing the hypotheses developed above.

4. DATA ANALYSIS AND RESULTS

Different analysis techniques were used to test the three principal hypotheses. To test hypothesis 1, univariate Mann Whitney U tests were used to study the differences between the two conceptualised types of public research organisations. Hypothesis 2 is evaluated using a 2X2 factorial design for MANOVA in order to assess the explanatory power of institutional origin on resource endowments. Finally, we test hypothesis 3 performing a two stage least squares regression analysis, allowing to separate the individual effects of the formality of technology transfer and start capital on the growth of science-based entrepreneurial firms. This section presents the analyses and the results for each hypothesis.

Hypothesis 1: Specific PROs are more actively engaged in technology transfer activities than generic PROs

Our primary goal for testing the first hypothesis is to provide an empirical validation of the conceptualisation of ‘generic’ versus ‘specific’ PROs, as we developed earlier.

Table 2 displays the descriptive data of the PROs in the sample, as well as the respective p-values representing the significance levels for the differences in technology transfer related activities between the PROs with a ‘generic’ and a ‘specific’ research base. The non-parametric tests show that the two groups of PROs differ on a number of research and technology transfer indicators. The results mostly point to the hypothesised direction: specific PROs score higher on research expenditure, invention disclosures, patent applications and license income. Additionally, the technology transfer offices seem to be somewhat older and they employ more personnel in technology transfer related activities.

INSERT TABLE 2 ABOUT HERE

The relatively young age of the technology transfer offices is in line with the findings from a recent OECD survey (2003, p. 38), reporting that most TTOs from public research organisations are less than 10 years old. The observation that specific PROs have more invention disclosures and patent applications, suggests intrinsic differences in the nature of the research activities, technological domains and the commercialisation trajectories adopted in the two groups of PROs. Moreover, generic PROs tend to patent almost only in the EU, while the specific institutes seem to have a much more global strategy, covering also the US.

When we relate some input and output indicators from the previous table, some clear differences emerge. Table 3 summarises some comparative output indicators for generic and specific PROs. Specific PROs have a more elaborated and professional staff involved in intellectual property issues: the IP staff tends to be more than twice as large in the specific group of PROs as compared to the generic ones (p=0,08), which is in turn reflected in the license income. Specific PROs generate more than 10 times the license income per full time equivalent employed in licensing activities as compared to the generic PROs (p=0,04).

INSERT TABLE 3 ABOUT HERE

Generic PROs employ 2 full time equivalent employees for every venture that is created as compared to almost 6 in specific PROs. This potentially suggests that the technology transfer offices of specific PROs are more intensely involved in the establishment and incubation of science-based entrepreneurial firms. Since there are twice as much persons involved in the creation of these companies, we might expect that the coaching and support will be more elaborated.

Overall, we find that specific PROs show clear indicators of a more professionalized technology transfer office: they patent more; if they patent, it is at a global rather than at a EU level; they generate significantly more license income; they have a larger staff, … Interestingly however, they seem to generate about the same amount of science-based entrepreneurial firms in general and spin offs in particular as the generic research organisations. This potentially indicates that the barrier to start-up a new firm is much larger. That is to say, licensing to incumbent firms seems to be favoured over starting up a science-based entrepreneurial firm. This is shown by the SBEF / patent ratio displayed in

Table, which is 1:1 for generic PROs as compared to 0,1:1 for specific research organisations (p=0,04). Additionally, if a specific PRO engages in establishing a SBEF, the data suggest that specific PROs put more effort in incubating and / or coaching the project.

Hypothesis 2 and 3: Institutional origin predicts founding resources and growth of SBEF

Whereas the *first hypothesis* is tested at the *level of the PRO* in order to empirically validate the conceptual distinction between generic and specific PROs, the *second and third hypothesis* are tested at the level of the *science-based entrepreneurial firm*. Each company in the sample is coded for the two dimensions of institutional origin at time of founding the company: the formality of technology transfer (two levels: formal transfer of technology – informal transfer of know how) and the research specificity of the PRO from which the venture emerged (two levels: generic PRO – specific PRO).

Table 4 shows the descriptive data and the correlations of the variables used to test both hypothesis 2 and 3. The data display a huge variety in the companies in the sample, mirroring observations from academics and practitioners that science-based entrepreneurial firms differ substantially in their resource conditions and growth patterns. The next section elaborates on the multivariate analyses and results for both hypothesis 2 and 3.

INSERT TABLE 4 ABOUT HERE

Hypothesis 2: Science-based entrepreneurial firms with a formal transfer of technology and emerging from specific PROs will display higher resource levels

In order to assess the nature and the magnitude of the potential effect of institutional origin on the resources endowed to science-based entrepreneurial firms at time of founding, a 2X2 factorial design for Multivariate Analysis of Variance is used. MANOVA is appropriate since we want to assess the effects of independent, categorical predictor variables on more than 1 dependent variable. More specifically, we test the effect of the formality of technology transfer (formal – informal) and the research specificity of the PRO (generic – specific) on the start capital and the number of employees of the science-based entrepreneurial firms.

We preferred a MANOVA to a series of separate ANOVA's primarily because it has been argued that resources are intrinsically multidimensional and interacting (Brush et al., 2001; Heirman and Clarysse, 2004a). Morevover, MANOVA has a number of empirical advantages over performing separate ANOVAs on each dependent variable (Bray and Maxwell, 1990, 9; Hair et al. 1995). For example, MANOVA protects against inflated type I error due to multiple tests of likely correlated dependent variables. However, MANOVA has some strict assumptions that need to be met before this type of analysis can be performed. The assumptions of normality of the dependent variables, homogeneity of variances, sufficient correlation between the dependent variables and a balanced design (Hair et al., 1995), are all tested for and the results allow us to proceed with the planned analysis (see appendix for an overview of the tests).

In the course of the discussion, we assess the interactive or joint effects between the two categorical variables on the dependent resource variables collectively. First, we evaluate the interaction effect between formality of technology transfer and the research specificity of the parent PRO. More specifically, this analysis addresses the question whether or not spin offs and start-ups differ in their resource endowments at time of founding, depending on the research specificity of the parent PRO. Second, we evaluate the main effects of each independent variable separately on the resource variables as a group.

The MANOVA design, constructed as 2X2 combinations of institutional origin, produces 4 groups of firms: (1) spin offs (receiving formal transfer of technology) from specific PROs, (2) spin offs from generic research organisations, (3) start-ups (receiving an informal transfer of know-how) from specific research organisations and (4) start-ups from generic PROs. The null hypothesis that the four groups of firms do not differ across the mean scores of the dependent variables can be rejected at the 0,05 level (F=2,9), suggesting that institutional origin is significantly associated with variations in founding resources.

Table 5 contains the MANOVA results for testing the interaction and main effects. Evaluation of the interaction effect is important because it is a condition to correctly interpret the main effects. The multivariate tests -- Wilks Lambda and Pillai's criterion[6] -- indicate that there is a significant interaction effect: the differences between the groups of the first categorical variable (formality of technology transfer) vary depending on the level of the second independent variable (research specificity). This indicates that the main effects to not operate independently: the differences between spin offs (formal technology transfer) and start-ups (informal transfer of know-how) are not equal across their origin from generic or specific parent organisations.

[6] Wilks Lambda and Pillai's criterion represent multivariate F values. Wilks' Lambda is the most commonly available and reported test statistic in a MANOVA setting. However Pillai's criterion is more robust and more appropriate when there are small or unequal sample sizes.

INSERT TABLE 5 ABOUT HERE

Figure 1 specifically documents the ordinal interaction effect that this entails[7]. Spin offs (with a formal transfer of technology) seem to be established with higher resource levels than start-ups (with an informal transfer of know-how), and this difference is reinforced by the research specificity of the PRO from which the science-based entrepreneurial firm emerges. Since the ordinal interaction effect is conceptually acceptable, we further evaluate the main effects separately and investigate the specific group mean differences using a post hoc procedure.

INSERT FIGURE 1 ABOUT HERE

First, we find a significant main effect of the formality of technology transfer and the resource endowments of the firms: the spin offs -- the science-based entrepreneurial firms that received a formal transfer of technology at time of founding -- are founded with higher resource levels as compared to the start-ups, which are launched based on an informal transfer of know-how. Conversely, we find no direct effect of the research specificity on the financial and human resource endowments of the science-based entrepreneurial firms at time of founding.

Second, we are also interested in the nature of the differences among the combinations of groups, for each dependent variable separately. This allows us to discern whether it is start capita and / or the number of employees that accounts most for the observed differences between the groups. To analyse this, we use a post hoc procedure. To avoid inflated type I errors commonly prevalent in relatively small samples such as ours, (Hair et al. 1995), we decided to use the Scheffe test, which is argued to be one of the most conservative post hoc tests (Winer et al., 1991). Doing so, we downsize the chance of obtaining false significance levels[8].

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[7] The lines are not parallel and do not cross between levels, indicating that the effects of both independent variables are not equal across the groups but the magnitude is in the same direction.

[8] Moreover, Kruskall Wallis tests display results in the same direction (KW=19,5; p<0,001) for start capital en degree of productisation of the technology (KW=8,2; p<0,05). For both dependent variables box whisker plots show 1>2,3,4; 2>3,4 and 3<4.

Scheffe tests show that the differences between spin offs and start-ups across the research specificity of their parent PROs, holds true for start capital (Table 6). Spin offs originating from public research organisations with a specific research or technology focus start activities with significantly higher capital levels than the other three groups. The univariate results indicate that the differences in employees are non significant across all groups.

INSERT TABLE 6 ABOUT HERE

These results potentially indicate that spin offs are the result of a clear strategic choice for commercialising intellectual property through setting up a new firm. Since these spin offs start with the highest capital levels, this mirrors the professionalisation of technology transfer activities in the originating parent from an organisational point of view and the observation that these companies probably have higher IP valuations at time of founding. In other words, the professionalisation trend of technology transfer activities in specific PROs seems to have the largest impact on the start capital of the spin offs.

In conclusion, hypothesis 2a is supported in that the formality of technology transfer predicts start capital. The effect does not hold true for the number of employees, which is remarkable. It means that spin offs start with more capital but with an equal amount of human resources, as compared to the start-ups. However, it is usually the human resources that make up the capital intensity and value of the venture. This suggests that the higher capital level can mainly be explained by the valuation strategy of the intellectual property going into the venture. Hypothesis 2b is not supported. However, there is a significant interaction effect between the research specificity and the formality of technology transfer, for the two resource variables taken together. The spin offs which have a formal transfer of technology, emerging from specific PROs start with significantly higher capital levels than the spin offs from generic PROs. Conversely, the start-ups -- that are established with an informal transfer of know-how -- from specific PROs have significantly less start capital that the start-ups from generic PROs. This indicates that technology transfer offices at specific PROs tend to focus on the support and/or incubation of science-based entrepreneurial firms that receive formal intellectual property of the research organisation at time of founding, whereas the generic universities seem to support both spin offs and start-ups.

Hypothesis 3: Science-based entrepreneurial firms with a formal transfer of technology will display higher growth

Since institutional origin seems to matter in understanding resource endowments of science-based entrepreneurial firms, we also need to address the issue whether institutional origin at time of founding has an enduring effect on the growth of these firms. In other words, do the spin offs grow more than the start-ups? Given the policy attention for IP based science-based entrepreneurial firms (the spin offs), hypothesis 3 stipulated that companies founded with a formal transfer of technology are more likely to grow in employees and capital, as compared to firms that are started without formal transfer of technology (the start-ups)[9]. The main reason for hypothesising this is the fact that governments are increasingly giving attention to the creation, ownership and exploitation of IP emerging from publicly funded research organisations, given the evidence and awareness that IP that can be protected through patents and copyright, contribute to technological innovation and growth (OECD, 2003, p. 21).

We analyse the association between the formality of technology transfer, start capital and growth using regression analysis[10]. We control for 'demographic' variables in the analysis that are generally acknowledged to potentially influence growth (Delmar, 2003): technology domain, age and firm size. First, we take into account whether or not the science-based entrepreneurial firm is a life sciences firm. Life sciences firms are argued to have a higher minimum critical scale (Mangematin, 2003) and therefore can be expected to display higher average growth. Second, since population ecologists

[9] We deliberately choose not to focus on growth in revenues because it has been argued that traditional accounting based measures are not appropriate for young firms in high technology sectors (Lee et al., 2001; Shane and Stuart, 2002).

[10] We choose not to include the growth variables as additional dependent variables in the 2X2 MANOVA for different reasons. First, it is conceptually confusing to combine resource variables at time of founding with growth variables that are inherently evaluated at a later stage. Second, the research specificity of the PRO will probably only impact the early stages of the companies' existence, whereas the formality of technology transfer can be argued to have more enduring effects on the firm, since the firm need to maintain its acquired technology base. Thus, for assessing growth we specifically focus on one aspect of institutional origin. Third, it is important to separate out the individual effects of formality of technology transfer and start capital on growth.

have traditionally argued that firm growth is age related we also take into account the age of the SBEF. Empirical studies indicate that firm growth decreases with firm age (Barron et al., 1994). Thus, the growth potential of new firms seems to be most apparent during their initial phase of evolution. Third, we use the number of active researchers, entrepreneurs / founders and managers in the company as a proxy of firm size. For convenience, we label all the active people in the firm as "employees", although not all of them are on the pay roll of the company. We take firm size into account because several noted studies have recently reached the conclusion that the basic tenet underlying Gibrat's Law - that growth rates are independent of firm size – actually does not hold (Audretsch et al. 2002). Estimating how the different factors affect growth would require the following regression equation:

Growth employees (capital) = f(Formality of technology transfer + Start Capital + Employees + Life sciences firm + Age)

However, estimating the full model in one equation is not appropriate because there is strong mutual dependence between start capital and growth of the science-based entrepreneurial firm, both in terms of employees and capital. More specifically, ventures might look for a high level of start capital to be able to recruit a high number of employees in the years to come, which implies that a priori growth expectations determine the start capital. Conversely, start capital might be a reflection of the soundness of the business plan, which allows the company to grow in terms of employees and raising additional capital. Moreover, the results from hypothesis 2 indicate that the formality of technology transfer is highly predictive for the start capital of the firm, which makes separating its individual effects necessary to tackle the issue of interest. In these cases, it is generally advised to perform a two stage least squares regression (Pindyck and Rubinfeld, 1991, 298), in order to separate out the effects of the problematic variables. Therefore, we estimate the following system of equations:

<u>Stage 1</u>: Start capital = f (Formality of technology transfer + Employees + Age of firm + Life Sciences firm)

<u>Stage 2:</u> Growth employees (capital) = f (Formality of technology transfer + Employees + Age of firm + Life Sciences firm + **Residual of stage 1 regression)**

The first regression estimates the extent in which the formality of technology transfer explains for start capital, taking into account some demographic characteristics. For assessing the significance levels of the variables included in the model on the growth of the SBEF, we include the residual of the first stage regression in the main regression. As a result, we include an instrumental variable in the main regression (stage 2), which is a proxy for start capital. More specifically, by taking the residual we include the variance of start capital that is not explained by the other independent variables in the model. This allows us to evaluate the exogenous effects of both formality of technology transfer and start capital on the growth of the SBEFs, both in terms of employees and capital. Table 7 provides an overview of the regression results.

INSERT TABLE 7 ABOUT HERE

The first stage regression clearly shows that both the formality of technology transfer and the number of employees explain significantly for the start capital of science-based entrepreneurial firms. In line with the findings presented earlier, spin offs start with higher capital levels as compared to start-ups. Moreover, in line with expectations, life science firms start with higher capital levels as compared to other firms.

The second stage regression results indicate that the formality of technology transfer has a direct effect on the growth in employees and capital, independent from the start capital ($p<0,05$). This means that being a ‘spin off’ – with a formal transfer of technology at time of founding – implies higher employee and capital growth, suggesting that IP based firms have intrinsically higher potential to grow given the protected technology and / or the breadth of the technology platform, irrespective of their start capital. Interestingly, start capital does not seem to affect growth independent from the fact whether or not technology was transferred formally.

Thus, starting as a spin off -- as opposed to a start-up -- has intrinsically higher potential to grow in terms of employees and to attract additional capital, irrespective of the capital at time of founding. This shows that investors in general and the venture capital community in particular seem to be more interested in companies with protected technology / intellectual property, favouring spin offs over start-ups.

Moreover, the individual effect of the formality of technology transfer on capital growth is intrinsic to the activities of the firm: spin offs often need additional (venture) capital in order to further develop and maintain their acquired technology base. On the other hand, however, the high valuations of these companies at the onset of activities may blur our perspective on the amount of working capital that is effectively available to develop the business. It may be that spin offs – as compared to start-ups – start up with too small an amount of working capital as compared to the total capital of the firm.
Hence, hypothesis 3 is supported in that the formality of technology transfer predicts growth in employees and capital, independent from the start capital that the firms can attract. Drawing conclusions from this requires some caution. The growth measures used in this paper illustrate capacity growth, mirroring employment and the propensity to attract (foreign) capital. A link to financial performance is a step further along the line and cannot be evaluated from this analysis.

5. CONCLUSION AND DISCUSSION

This study explicitly recognises the heterogeneity of science-based entrepreneurial firms in Europe and provides a mutually exclusive categorisation for these firms denoting their institutional origin at time of founding. More specifically, we attempted to understand whether institutional origin affects the resource endowments of science-based entrepreneurial firms and whether this matters in terms of the growth of these companies. We operationalised institutional origin as a two-dimensional construct, consisting of the formality of technology transfer (formal or informal) and the research specificity of the PRO (generic or specific). The main argument of the paper is that institutional origin matters in predicting the starting resources and growth of science-based entrepreneurial firm. We tackled these issues in three steps.

First, we hypothesised that specific PROs are more active in technology transfer related activities as compared to PROs with a generic research base. In recent years, a lot of research organisations have attempted to formalise technology transfer and capture a larger share of the economic rents associated with technological innovation by establishing technology transfer offices (TTOs) (Siegel et al., 2003). Although

TTOs have in common that they facilitate technological diffusion through the licensing to industry of inventions or intellectual property resulting from university research, research organisations seem to differ significantly in the magnitude of these activities. We have shown that specific PROs engage much more in commercialisation activities than generic ones. This is particularly reflected in the research expenditure, invention disclosures, patent applications and license income. Looking at the relative productivity by comparing some input indicators to output measures, it was shown that despite the larger critical mass of specific PROs in terms of persons employed in the technology transfer departments, the number of science-based entrepreneurial firms they start in a given year is not significantly different from the generic PROs which seem to have a less elaborated technology transfer office. This seems to suggest that the research portfolio is the critical factor in the establishment of SBEFs and that the TTO plays a mediating role.

Second, we tested whether institutional origin predicts firm resources at time of founding. We found that spin offs clearly display higher capital levels than the start-ups in the sample. The fact that the spin offs are established with higher capital levels reflects that PROs want to value their technology by converting it into equity shares. In turn, this leads to a higher valuation of the venture at time of founding and, by definition, to higher capital levels (otherwise the PRO would own 90 + % of the company). In this respect it is interesting to find that the spin offs from specific PROs start up at an even larger scale than the spin offs from the generic PROs. Conversely, the start-ups from the PROs with a specific research base show the lowest resource levels. This might indicate two interrelated issues. Firstly, setting up start-ups seems to be of less strategic importance for PROs that specialise in one or a number of technological domains. This would be in line in what we found in a parallel study (Moray and Clarysse, 2004): IMEC, for example changed its strategy the last 5 years to focusing on establishing spin offs. But even when the research institute was only active in spinning off ‘start-ups’ (late eighties - early nineties), these companies were significantly ‘smaller’ as compared to the spin offs from other PROs (Moray, 2004). Secondly, in the same study we found that the average starting capital of the science-based entrepreneurial firms from a specific PRO has more than quadrupled over the last ten years. This increase in capital went together with the professionalisation of the technology transfer office and an increasing focus on transfer of intellectual property into new companies. Thus, if PROs want to commercialise their technology using spin offs as a vehicle, this usually means that they need to set up an equity relation with the new firm. However, doing so, this boosts the value of the company at time of founding and makes external capital a necessity to balance the shareholder structure. In order to attract capital, the business plan needs to be more ambitious, more oriented on quick return ad growth and more focused on exit related valuation. All this implies however, that even more capital is needed while only a few of all invention disclosures have the intrinsic potential to establish such a growth path. This seems to be what professionalized TTOs at specific PROs are learning: if one wants to create spin offs with the potential to become high growth ventures, scrutinised selection of ideas needs to be done, much support will be needed to incubate them and they will have to be established at sufficiently large scale. Ideas that not match these criteria are much less likely to receive a formal transfer of technology in terms of equity participation, but start up as a small SME. This is much less true for generic PROs where also start-ups -- receiving informal know how – tend to be guided towards the public / private equity funds and start at a larger scale. A lot of these generic PROs are universities that want to meet today's expectations of being an "entrepreneurial university". Following a second academic revolution (after research had complemented their teaching mission), they also want to envision themselves as hotbeds of entrepreneurial activity. In this perspective, it is likely that they equally want to emphasise spin offs and start-ups, resulting in a supportive structure for both types of firms. This interconnectedness of different objectives may partly explain the fact that start-ups and spin offs from generic PROs do not differ as much in their starting resources as spin offs and start-ups in general.

To conclude, the mechanism by which research organisations have traditionally developed and commercialised a technology: licensing of an intellectual property to a large, established firm who ultimately develops the technology in a saleable good (Powers and McDougall, 2004), still happens much more frequently than establishing SBEFs. Licensing or equity participation to a new firm has become a logical extension and potential trade off. This alternative commercialisation route represents research organisations' efforts at increasing external prestige and legitimacy (Feldman et al., 2002) enhancing revenues streams (Bray and Lee, 2000). The Lambert Review of Business-University Collaboration (2003) raises concern that some public research organisations may be actually setting too high a price on their IP. It is argued in this respect that public funding for research, and for the development of technology transfer offices, is intended to benefit the economy as a whole rather than to create significant new sources of revenues for the research organisations.

Finally, without having the ambition of performing an in depth growth analysis, we looked at whether spin offs display higher growth as compared to start-ups. This analysis is informed by the fact that European public research organisations have been strongly stimulated by policy makers to focus on the commercialisation of intellectual property, because of the greater awareness that results of scientific research, in the form of IP that can be protected through patents and copyright, contributes to technological innovation and economic growth (OECD, 2003, p21). Hence, for PROs having a critical mass of science-based entrepreneurial firms in general and spin offs in particular seems to be an important signal to the broader environment and policy makers that PROs research activities provide sufficient return to society.
The regression results indicate that the formality of technology transfer has an isolated effect on employee and capital growth, irrespective of the start capital. In practice this means that having protected technology formally transferred into the company is a powerful predictor of employment and capital growth in the subsequent years, irrespective of the level of start capital. Thus, receiving a formal transfer of technology does not only impact the start capital but also the capital that can be attracted in the years to come. This reinforces our finding that these ventures are under scrutinised selection procedures since most ideas have not the intrinsic potential to justify a large capital basis and subsequent capital injections. Further, these companies need be incubated or embedded in a supportive entrepreneurial / business development network, to raise their chance on success.

These results open the perspective for policy makers to be cautious for focusing their measures solely to (IP based) spin off companies, which are argued to have most potential to become high growth ventures, given the breadth of their technology platform, the possibility of mass production of a revolutionary product / new material and / or the scope of their market. Technology transfer offices have often been established or re-structured exactly to serve this type of science-based entrepreneurial firms. Start-ups however, embody tacit know how and often do not require a full-fledged organisational structure to support the start-up process. However, in some cases we observe that companies that could potentially start without formal transfer of technology from the PRO, are expected to do so given the upsurge of the phenomenon since the mid nineties, resulting in high valuations and necessary capitalisations. From a purely economic development perspective, stimulating start-ups could be argued to be equally important, especially given the lower costs involved in setting up these ventures.

Contribution to theory and limitations

This study contributes indirectly to theory in that it dynamically integrates elements of two theoretical perspectives in one empirical analysis that have traditionally been argued to emphasise competing aspects of an organisation's struggle for viability and competitive advantage. Resource dependence theorists posit that firms differ in their possession of resources and that, if used effectively, this resource asymmetry can be a source of sustained competitive advantage (Barney, 1996; 2001). Institutional theorists however, suggest that -- while resource based theory assumes that resource acquisition is guided by economically rational choices motivated by efficiency and profitability -- in fact, normatively rational choices are made for attracting the necessary resources, induced by historical precedent and social context (Oliver, 1997).

Based on these perspectives, we designed an empirical analyses typically focused towards better understanding the potential predictive capacity of institutional origin on the founding resources and growth of science-based entrepreneurial firms. The research has shown that institutional origin matters and therefore needs to be taken into account by technology transfer managers as well as potential, (academic) entrepreneurs when commercialising research results through setting up new ventures.

Our study also contribute to academic entrepreneurship research, in that this study is one of the very few attempts trying to better understand the intrinsic effect of institutional origin on the resource endowments of science-based entrepreneurial firms. Traditionally, researchers have looked at broader environmental circumstances in understanding the resource constraints and opportunities for new ventures. For example, the availability of venture capital or public capital in a region and a network of entrepreneurs / experienced managers have traditionally been argued to be important for the successful establishment of the resource base of a firm (Roberts, 1991). In most studies to date, resources of new firms are evaluated in view of their external environment and how the company succeeds in managing these interrelationships. This study substantially adds to these research endeavours by taking another lens: the parent organisation in general and the nature of the knowledge base, including varying emphases on respective transfer modalities seem to be equally important to take into account when assessing the founding resources and growth of science-based entrepreneurial firms. Interestingly, institutional origin seems to be an issue that cannot only be managed by an (academic) entrepreneur: it is also intrinsic to the PRO from which the company emerges.

Although this study offers new insights in sources of explanation for the diversity of science-based entrepreneurial firms, it is not without its limitations. First, the data of the technology transfer related activities from the public research organisations is limited to one year. Although for the purposes of our study – empirically validating the difference between PROs with a generic and a specific research base – this is not necessarily a problem it misses out a number of research opportunities to be addressed. One issue that could be tackled with multi year data is whether or not PROs with a specific research base do set up more spin offs as opposed to start-ups, for example during the last five years, in order to capture the broader institutional / environmental changes. Testing this intuition with the company data was not possible given the range of the period in which the ventures are established. Nevertheless, temporal considerations are a potentially important issue regarding the time horizons involved in potential strategic changes in setting up different types if science-based entrepreneurial firms. The same is true for developing a technology, licensing it, and seeing it produce an income stream (Powers and McDougall, 2004). Second, this offer does not offer insight in the intrinsic quality of the technology transfer offices. The indicators are used to display the numeric variation across PROs and as signals of technology transfer related activities. Today, a lot of European PROs run their own technology transfer operations. Following Lambert (2003), this study opens up the question whether all these PROs have a strong enough research base to be able to build the high-quality offices of their own. Further research should shed light on whether or not the development of shared services in technology transfer on a regional basis and/or technological specialisation basis should be encouraged. Third, since some companies in the sample are still relatively young (ranging from 1 – 13 years), it might be too early to rightfully assess the growth that these companies display. On the other hand, this is not necessarily a problem for our research purpose, which was specifically aimed at discerning the individual impact of the formal transfer of technology and start capital on the growth in employees and capital science-based entrepreneurial firms display.

FIGURES AND TABLES

Figure 1: Plot of interaction effect in 2X2 factorial design MANOVA

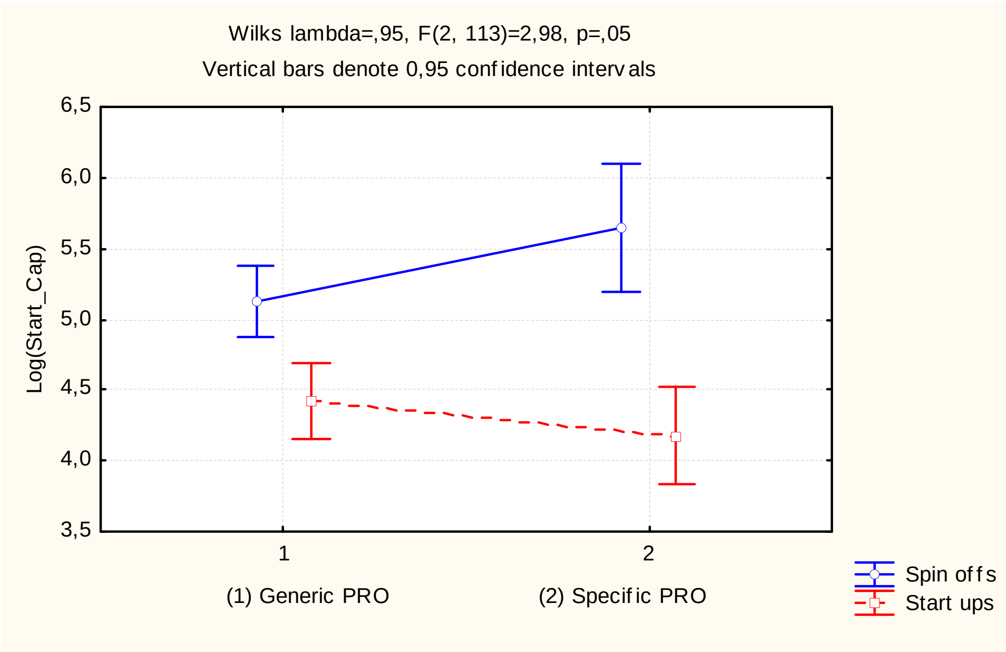

Table 1: Investment in R&D and output from de research sector

Selected regions in Europe	R&D expenditure as % of GDP, 2001 (1)	Number of Researchers / 1000 labour force (2)	Articles per researcher (2)	Number of triadic patent families per million population (3)	**Rank**	Share of triadic patent families in total applications (3)	**Rank**
EU-15	*1,93*	*5*	*0,3*	*36,61*		*32,39%*	
Sweden	3,78	8,6	0,37	102,39	2	4,16%	7
Belgium	1,96			37,66	11	0,9%	12
Germany	2,52	5,9	0,25	73,02	5	14,07%	4
Hungary	0,95					0,07%	26
France	2,13	6	0,29	35,23	13	4,99%	5
Italy	1,04	3,2	0,36	12,4	19	1,68%	9
UK	1,84	5,1	0,44	30,26	15	4,16%	6

(1) GDP = Gross Domestic Product
(2) OECD, MSTI Database, 2000

(3) OECD, Patent Database, July 2003, 1999 estimates; Patents all applied for at the EPO, USPTO and JPO.

Table 2: Descriptive data and non parametric tests for generic and specific PROs

Data for 2002	**M-U**	**GENERIC PRO'S**				**SPECIFIC PRO'S**			
Variables	**P level**	N	Mean	Median	SD	N	Mean	Median	SD
Research expenditure, mio €	0,04 **	21	75,9	48,9	72,4	12	247,9	132,8	402
IP protection expenditure, K €	0,2	23	246,3	100	424,3	13	1016	100	1749
Invention disclosures	0,1 *	23	27,4	14	33,3	12	65,8	29,5	79,4
Patent applications US	0,005 ***	21	1,3	0	2,4	11	30,6	3	57,7
Patent applications EU	0,01 **	12	1,7	0	2,5	10	18	12,5	18
Total active license agreements, options, assignments	0,6	24	30	8	43,9	12	97	20,5	164
License income 2002, K €	0,1 *	23	445,4	80	775,5	13	2560,9	6,70	4392
Number of spin offs	0,5	26	2,4	2	2,5	15	3,3	2	3,4
Number of start-ups	0,5	26	3,7	1	5,5	14	2,6	0,5	5,5
Age of Technology Transfer Office	0,08 *	31	7,4	6	6,8	15	12	9	10
FTE in Technology Transfer	0,08 *	31	5,9	4	5,2	15	17	8	24,7
FTE in licensing	0,1 *	31	2,3	1,5	2,3	15	6	2,5	9
FTE for SBEF	0,1 *	31	2,05	1,3	2	15	3	3	2,7

* p < or = 0,1   ** p < or = 0,05   *** p < or = 0,01

FTE=Full Time Equivalents
SBEF=Science-based entrepreneurial firm

Table 3: Comparative output indicators for generic and specific PROs

Median	**M-U, p value**	**Generic PRO (Valid N)**	**Specific PRO (Valid N)**
License income / FTE in licensing	**0,09 ***	47 190 € (18)	250 000 € (11)
License income / patent EU	**0,04 ****	7140 € (4)	86 110 (7)
License income / IP protection expenditure, K €	0,25	0,54 (19)	1,7 (10)
SBEF / Patents EU	**0,04 ****	1 (5)	0,11 (7)
FTE SBEF / SBEF	0,27	0,5 (23)	0,6 (12)
FTE TT, licensing and SBEF / SBEF	**0,08 ***	2,33 (23)	5,6 (12)

* p < or = 0,1 ** p < or = 0,05 *** p < or = 0,01

Table 4: Means, standard deviations and correlations

*** p < 0,05**	Total capital	Empl.	Growth capital	Growth empl.	Age
Resources at time of founding					
1. Total Capital, K €					
2. Employees, N	**0,38***				
Growth measures					
3. Average annual growth in capital, K€	0,08	0,11			
4. Average annual growth in employees, N	**0,32***	0,16	**0,41***		
Contextual variable					
5. Age (years)	-0,04	0,1	-0,12	**-0,30***	
Mean	587	3	1004	3	5
Median	45	2	0	0,82	4
SD	1508	6	4083	8	3
Valid N	151	162	124	160	184

Table 5: MANOVA for founding resources: Start capital and number of employees

MANOVA	Wilks Lambda	Pillai's criterion	Df	F	P
Formality of technology transfer (a)	0,71	0,29	2	23,22	**0,00**
Research focus (b)	0,98	0,02	2	1,14	0,32
Formality * research focus (c)	0,95	0,05	2	2,99	**0,05**

Adjusted R^2 = 28%

Table 6: Post hoc tests for hypothesis two

	Spin offs from specific PROs (1)		**Spin offs from generic PROs (2)**		**Start-ups from specific PROs (3)**		**Start-ups from generic PROs (4)**		**Total Sample**		**Scheffe test**
	Mean (Sd)	N	Mean (Sd)	N	Mean (Sd)	N	Mean (Sd)	N	Mean (Sd)	N	
Start capital, K €	2137 (2769)	25	566 (1213)	52	51 (1138)	33	102 (239)	40	587 (1508)	151	**1 > 2 **** **1 > 3, 4 ***** **2 > 3 ***** **2 > 4 ****** 3 < 4
Employees	3 (3)	22	3,8 (4)	55	3,15 (8,4)	36	3,4 (6,1)	47	3,4 (6)	162	2 > 3,4 3 < 4

* p < or = 0,1   ** p < or = 0,05   *** p < or = 0,01   ****p < or =0,001

Table 7: Two-stage least-squares regression to test hypothesis 3

	STAGE 1		**STAGE 2**			
Variables	**Start capital** Beta (St. err.)	Sign	**Growth in employees** Beta (St. err.)	Sign	**Growth in capital** Beta (St. err.)	Sign
Formality of technology transfer	0,45 (0,14)	**0,000** ****	0,22 (0,12)	**0,03 ****	0,29 (0,41)	**0,04 ****
Employees	0,26 (0,21)	**0,001** ****	0,12 (0,19)	0,24	0,2 (0,59)	0,17
Life sciences firm	0,18 (0,18)	**0,02** **	0,81 (0,14)	0,4	0,11 (0,48)	0,44
Age	-0,09 (0,02)	0,19	-0,35 (0,02)	**0,001** ****	-0,24 (0,07)	0,1
Residual			0,12 (0,06)	0,21	0,07 (0,21)	0,62
R Sq	36%		21%		25%	
R Sq adjusted	34%		16%		16%	
F	16,07		4,6		2,7	
P model		**0,000** ****		**0,01** ***		**0,03** **

** p < or = 0,05   *** p < or = 0,01   **** p < or = 0,001

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