Asia Triple Helix Society Summer Seminar, 25 June 2014, Daegu South-Korea

Triple Helix Interaction: Importance of Spin-off Firms' Networks and the University as Partner

Marina van Geenhuizen*, Mozhdeh Taheri*, Danny Soetanto**
*Faculty of Technology, Policy and Management,
Delft University of Technology, The Netherlands.
E-mail: m.s.vangeenhuizen@tudelft.nl
**Lancaster Business School, University of Lancaster, UK

1. INTRODUCTION

Though transfer of knowledge from university to the business world is not a new phenomenon, scholars do agree that developments in the 1990s and 2000s both in the US and Europe, including measures that regulate intellectual property rights, have implied a more direct and broader involvement of universities in the business world (van Looy et al., 2011; Mowery et al., 2004). In this vein, universities are not only seen as creators of new knowledge but also as being involved in contract-research commissioned by the business sector, in collaborative research projects with business partners, in the creation of spin-off firms, etc. (Etzkowitz, 2008; van Geenhuizen and Nijkamp, 2006; Shane, 2004). For a long time, however, academics have isolated themselves from problems in society and value creation using inventions, with the aim to be involved in 'value-free' research, a situation which we may qualify as 'ivory tower'. Accordingly, the issue in the US and Europe today is not to establish knowledge interaction between universities, business world and society, but to improve a small effectiveness of the existing interaction, in a time in which the pressure from the knowledge economy gets stronger. A low effectiveness holds true for university spin-off firms in Europe as most of them stay (very) small (Mustar et al. 2008), for technology transfer offices suffering from a lack of capabilities (Geuna and Muscio, 2009), and for direct university-business links that are less productive due to different cultures and attitudes (Bruneel et al., 2010).

Of the various channels used in the commercialization of university knowledge, spin-off firms established by university staff and/or graduates have attracted most attention (D'Este and Patel, 2007). This is not only because spin-off firms are clearly visible and can be easily used in marketing by the university and local authorities, they are also thought to contribute to a larger diffusion of new knowledge and to an improved business ecosystem while bringing various multiplier effects in the region (Huggins and Johnston, 2009). As above indicated, spin-off firms' growth in Europe stays behind expectations, as can be illustrated with an average employment growth since the start for two pooled samples in Europe of 1.2 fte (full time equivalent) and 1.6 fte per year (van Geenhuizen and Ye, 2012; Taheri, 2013).

The modest growth level urges a pressing need to identify and better understand the causes and circumstances that inhibit growth (Taheri, 2013). To this purpose, the paper adopts the resource-based view and related network perspective to growth.

Within a resource-based view on small firms, main attention is given to internal resources in the founding team and to the ability to access external resources that are valuable, unique and unparalleled, inimitable and non-substitutable, all causing a clear competitive edge over other firms (Barney, 1991; Barney and Clark, 2007; Lavie, 2006; McEvily and Marcus, 2005; Wernerfelt, 1995). There are however, some controversies in the empirical results so far, particularly about the impact of diversity in the founding team, that can be summarized as 'lack of integration between different members' versus 'benefits from rich information from different members' (Chowdury, 2005; Colombo and Grilli, 2010; Horwitz and Horwitz, 2007). In the context of networks, special attention in the paper is given to the university as the parent organization, that could typically provide access to financial capital, credibility and legitimacy.

The focus in the paper is on the Netherlands, and to a smaller extent to Norway. The Netherlands serves as an example for a larger group of European countries that are facing the so-called 'knowledge paradox' of a relatively high R&D input and a low innovation output (or growth) (Audretsch and Keilbach, 2008; Bitard et al., 2008). Conform the idea of the paradox, a good performance is found in scientific knowledge production and collaboration while performance scores are much lower for indicators such as in-house innovation among small and medium-sized enterprises (SMEs) and introduction of various types of innovation by these firms (ProInno Europe, 2011).

The paper unfolds as follows. First, the knowledge paradox of the Netherlands and various other European Union countries is highlighted (section 2). Attention then moves to theoretical insights that help understanding the variation in growth of university spin-off firms, particularly the role of their networks (section 3). Next, methodological aspects of the empirical results study are discussed (section 4) and empirical results are presented on the influence of networks on growth compared to the influence of the founding team on growth (section 5). A special analysis of the networks with the university follows in section 6, both in terms of attributes of the networks and type of influence, linear and non-linear. Implications of the results regarding policy and further research conclude the paper.

2. KNOWLEDGE PARADOX

The Netherlands is the home of 14 government approved research universities, 13 of which focus on research as well as education (offering bachelors, masters and PhD degrees). Among the research universities there are three universities of technology, in the cities of Delft, Eindhoven and Enschede. Aside from research universities, there are universities of applied sciences (not covered in this paper). The Netherlands is also home to many non-university research institutes, most of them publicly funded, such as the institutes connected with the Netherlands Organization for Scientific Research (NWO) and those connected to the Royal Netherlands Academy of Arts and Sciences (KNAW).

Government policy for research and innovation at the national level in the Netherlands is the joint responsibility of the Ministry of Economics, Agriculture and Innovation and the Ministry of Education, Culture and Science. Support to spin-off firms from universities goes back to the late 1990s with different national arrangements for different sectors, like biotechnology and ICT, but also different local arrangements. Since 2004, the so-called Action Program TechnoPartner (MEZ, 2004) provides a unified national set of support for university spin-offs, this as one step in various efforts to accelerate bringing The Netherlands back into the top 5 European countries (Innovation Platform, 2010). Since 2008, the Innovation Platform has been actively involved in commercialization of university knowledge.

With regard to production of scientific knowledge, we may observe identical patterns in various small and some large European economies qualified as 'innovation followers', such as Austria, Belgium, Norway and UK (Pro-Inno 2011) (Table 1). For example, the Netherland compares with Norway with regard to the contrast between science-business co-publications and the relative low level of firm investment and SMEs innovative behavior. In Austria, the contrast is somewhat smaller, except for venture capital. The Netherlands and UK compare with regard to modest investment levels, except for high levels of venture capital in UK, and modest SME innovation performance, i.e. innovation introduction and sales of innovations. In order to picture some of the differences with 'innovation leaders', Finland is also shown in Table 1. At least on six of the selected indicators Finland gains relatively high scores. Given the relatively good performance in science and publications, but poor performance of innovation output indicators mainly connected to SMEs, we may assume that many barriers seriously hinder university commercialization processes and growth of university spin-off firms in the Netherlands.

Table 1 Scores on selected science and innovation performance indicators

	NL	**Austria**	**Belgium**	**UK**	**Norway**	**Finland**
-Intern. scientific co-publications	>250	>250	> 300	>250	n.a.	>300
-Worldwide scientific citations	137	108	122	118	106	101
-Public-private co-publications	248	156	170	171	>240	290
-Public R&D expenditure	128	108	83	89	115	148
-Venture capital	100	26	128	>250	95	131
-Business R&D expenditure	70	155	106	93	76	226
-Non-R&D innovation expenditure	73	66	80	n.a.	15	80
-SMEs innovating in-house	87	113	133	n.a.	84	127
-Collaboration innovative SMEs	116	132	199	240	117	137
-SMEs introducing product/ process innovation	92	116	129	73	85	122
-SMEs introducing market or organizational innovation	73	109	113	79	79	81`
-Sales of innovations new to market or to firm	67	85	72	55	25	118

Source: Pro-Inno 2011 (EU-27 Innovation Union Scoreboard) EU-27 =100. Adapted from van Geenhuizen (2013).

3. THEORY AND MODEL BUILDING

In general, the decision by spin-off firms to take an invention to market and the subsequent speed of market introduction of a new product, process, method etc. depend among others on the character of the invention in terms of being radical or incremental (Utterback, 1996; Christensen, 2003). Radical inventions require structural changes in infrastructures - like the fuelling infrastructure in the case of electric cars – reason why they face more obstructions than inventions that are incremental and fit into existing structures (Geels, 2004). Of course, the amount of investment capital necessary for development activity plays a role in the decision of spin-offs to bring an invention to market or to continue this process, and this may be more pronounced if regulation is strong, including testing procedures and approval, like in medical biotechnology. The remaining section discusses theoretical perspectives and empirical results on learning in teams and networks, and on the relationship with the university. It also highlights the main components of the models concerned.

Teams, networks and growth

According to the upper-echelon perspective on firms, the quality of the founding team and subsequent management team are perceived to have main impacts on the performance of start-up firms (e.g. Agarwal et al., 2004; Fern et al., 2012). Given the absence of hierarchal structures in new ventures, the tasks of coordination and strategic planning are mainly performed by the founding team. In this vein, a large number of studies in recent years focused on team diversity (Ensley and Hmieleski, 2005; Amason, 2006; Fern et al., 2012), in terms of age, gender, cultural background (nationality), education, functional and industry experience, business skills, academic members, etc. (Beckman et al., 2007), each of these attributes being connected with a different availability and access to resources. This conceptualization connects with the resource-based view as a major approach to firm growth in which the emphasis is on access to resources, enabling a firm to gain better growth opportunities compared to its competitors, while adjusting to the requirements of a changing environment. Resources are the set of tangible and intangible assets tied semi-permanently to the firm, like capital, research facilities, and experience gained from the past, and a firm competes to possess scarce and hard to imitate resources in order to be capable to stand ahead of other firms (Wernerfelt, 1995; Barney and Clark, 2007). Diversity in founding teams and networks allows for a positive use of resources if founding team members remain integrated and are able to enjoy the benefits from information richness, diverse knowledge and skills abilities.

We focus on diversity of team members in education type (discipline) and type of prestart working experience, because other diversity dimensions show minor variation in the current sample of spin-off firms. The challenge is to identify the direction of the impact of team diversity because there is no consensus in the results so-far. According to one line of argumentation, education type differences could create group fault lines (social categorization). Group fault lines could particularly arise with different types of disciplines through which team members have difficulty in understanding each other's language and narratives (Colombo and Grilli, 2010). By contrast, according to the cognitive resource perspective, diversity in education has a positive impact through the increase in skills and

abilities (practical and conceptual) and increase in information and knowledge richness (Hambrick et al., 1996; Williams and O'Reilly, 1998; Chowdury, 2005; Horwitz, 2005). Such a positive influence would particularly be true if the diversity deals with the distinct skills and abilities needed in exploration activity (research oriented) and those needed in exploitation activity (market oriented). Differences in professional experience of team members gained before starting the firm may also cause the rise of social categorization and creating fault lines accordingly (Pelled 1996; Horwitz 2005). Similar to educational differences, there are two opposing lines of argumentation. Less effective founding teams will be those that act according to social categorization and differences in business culture in which the experience has been achieved. By contrast, effective teams are those that take advantage of different skills and abilities and integrate them to avoid experience-based constraints (Delmar and Shane, 2006; Fern et al., 2012).

The establishment of external networks is seen as a vital way for young high-technology firms to access missing resources and to achieve new competences. In the literature, there is a rather clear consensus about the effect of diversity in networks on firms' performance, namely, positive, and such positive influence would be the more true if the gained resources allow being simultaneously active in research-oriented and market-oriented activity (Grandi and Grimaldi 2003; Reagans and McEvily, 2003; Simsek, 2009). In our model, we include two types of networks as the source of diversity, first the social network that typically develops in the early years with diversity in social background of the partners and interaction with the local/regional community (Brüderl and Preisendörfer, 1998; Johansson et al., 2005), and secondly, the international, more formal, network.

We also assume interaction effects between networks and the type of city (location) and the economic sector in which the spin-off operates, including different levels of competition. In many regional economic studies, the type of urban location is an important factor thought to influence innovative activities and growth of young firms, with large cities in metropolitan areas being better endowed with external resources compared to smaller towns and rural areas (Audretsch and Feldman, 1996; Capello, 2006). Accordingly, we expect that firms in isolated cities in rural regions experience a smaller growth due to lower levels of knowledge spillovers, less diversity in the labor market of knowledge workers, absence of launching customers, etc. (Gordon and McCann, 2000). With regard to the economic sector, competition in the market may cause different growth patterns (Laursen and Salter, 2006**),** but more importantly it may call firms to search for diversity in information/knowledge in different ways. Various studies indicate that the search for external knowledge is strongly influenced by the availability of technological opportunities and by the pressure from other firms (Levinthal and March, 1993; Chesbrough, 2007). Thus, in industries with strong technological opportunities and competitive search by firms, there is a need to search for a higher diversity in knowledge (Laursen and Salter, 2006). In terms of interaction effects: while diversity in firm networks might have a positive influence on firm growth, a location in a metropolitan urban area might reinforce this influence, due to a larger availability of additional networks and information and other supporting urban assets, compared to isolated cities in more peripheral areas (Capello, 2006). Furthermore, the business environment may

play a role in influencing impacts from social networks. In a highly competitive market, there is a rapid change in demand, competitors and quick technology changes. Thus, firms have to be flexible and agile in a range of activities from acquiring, scanning, selecting and assimilating of external knowledge to enable a quick and adaptive responding. Young high-technology firms, however, due to limited resources, cannot easily manage multiple networking activities and taking benefits from them necessary in giving quick, adaptive responses under fierce competition (Simsek, 2009; Mohr et al., 2010), reason to assume that the beneficial influences of diverse ties are likely to be dampened in a highly competitive environment.

In the growth models on employment and turnover, we control for some additional factors from various backgrounds. First, the early growth strategy by considering the team's vision on opportunities for growth in terms of size and globalization (Wiklund et al., 2009). We also control for year of establishment indicating age and cohort effects, size of the founding team, and education level of the founding team. While age and pre-start experience of founders are found to have contradictory influence on firm performance (Colombo and Grilli, 2005; Feeser and Willard, 2006), education level seems a more straightforward positive influence, as team members with a higher education and related higher credibility tend to attract more funding and other resources to the firm (Colombo and Grilli, 2010).

Networks with university

It is from the university that spin-offs receive their initial and much needed resources, such as access to research facilities, temporary accommodation, knowledge on patenting, manufacturing and practical issues (Lindelöf and Löfsten, 2004). More importantly, the university often provides access to public funding (pre-seed capital) under favourable conditions that allows spin-offs to develop their invention in the very early stage, often together or followed by support from family and friends. A spin-off's decision which funding to select can be understood by the 'pecking order hypothesis; (Myers, 1984; Myers and Majluf, 1984). The theory assumes that any small firm would prefer to use internal funding and funding by family/friends rather than funding generated from debt or equity connected to banks or venture capital firms. External funding by (financial) organizations is riskier and would acquire an equity control or stake in the spin-off firm. On the other side, internal funding is often insufficient and spin-offs need to seek additional capital sources. Compared to the US, the option for external financing from private organizations, like venture funds, is also relatively limited for European spin-offs (Saetre et al., 2006). In the US, there is more venture capital available and also in earlier development stages of spin-offs. In a situation in which the venture capital market is still underdeveloped, we would expect spin-offs in Europe to look for different forms of funding from or acquired through the university as an alternative to private investment (Wright et al., 2006).

We may distinguish between direct and indirect involvement of the university. Direct involvement means that the university actively provides funding for spin-offs. This funding originates from the government or industry, but it is delivered through university involvement. In some cases, researchers at university work together with academic spin-offs in submitting

grant proposals, like in EU research programs, while in other cases, university researchers provide spin-offs with contract research. The indirect role of university can involve promoting the spin-offs' image in the eyes of potential investors. Like other new start-ups, academic spin-offs are constrained by their limited legitimacy, credibility and acceptance from external investors and other providers of financial resources (Lockett et al., 2002; Moray and Clarysse, 2005). The ties developed with the university can help improve a spin-off's reputation and legitimacy and attract interest from potential investors, such as industrial leaders and agents concerning public sources. We mention that not all university influence on attracting funding for spin-offs go through the spin-off's network, for example, the transfer office may also be involved.

In an in-depth exploration of university networks, we distinguish various network characteristic that may influence performance in gaining financial resources. We limit the model to the following characteristics: size as number of partners, density as the mutual connection of ego's partners, strength as frequency of interaction, and multiplexity as number of different knowledge domains involved in the network. In addition, we also explore the type of relations, both linear and curvilinear. By adopting an evolutionary perspective, taking general ideas on increasing/decreasing returns and path dependency into account (Arthur, 1994; Grabher, 1993), we may expect increasing returns if networks are built and elaborated, for example derived from experience, followed - after a certain point – by diminishing returns, accompanied by lock-in effects (Ebers, 2003; Fried et al., 2006; Maurer and Ebers, 2006). These negative effects tend to impede the ability of spin-offs to adapt to the new configuration of their networks, as it takes more time and effort to build trust and adjust to new routines, with regard to the size, density, strength and multiplexity of the networks. The network may still provide support to spin-offs, but it offers limited scope and value added. Based on this assumption, we argue that a spin-off's ability to obtain funding will be diminished if it keeps depending heavily on the university network.

4. METHODOLOGICAL ASPECTS

The sample used in this paper, is a given sample drawn from two universities in Europe, Delft University of Technology (Delft, the Netherlands) and the Norwegian University of Science and Technology (NTNU) (Trondheim, Norway). The incubator organizations were identified as two different cases, mainly due to urban location, core metropolitan (Delft) versus non-metropolitan peripheral (Trondheim). By contrast, we assumed there are no significant differences between the national innovation systems of the two countries, they share a somewhat risk-avoiding entrepreneurship culture (GEM, 2010), show as previously discussed similar scores on the European Innovation Scoreboard indicators (ProInno Europe, 2011), and both have relatively small domestic markets.

The population of spin-off firms from the two universities satisfies two important conditions: involved in the commercialization of university knowledge and survived to 2006/7 with an age not older than 10 years. All the firms in the population (150) were contacted and the overall response rate was 70 per cent. In 2006/7, data were collected using a semi-structured questionnaire in face-to-face interviews with the firms' principal

manager(s) (founding team), using a focus on firm characteristics (e.g. product/service, sector, firm size, R&D, profile of the founding team members and profiles of the networks, particularly the social network and university relationships). In 2011, data were collected on firm size, in terms of employment and turnover and on changes in main products/services, using e-mail, telephone, and wherever necessary, websites.

We apply multiple regression analysis to explore the influence of a firm's founding team and network diversity on growth. With regard to employment growth, measured on a continuous scale, ordinary least square regression is a reasonable choice if mostly linear relationships are expected. Further, we use ordered logistic regression to estimate the influence of the same variables on turnover growth, this variable is measured as an ordinal variable in five classes. The model results are presented in a stepwise approach, differentiating between the model with controls, the model including team diversity only, the model with network diversity only, the full model including both team and network diversity, and the full model including various interaction effects.

We check for multi-collinearity as a common routine, and we also check for reverse causality and simultaneity bias - since all the explanatory variables, except for network diversity, are measured at firm foundation, and the results reveal no cause for concern. Regarding network diversity variables, as both diversity through social networks and through international networks are measured after firm foundation, we test for endogeneity of employment growth and turnover growth. In both tests, endogeneity of the dependent variable is rejected, and the results of regression are found to be consistent. Appendix 1 shows outcomes of various tests. In addition, in exploring the influence of university networks on attracting financial sources by spin-offs, we also use stepwise regression, and aside from a linear model we also include non-linear models. We perform similar tests and these provide results which cause no serious concern. Measurement of the variables are given in Table 2 and Table 3, including descriptive statistics.

In measuring the *dependent* variable in the analysis of the university network (Table 3), we take substantial subsidies, external (equity) investment and other professional funding as a percentage share of turnover used for R&D over the last three years. For new ventures without a portfolio, the success in attracting financial capital for innovation reflect their ability to tackle liabilities of newness. According to Clarysse et al. (2007), start-up investment in the early years of establishment, especially prior to initial public offering (IPO), can be seen as a performance variable. How the independent variables, representing the model components, are measured, is shown in Table 3.

Table 2 Measurement of growth model variables and descriptive statistics

Variables	Measurement	Descriptive statistics
Dependent variables		
Employment growth since start	Continuous variable as growth until 2010 (fte)	Average: 1.20; s.d.: 2.57; Median: 0.55; Min-Max: -1-16.3
Turnover growth since start	Categorical variable in five classes	Failed without turnover: 15.5% X <100,000 Euro: 13.5% 100,000 <=X <300,000: 13.5% 300,000 <=X <500,000: 11.5% X >500,000 : 46%
Controls		
Early growth strategy	Variable in three categories	Large and international (37%) Small and international (53%) Small and local (10%)
Competition	Variable in two categories	Many competitors (65%) Few/no competitors (35%)
Year of foundation	Continuous variable as the year of foundation	Average: 2001.1 Standard deviation: 3.08 Min-max: 1996-2006
Urban location	Variable in two categories (cities)	Core, metropolitan (58%) versus small city (peripheral) (42%)
Founding team education	Continuous variable as number of doctorate degrees among members	Average: 0.61; s.d.: 0.88; Min-max:0-3
Founding team size	Continuous variable as number of team members	Average: 2.29; s.d.:1.19; Min-max:1-5
Founding team diversity		
Education diversity	Continuous variable derived from three types of education; calculated using $(1-\sum p_i^2)$, where *p* is the proportion (per cent) of team members in a category and *i* is the number of different categories	Average: 0.51; s.d.: 0.32 Min-max:0 - 0.89
Pre-start experience diversity	Continuous variable derived from experience of founders, i.e. technical, managerial and others; calculated using $(1-\sum p_i^2)$\, where *p* is the proportion (per cent) of team members in a category and *i* is the number of different categories	Average: 0.48; s.d.: 0.39 Min-max: 0 – 0.89
Network Diversity		
International networks	Variable in two categories indicating established knowledge relations abroad (customers, suppliers, knowledge institutes, etc.)	Yes (62%), No (38%)
Social network diversity	Continuous variable as explained in Appendix 1	Average: 0.34; s.d.: 0.18 Min-max: 0-0.88

N (firms) = 105

Table 3 Measurement of model variables of attracting financial capital and descriptives

Variables	Measurement	Descriptive statistics
Dependent variable		
Attracted financial capital	Continuous variable as the sum of professional capital attracted as a percentage share of turnover, used for R&D over the last three years	Average: 20.79; s.d: 23.82
Independent variables (model components)		
Network size	Continuous variable as the total number of partners in the network, with the maximum set at a core of five partners.	University network: Average: 1.14; s.d.: 0.86 Non-university network: Average: 2.52; s.d.: 1.15 Min-max: 1-5
Network density	Continuous variable as an index based on the extent network partners are connected to each other. A high value indicates a relatively dense network.	University network: Average: 0.81; s.d.: 0.64 Non-university network: Average: 0.49; s.d.: 0.31 Min-max: 0-1
Strength of relationships a)	Continuous variable derived from the number of interactions with each partner on a weekly basis, on the basis of the network as shaped in the last three years.	University network: Average: 0.43; s.d.: 0.25 Non-university network: Average: 0.47; s.d.: 0.24 Min-max: 0-1
Multiplexity	Continuous variable as an index of diversity based on the share of three knowledge domains: markets and related topics, management, and technology and innovation.	University network: Average: 0.37; s.d.: 0.25 Non-university network: Average: 0.55; s.d.: 0.31 Min-max: 0-1

a) Strength is often measured as a combination of frequency of interaction, emotional intensity and time of existence of the relationship (Burt, 1992). However, these three indicators in our sample did not correlate in a linear way and were not compatible with each other, reason why we selected frequency of interaction as the most obvious manifestation of them.

5. TEAM VERSUS NETWORK

This section explores the influence of diversity in a spin-off's founding team and in a spin-off's network on employment growth and turnover growth. The model results as presented in Table 4 and Table 5 include the various steps taken, i.e. entering the set of control variables, founding team diversity variables, network diversity variables and finally interaction effects, all including the model power, R^2, at each step. With regard to employment, in Model 1, only control variables are included, while R^2 (0.15) is reached. Next (Model 2), the variables of founding team diversity are added making the model power to only slightly increase (0.01) while no more coefficients become significant. Model 3, however, improves substantially having the two network diversity factors added, as witnessed by R^2 increasing from 0.16 to 0.34. In this model (Model 3), five variables' coefficients are significant. In Model 4 to 6 interaction effects are added, with interaction between social network diversity and type of city producing another substantial increase of R^2, i.e. from 0.34 to 0.44 (Model 5). Model 5, accordingly, turns out to be the best model.

In more detail, with regard to the control variables, the coefficient of number of PhDs in the founding team appears negative and significant, thus pointing to a smaller growth if one of the founding team members has PhD level skills and experience. This situation is surprising given previous results, but can be understood as follows. As 72 per cent of the firms with founding members owning a PhD are involved in highly innovative activities and 40 per cent of them in science-based industries, they are more likely to be involved in longer periods of product development and a lagging employment growth compared to the other spin-offs. The sign of all other significant coefficients of control variables in Model 3 are as expected.
Remarkably, inserting diversity through founding team members in the model does not yield significant results. This pattern is in line with several studies, for example, Chowdhury (2005). However, including firm diversity through networks, a substantial model improvement is apparent while the two network coefficients are positive and significant. Apparently, diversity through social networks and through business networks abroad supports a better firm performance in terms of employment growth. A positive impact of knowledge networking with a variety of firms (customers, suppliers, competitors) and organizations on a global level has also been observed in other studies (Knight and Cavusgil, 2004; Clercq et al., 2012).Young high-technology firms might be better in balancing exploration and exploitation through their diverse networks, which is in line with earlier studies (Reagans and McEvily, 2003; Simsek et al., 2009). In addition, a location in a core metropolitan area positively moderates the influence of network diversity on firm growth. Models 4 and 5 indicate that firms in core metropolitan areas benefit more strongly from their diverse social networks and international networks compared to firms in more isolated cities. As earlier suggested, this might be related to different qualities of the network, namely, a higher frequency of interaction between local/regional partners or stronger connectedness among them, but also a stronger presence of supportive networks in metropolitan areas compared to isolated cities.

Moreover, the interaction effect of social networks and competition is found negative and significant, indicating that being involved in a diverse social network in a business environment with many competitors, hinders spin-off firm growth. Apparently, it is hard for spin-off firms to manage and benefit from their external network relationships when they are facing a highly turbulent environment, resulting in a trend of lower employment growth.

Table 4 – Estimation of employment growth (OLS)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	β-coeff. (s.e.)	β-coeff. (s.e.)	β-coeff. (s.e.)	β-coeff. (s.e)	β-coeff. (s.e.)	β-coeff. (s.e.)
Controls						
Early growth strategy	1.28 (0.50) **	1.24 (0.50) **	0.92 (0.49) *	0.88 (0.49) *	0.95 (0.45) **	1.02 (0.49) **
Competition (strong = 1)	-0.64 (0.51)	-0.66 (0.51)	-0.75 (0.46)	-0.68 (0.46)	-0.48 (0.43)	-0.87 (0.46)*
Year of foundation	-0.06 (0.08)	-0.06 (0.08)	-0.00 (0.07)	-0.02 (0.07)	0.03 (0.07)	-0.00 (0.07)
City (metropolitan area = 1)	1.23 (0.50) **	1.21 (0.51) **	1.53 (0.47) †	0.46 (0.76)	1.58 (0.43) †	1.39 (0.46) †
Founding team education	-0.28 (0.40)	-0.26 (0.40)	-0.62 (0.38) *	-0.52 (0.38)	-0.49 (0.35)	-0.50 (0.37)
Founding size	0.26 (0.20)	0.41 (0.26)	0.23 (0.24)	0.21 (0.24)	0.28 (0.22)	0.24 (0.24)
Diversity: founding team						
Experience type	-	-0.30 (0.68)	-0.23 (0.62)	-0.54 (0.64)	-0.37 (0.57)	-0.32 (0.61)
Education type	-	1.07 (0.96)	0.03 (0.89)	-0.03 (0.88)	-0.04 (0.82)	0.12 (0.87)
Diversity: networks						
International networks	-	-	1.18 (0.50) **	0.13 (0.77)	1.17 (0.47) **	1.05 (0.50)**
Social networks	-	-	4.56 (1.36) †	4.71 (1.34) †	-0.00 (1.68)	8.44 (2.23) †
Interaction effects a)						
International networks x City	-	-	-	1.68 (0.94) *	-	-
Social networks x City	-	-	-	-	9.15 (2.23) †	-
Social networks x Competition	-	-	-	-	-	-5.59 (2.59)**
N	105	105	105	105	105	105
F	2.94 **	2.35 **	4.77 †	4.72 †	6.58 †	4.93†
R^2	0.15	0.16	0.34	0.36	0.44	0.37
Adjusted R^2	0.10	0.09	0.27	0.28	0.37	0.29
Root MSE	2.44	2.45	2.20	2.18	2.04	2.16

* P<0.1, ** P<0.05, *** P<0.01, †P<0.005. a) selection on significance.

Source: Adapted from Taheri (2013)

With regard to turnover, the following can be observed (Table 5). Model 1 includes all control variables. In Model 2, the variables covering founding team diversity are added, with pseudo-R^2 slightly increasing, from 0.06 to 0.09. An improvement of the model strength also occurs after inserting network diversity (Model 3), from 0.09 to 0.14. In this full model, a pseudo-R^2 is reached of 0.14 while six coefficients are found to be significant. After adding various interaction effects, the model strength does not increase substantially witness the best at a pseudo R^2 level of 0.16 (Model 4).

In more detail, regarding the control variables, the early growth strategy tends to have a positive effect in a consistent way. With regard to the founding year, firms that started earlier tend to experience a higher turnover growth, which may be because of easy access to financial and technical resources compared to younger firms (Freeman et al., 1983). Taking birth cohort and period effect into account, firms founded before 2000 have faced better chances of realizing turnover growth, possibly because, before the crisis, opportunities and access to resources were more favorable. With regard to diversity, the following trends can be observed. Diversity in the founding team, both through education level and type of pre-start experience, cause a smaller growth. This situation may be ascribed to a higher level of conflicts in teams with large diversity, in the context of taking strategic decisions (Hambrick and Mason 1984; Pelled 1996; Simsek 2009), potentially enhanced by the relatively young age of most spin-offs and the associated lack of management abilities and capacities to benefit from internal diversity. However, in contrast to founding team diversity but similar to employment growth, diversity through international networks and social networks turns out to have a positive influence on turnover growth.

In addition, as already suggested by the employment growth model, a location in a core metropolitan area positively moderates the influence of network diversity on turnover growth (Model 4), indicating that firms in core metropolitan areas benefit more strongly from their international networks in promoting growth compared to firms in more isolated cities. This might be related to different qualities of the network and different assets in the local/regional environment. Moreover, also suggested by the employment growth model, the interaction effect of network diversity and business competition level is found negative, but only significant for international networks, indicating that being involved in networks abroad in an environment with many competitors, tends to hinder spin-off firm growth. This situation could also indicate that young spin-off firms are not able to manage their external network relationships in highly turbulent business environments.

Table 5. Estimation of turnover growth (ordered logistic regression) a)

Variables	Model 1 Logit coeff. (S.E)	Model 2 Logit coeff. (s.e.)	Model 3 Logit coeff. (s.e.)	Model 4 Logit coeff. (s.e.)	Model 5 Logit coeff. (s.e.)
Controls					
Early growth strategy	0.91 (0.40) **	0.84 (0.41) **	0.87 (0.45) *	0.89 (0.46) *	0.85 (0.45) *
Competition (high level = 1)	-0.23 (0.41)	-0.13 (0.41)	-0.13 (0.43)	-0.06 (0.43)	0.75 (0.68)
Year of foundation	-0.23 (0.06) †	-0.25 (0.07) †	-0.27 (0.07) †	-0.29 (0.07) †	-0.27 (0.07) †
City (metropolitan area = 1)	0.56 (0.39)	0.47 (0.40)	0.59 (0.42)	-0.37 (0.65)	0.51 (0.42)
Founding team education	0.14 (0.31)	0.23 (0.32)	-0.13 (0.35)	-0.04 (0.35)	-0.06 (0.35)
Founding team size	0.21 (0.16)	-0.01 (0.20)	-0.08 (0.21)	-0.10 (0.21)	-0.12 (0.21)
Diversity: founding team					
Experience type	-	-1.04 (0.54) *	-1.03 (0.57) *	-1.40 (0.60) **	1.24 (0.59) **
Education type	-	-0.93 (0.77)	-1.81 (0.84) **	-1.95 (0.85) **	-1.80 (0.84) **
Diversity: networks					
International networks	-	-	1.21 (0.47) **	0.28 (0.67)	2.20 (0.77) †
Social networks	-	-	3.03 (1.34) **	3.30 (1.36) **	2.95 (1.36) **
Interaction effects b)					
International networks x City	-	-	-	1.63 (0.86)**	-
International Networks x Competition					-1.47 (0.88) *
N	104	104	104	104	104
LR Chi square	19.81 †	25.83 ***	42.82 †	46.43 †	45.65 †
Pseudo R^2	0.06	0.09	0.14	0.16	0.15
Log likelihood	-139.21	-136.21	-127.71	-125.91	-126.30

* P<0.1, ** P<0.05, *** P<0.01, †P<0.005 a) turnover measured in five classes; b) selection on significance.
Source: adapted from Taheri (2013)

6. UNIVERSITY NETWORKS

We next take a closer look at spin-offs' networks with the university by distinguishing between various attributes, like size, strength of ties, and information flows, and explore the influence on the ability of spin-offs to attract financial capital. In this in-depth analysis, we also explore to what extent the network influences are non-linear, indicating the phenomenon of decreasing returns.

Table 6 shows the characteristics of the university networks, compared to other networks. In terms of network size, the number of university contacts tends to be considerably smaller, witness an average of 1.14 contacts versus 2.52 for non-university contacts. This finding is interesting, as we initially thought that the university network is crucial and important to spin-offs, especially in the early years. However, the university network is significantly denser than

the non-university network, with a density index of 0.81 and 0.49 respectively. Spin-offs are usually well-connected with former colleagues, professors or other staff from previous study or work at the university, while the interviews indicated that the non-university networks had many different backgrounds making the network less dense. In addition, strength of university relationships - as indicated by the frequency of face-to-face interaction - tends to be somewhat higher than strength of non-university relationships, with 0.43 and 0.47 times per week respectively. With regard to the duration of relationships, there is no significant difference. The final network characteristic to be discussed here is multiplexity. Using diversity as an indicator, spin-offs with a high diversity in knowledge domains will be likely to score high in terms of network multiplexity. The results indicate that the network multiplexity index is significantly higher for non-university networks than for university networks, with scores of 0.55 and 0.37 respectively. In more detail, 70.8 per cent of the domains discussed between spin-offs and university network partners is related to technology and technical issues, including applications for national and EU research programs' funding, with other issues, like the market, as minor (25.5 per cent). This contrasts with a balanced set of domains discussed with non-university spin-offs, most of the domains involving the market (70.3 per cent), followed by small business and management (65.8 per cent) and technology and technical issues (40.9 per cent).

Table 6. Characteristics of university and non-university networks

	University	Non-university	t-test
Size of network	1.14 (0.86)	2.52 (1.15)	-9.54***
Density of network	0.81 (0.64)	0.49 (0.31)	3.23**
Strength of relationships	0.43 (0.25)	0.47 (0.24)	-0.36*
Duration of relationship (years)	5.05 (4.90)	4.64 (4.22)	0.85
Multiplexity	0.37 (0.25)	0.55 (0.31)	-4.35***
Share (%) of domains in discussion			
- market	25.5	70.3	
- small business and management	10.3	65.8	
- technology and technical issues	70.8	40.9	

*p<0.10; ** p<0.05; *** p<0.01 (two-tailed test)

In order to explore the nature of the influence of university networks on spin-offs' ability to attract financial capital, two sets of models are estimated, linear and curvilinear (quadratic terms). The results are shown separately, for the linear model (Model 1, 3, 5, 7) and for the curvilinear model (Model 2, 4, 6, 8) (Table 7). In most models, the control variables turn out to be not significant, except for age and level of innovativeness in several models. The sign of age is negative, which indicates that younger spin-offs are more likely to attract external funding for their research and development activities. This result is consistent with the logic that younger spin-offs still need to attract financial capital and are highly active in finding financial resources, whereas older firms, which have already accessed the market, have a different focus, namely expanding the market. With regard to level of innovativeness, which is measured based on patenting and newness of the product in the market, the results show a positive and significant relationship with the ability to attract funding. This finding can be understood as follows: spin-offs involved in highly innovative product development are more likely to need a

lot of financial capital and, if they also have a good patent position, are highly attractive for professional investors. In addition, the coefficient of the spin-offs' size is not significant and this also holds for 'university-employed as a founder', the last meaning that such connection to the university does not significantly improve a spin-off's ability to attract funding.

With regard to the linear models, all four characteristics of university networks, size, density, strength of relationships and multiplexity, tend to have a positive and significant influence on the spin-offs' ability to attract funding. In addition, two characteristics of non-university networks, network size and strength, have a positive and significant influence on spin-offs capability to attract funding. In the second step of the analysis, the squared terms of each network characteristic are entered. Two characteristics of university networks, namely strength of ties and multiplexity, indicate a curvilinear trend, as is witnessed by a negative and significant coefficient, meaning the emergence of decreasing returns. By contrast, network size indicates a curvilinear trend in the sense of increasing returns. This trend indicates that after having passed a certain size, the benefits in terms of ability to attract funding through a larger size increase disproportionally. Curvilinear trends are absent with regard to network density. The following more detailed explanation for the latter may be true. Most technology-based spin-offs are not in favor of patenting their invention, due to the high costs of application and maintenance, but also due to the need to provide a detailed description of the invention in the patent application (Davis, 2005; Graham et al., 2009). Alternatively, these spin-offs keep the network with the university dense with the aim to gain a certain protection, at least against the knowledge being leaked via bridging ties with other networks, and may emphasize exclusivity in the relationship with the university which in turn may lead to increased research funding applications. Note that curvilinear trends happen among other than university networks only with regard to strength of ties.

We may conclude the analysis with the following observations. University networks, as an example of support in growth among spin-off firms turn out to be important in filling one of strongest deficits of these firms, namely financial capital. First, using a linear model, all four characteristics of university networks tend to positively influence spin-offs' ability to attract funding. Among these four, two characteristics, namely, strength of relationships and multiplexity, are faced with decreasing returns meaning that there is an optimum, after which the effectiveness of the network diminishes, a too strong network and too much different subject matter circulating in the networks tend to reduce benefits from the network. However, network size which also indicates a curvilinear pattern, is faced with increasing returns, meaning that after a 'threshold' size the benefits from the networks tend to increase. Accordingly, spin-offs enjoy advantages from elaborating and increasing the relationships with their parent organization, but this requires a subtle and balancing approach with regard to frequency of interaction and knowledge domains addressed.

Table 7. Attraction of financial capital (OLS) a)

	Network size Models		Network density Models		Strength of ties Models		Multiplexity Models	
	1	2	3	4	5	6	7	8
Controls								
Innovativeness	.17	.18*	.19*	.19*	.21*	0.19*	.13	.14
Age of firms	-.13	-.10	-.05	-.05	-.05	-.07	.09	-.09
Size of firms	.04	.04	.04	.04	.07	.08	.06	.05
University employed founder	.05	.03	.07	.07	.03	.03	.04	.03
University network								
Network size	.31**	.12						
Network density			.68***	.64**				
Strength of ties					.46***	.41**		
Multiplexity							.45**	.32**
Network size^2		.46*						
Network density^2				.05				
Strength of ties^2						-.20*		
Multiplexity^2								-.24**
Other networks								
Network size	.29**	.53**						
Network density			.28	.39				
Strength of ties					.36**	.38**		
Multiplexity							.08	.19
Network size^2		-.34						
Network density^2				-.31				
Strength of ties^2						-.43**		
Multiplexity^2								-.10
Adjusted R^2	.21	.23	.50	.51	.40	.42	.55	.55
F	5.23***	4.59***	18.06***	13.56***	12.23***	9.90***	21.54***	16.11***
df	6	8	6	8	6	8	6	8

*p<0.10; **p<0.05; ***p<0.01; a) standardized betas.

7. CONCLUSION AND IMPLICATIONS

With the aim to increase understanding of growth among university spin-off firms, the paper explored the influence of the founding team and the external network on employment and turnover, with a focus on diversity. Using data on 105 university spin-off firms, a trend could be observed of a positive influence of diversity in social networks (domestic) and international networks on employment and turnover growth, broadly confirming the ideas on richness of information in the 'cognitive resource diversity paradigm'. In contrast, with regard to founding team diversity regarding education type and prestart professional experience, a negative influence was found mainly on turnover growth, broadly confirming the ideas on the rise of 'fault lines' between group members preventing the founding team to act as an integrated unit. Our results would mean that being involved in exploration and/or exploitation

occurs more successfully through networks than through the founding team in the early years of spin-off firms. However, diversity in networks tends to negatively influence growth in highly competitive environments, thus requiring a subtle balancing of managers between the network and the founding team. With regard to other factors (controlled for), the early growth strategy in terms of high ambitions has an important impact on growth, as has the year a firm was started, however the latter in a negative sense and as far as turnover growth was concerned, referring to better opportunities for firms established before 2000. Although education level was found to be significant, the sign was different from assumed: a PhD level resulted in smaller growth, this was mainly due to the firms in question being active in more innovative activities and facing longer development times of new products/services. Further, as expected, growth taking place in a core, metropolitan, area was enhanced, though this trend only applied to employment growth. Overall, while the founding team at young firm's age lacks the ability to benefit from diversity within the team in pursuing growth, through establishing a collaborative environment, it is able to benefit from diversity in external networks. With these results, we address the gaps in existing literature with regard to the impact of diversity on young high-technology firms and their networks, partly in the context of open innovation and exploration and exploitation activity (Simsek, 2009; Lichtenthaler, 2012).

Next, the paper focused on the influence of a particular network, namely, that with the parent organization, on gaining financial capital as one of the most pressing missing resources of spin-off firms. The network with the university turned out to be more important than non-university networks in terms of facilitating the attraction of external funding, with four university network characteristics - size, density, strength of ties and multiplexity - having a positive influence, while this was true only for two non-university network characteristics. The greater importance of university relationships in this respect was, however, associated with complexity in the type of relationship, namely linearity compared to non-linearity, the latter indicating diminishing returns for the characteristics strength of ties and multiplexity, but increasing returns for network size. This part of the paper contributes to the recently growing attention in literature on university spin-offs in several ways. First, it adds to the very limited pool of research on personal relationships between spin-offs and their parent organizations (Sorenson and Waguespack, 2005; Semadeni and Cannella, 2011). Limiting ourselves to university spin-offs, we notice that there are many studies on spin-off firm growth, but not on the relationship with the parent organization, nor on how that relationship may affect a spin-off's abilities in finding resources for innovation activity. The second contribution has to do with the focus on detailed features of university networks, such as density, strength of ties and multiplexity, and with the attention to the position of university networks towards other networks which is found in only a few studies (Pérez and Sánchez, 2003; Walter et al., 2006). The third contribution, more on the side of theory, resides in the approach to the nature of relationships between spin-offs and university. While attention for non-linear relations is not new (Thorgren et al., 2011; Villena et al., 2011), to apply such an approach to the relationships between spin-offs and university, while drawing on ideas of evolutionary thinking and diminishing returns, is new.

This study also contributes to practical issues and policy-oriented debates. With regard to practical implications for increasing the growth of young spin-offs (Mustar et al., 2006; Wright et al., 2009; Colombo and Grilli, 2010), we recommend staffing decisions to enhance a low diversity in education type and pre-start experience in the founding team, while also recommending decisions to build external networks to increase diversity, regarding types of partners and regions, keeping in mind that these recommendations may have the opposite effect particularly when competition is increasing. Furthermore, many universities provide accommodations, shared services and access to pre-seed capital, as well as programs aimed at improving the entrepreneurial capabilities of founders. In the past few years, however, a critical debate has emerged on the role of the universities, especially with regard to the actual impact of their support (Mustar et al., 2008), specifically because most European university spin-offs tend to remain relatively small. Despite the fact that many studies have been conducted to understand the growth barriers spin-offs are facing (e.g., Clarysse et al., 2005; Rothaermel and Thursby, 2005; van Geenhuizen and Soetanto 2009), evidence on how universities engage with the development of spin-offs is relatively scarce. In this study, we found that network connections with the parent organization apparently have ‘subtle’ effects on a spin-off's innovative capability through external funding, and this requires a conscious management by spin-offs in terms of maintaining or terminating existing relationships and establishing new ones, and in increasing/decreasing size of the network, strength (contact frequency) and addressing diversity in knowledge domains and subjects. Accordingly, awareness needs to be increased about different impacts of relationships with the university, particularly the potentially detrimental effects that tend to occur if the network relationships become too strong or the knowledge content too diverse.

The outcomes of this study can be generalized for technical universities in countries in the European Union that share some of the main characteristics of the Netherlands and Norway, i.e. a somewhat risk-avoiding entrepreneurial culture, being an ‘innovation follower’ and a small but open national economy, while the universities in question specialize in new technology in seashore activities, mainly energy and transport, for example Denmark, Sweden and part of the UK (the North). In addition, our results involving founding teams and external networks of university spin-off firms tend to allow a generalization for all categories of young high-technology firms (Simsek, 2009), however, university spin-offs benefit from being connected to universities, which was the second focus of the paper.

This study has also various limitations. The relatively small sample and the database made us decide to exclude some factors related to firm growth, such as network characteristics like centrality. Also, the behavioral capacity of team members to collaborate across diverse social units potentially demonstrating alignment and adaptability, has remained beyond the scope of the study (Gibson and Birkinshaw, 2004). Moreover, the management team composition may change over time, after being adapted to emerging management needs, and a firm's network characteristics may also evolve over time as the need to access external resource changes. Accordingly, a longitudinal study would yield a better understanding of the role of diversity and its ‘counterpart’ integration (Vanaelst et al., 2006), with several studies indicating that diversity within the firm gives way to more integrated models in later stages of development (e.g. Jansen et al., 2009).

Bibliography

Agarwal, R., Echambadi, R., Franco, A.M. and Sarkar, M.B. (2004) Knowledge transfer through inheritance: spinout generation, development and survival. *Academy of Management Journal* 47(4), 501–522.

Amason A., Shrader R.C., Tompson G.H. (2006) Newness and novelty: relating top management team composition to new venture performance, *Journal of Business Venturing*, 21, 125–148

Arthur, W.B. (1994) *Increasing returns and path dependence in the economy*, University of Michigan Press.

Audretsch, D.B. and M. P. Feldman (1996) R&D spillovers and the geography of innovation and production, *American Economic Review* 86: 630-640.

Audretsch, D.B. and M. Keilbach (2008) Resolving the knowledge paradox: knowledge-spillover entrepreneurship and economic growth, *Research Policy*, 37 (10): 1697-1705.

Barney, J.B. (1991) Firm Resources and Sustained Competitive Advantage, Journal of Management, 17 (1): 99-120.

Barney, J. B. and Clark D.N. (2007) *Resource-Based Theory*. Oxford: Oxford University Press.

Beckman, C. M., Burton, M.D. and O'Reilly, C. (2007) Early teams: The impact of team demography on VC financing and going public. *Journal of Business Venturing* 22, 147-173.

Bitard, P., Edquist, C., and A., Rickne (2008) The paradox of high R&D input and low innovation output: Sweden. Lund: Lund University, CIRCLE Paper 2008/14.

Bjerregaard, T. (2010) Industry and academia in convergence. Micro-institutional dimensions of R&D collaboration, *Technovation* 30 (2): 100-108.

Bruderl, J. & Preisendorfer, P. (1998). Network Support and Success of Newly Founded Businesses. *Small Business Economics*, 10, 213-225.

Bruneel, J., d'Este, P., Salter, A. (2010) Investigating the factors that diminish the barriers to university, industry collaboration, *Research Policy* 39: 858-868.

Burt, R. (1992) *Structural holes. The social structure of competition*. Cambridge, Mass: Harvard University Press.

Burt, R. (2005) *Brokerage and closure: An introduction to social capital*. Oxford and New York: Oxford University Press.

Capello, R. (2006) *Regional Economics*. London: Routledge.

Chesbrough, H. (2003) *Open Innovation. The New Imperative for Creating and Profiting from Technology*. Cambridge: Harvard Business School.

Chowdhury, S. (2005) Demographic Diversity for Building an Effective Entrepreneurial Team: Is it Important? *Journal of Business Venturing*, 20(6), 727-746.

Christensen, C. (2003) *The Innovators Dilemma*, Cambridge (US): Harvard University Press.

Clarysse, B., Wright, M., Lockett, A., Van de Velde, E., and Vohora, A. (2005) Spinning out new ventures: a typology of incubation strategies from European research institutions. *Journal of Business Venturing*, 20 (2), 183-216.

Clarysse, B., Wright, M., Lockett, A., Mustar, P. and Knockaert, M. (2007) Academic spin-offs, formal technology transfer and capital raising. *Industrial Corporate Change*, 16(4), 609-640.

Clercq D.D., Sapienza H.J., Yavuz R.I., Zhou L. (2012) Learning and knowledge in early internationalization research: Past accomplishments and future directions, *Journal of Business Venturing* 27, 143–165.

Colombo, M.G. & Grilli, L. (2005) Founders' human capital and the growth of new technology-based firms: A competence-based view. *Research Policy*, 34(6),795–816.

Colombo M.G. & Grilli L. (2010). On growth drivers of high-tech start-ups: exploring the role of founders' human capital and venture capital. *Journal of Business Venturing*, 26(6), 610-626.

Combes, P.P., Duranton, G. and L. Gobillon (2010) The identification of agglomeration economies, Working Paper University of Toronto.

Davis, L. (2005) Why do Small High-tech Firms Apply for Patents, and Why Not? Andersen, B. (Eds) Intellectual Property Rights: Innovation, Governance and the Institutional Environment, Edward Elgar.

Delmar, F. and Shane, S. (2006). Does experience matter: The effect of founding team experience on the survival and sales of newly founded ventures. *Strategic Organization*, 4 (3), 215–247.

D'Este, P. and Patel, P. (2007) University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy*, 36: 1295-1313.

Djokovic, D., Souitaris, V. (2008) Spinouts from academic institutions: a literature review with suggestions for further research. The Journal of Technology Transfer, 33, 225-247.

Ebers, M. (2003) Geleitwort. In: I. Maurer: Soziales Kapital als Erfolgsfaktor junger Unternehmen. Eine Analyse der Gestaltung und Entwicklungsdynamik der Netzwerke von Biotechnologie Start-Ups. Wiesbaden: Westdeutscher Verlag.

Ensley, M. D. and Hmieleski, K. M. (2005) A comparative study of new venture top management team composition, dynamics and performance between university-based and independent start-ups. *Research Policy*, 34 (7), 1091-1105.
Etzkowitz, H. (2008) *The Triple Helix: University-Industry-Government Innovation in Action*. London: *Routledge*.
Feeser, H. and Willard, G. (2006) Founding strategy and performance: A comparison of high and low growth high tech firms. *Strategic Management Journal*, 11(2), 87–98.
Feldman, M. (1999) The New Economics of Innovation, Spillovers and Agglomeration, *Economics of Innovation and New Technology*, 8, 5-25.
Fern, M.J., L. Cardinal, and H.M. O'Neill (2012) The genesis of strategy in new ventures: Escaping the constraints of founder and team knowledge. *Strategic Management Journal*, 33, 427-447.
Freeman, J., Carroll G. R., and Hannan M. T. (1983) The liability of newness: age-dependence in organizational death rates. *American Sociological Review*, 48, 692-710.
Fried, A., Knoll, M., and Duschek, S. (2006) Networks of entrepreneurs revisited – dilemmatic settings and dysfunctional effects during company foundation processes. Institute of Innovation Research, Chemnitz University of Technology.
Geels, F.W. (2004) From sectoral systems of innovation to socio-technical systems insights about dynamics and change from sociology and institutional theory, *Research Policy*, 33: 897-920.
Geenhuizen, M. van, and P. Nijkamp (2006) Learning regions in an evolutionary context: policymaking for high-technology firms. *Int. Journal for Entrepreneurship and Innovation Management*, 6 (3), 265-282.
Geenhuizen, M. van, and Soetanto, D.P. (2009). Academic spin-offs at different ages: A case study in search of obstacles to growth, *Technovation*, 29 (10), 671-681.
Geenhuizen, M. van, and Ye, Q. (2012) Research Report Spin-Up, Delft, TU Delft.
Geuna, A. and A. Muscio (2009) The Governance of University Knowledge Transfer: A Critical Review of the Literature, *Minerva* 47 (1), 93-114.
Gibson, C. B. and Birkinshaw, J. (2004) The antecedents, consequences, and mediating role of organizational ambidexterity. *Academy of Management Journal*, 47, 209–26.
Gordon, I. and McCann, P. (2000) Industrial clusters' complexes, agglomeration and/or social networks? *Urban Studies*, 37(3), 513-532.
Grabher, G. (ed.) (1993) *The Embedded Firm. On the Socioeconomics of Industrial Networks*. London, Routledge.
Graham, S.J.H., R.P. Merges, Samuelson, P. and Sichelman, T. (2009) High technology entrepreneurs and the patent system: Results of the 2008 Berkeley Patent Survey. Berkeley.
Grandi, A. and Grimaldi, R. (2003). Exploring the Networking Characteristics of New Venture Founding Teams, *Small Business Economics*, 21(4), 329-370.
Hambrick, D., Cho, T., Chen, M. (1996) The influence of top management team heterogeneity on firms' competitive moves, *Administrative Science Quarterly*, 41, 659-684.
Horwitz, S. (2005) The compositional impact of team diversity on performance: Theoretical considerations. *Human Resource Development Review*, 4 (2), 219-245.
Horwitz, S. and Horwitz, I (2007) The effects of team diversity on team outcomes: A meta-analytic review of team demography, *Journal of Management* 6, 987-1015.
Huggins, R. and A. Johnston (2009) The economic and innovation contribution of universities: a regional perspective, *Environment and Planning C: Government and Policy*, 27, 1088-1106.
Hughes, A., Kitson, M., Probert, J.; Bullock, A. and Milner, J. (2011) Hidden connections – knowledge exchange between the arts and humanities and the private, public and third sectors. Cambridge University: AHRC-CBR.
Hussler, C., Picard, F., and M.F. Tang (2010) Taking the ivory from the tower to coat the economic world: Regional strategies to make science useful, *Technovation*, 30, 508-518.
Innovation Platform (2009) From aims to a position ahead. Enhancing knowledge circulation (in Dutch). The Hague (NL): Innovation Platform.
Innovation Platform (2010) The Netherlands back in the top-5 (in Dutch). The Hague (NL): Innovation Platform.
Jansen, J.J.P., Tempelaar, M.P., Van den Bosch, F.A. and Volberda, H.W. (2009) Structural differentiation and ambidexterity: the mediating role of integration mechanisms. *Organization Science*, 20 (4): 797-811.
Johansson, M., Jacob, M., and Hellstrom, T. (2005) The strength of strong ties: university spin-offs and the significance of historical relations, *Journal of Technology Transfer*, 30(3), 271-286.
Knight, G. A. and Cavusgil, S. T. (2004) Innovation, organizational capabilities, and the born-global firm. *Journal of International Business Studies*, 35(2), 124-141.
Laursen, K. and Salter, A. (2006) Open for Innovation: The Role of Openness in Explaining Innovation Performance Among U.K. Manufacturing Firms. *Strategic Management Journal*, 27, 131-150.
Lavie, D. (2006) The Competitive Advantage of Interconnected Firms, and Extension of the Resource-based View, *Academy of Management Review*, 31 (3): 638-658.

Levinthal, D. A. and March, J.G. (1993). The myopia of learning. *Strategic Management Journal*. 14, 95–112.
Lichtenthaler, U. (2012) Technological Turbulence and the Impact of Exploration and Exploitation Within and Across Organizations on Product Development Performance, *Entrepreneurship Theory and Practice*
Lindelöf, P. and Löfsten, H. (2004) Proximity as a Resource Base for competitive advantage: University–Industry links for technology transfer. *Journal of Technology Transfer*, 29(3), 311-326.
Lockett, A., Murray, G., Wright, M. (2002) Do UK venture capitalists still have a bias against high tech investments? *Research Policy*, 31, 1009-1030.
Lockett, A., Wright, M. (2005) Resources, capabilities, risk capital and the creation of university spin-off firms, *Research Policy*, 34 (7) 1043-1057.
Looy, B. van, Landoni, P., Callaert, J., Pottelsberghe, B. van, Sapsalis, E. and Debackere, K. (2011) Entrepreneurial effectiveness of European universities: an empirical assessment of antecedents and trade-offs. *Research Policy* 40: 553-564.
Maurer, I., Ebers, M. (2006) Dynamics of social capital and their performance implications: Lessons from biotechnology start-Ups. *Administrative Science Quarterly*, 51(2), 262-292.
McEvily, B. and Zaheer, A. (1999) Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal*, 20, 1133-1156.
McEvily, B. and Marcus, A. (2005) Embedded ties and the Acquisition of Competitive Capabilities, *Strategic Management Journal*, 26 (11): 1033-1055.
Ministry of Economic Affairs (MINEZ) (2004) Action Program Technopartner (in Dutch), The Hague.
Ministry of Economics, Agriculture & Innovation (MEAI) (2011) Policy to boost 'Top Sectors'. The Hague.
Mizruchi, M.S. and Stearns, L.B. (2001) Getting deals done: The use of social networks in bank decision-making. *American Sociological Review*, 66 (5), 647-671.
Mohr, J., Sengupta, S. and Slater, S. (2005) Marketing of High Technology Products and Innovation. Pearson/Prentice Hall (2nd edition).
Moray, N., and Clarysse, B. (2005) Institutional change and resource endowments to science-based entrepreneurial firms. *Research Policy*, 34 (7), 1010-1027.
Mowery, D., Nelson, R, Sampat, B. and A. Ziedonis (2004) Ivory Tower and Industrial Innovation. University-Industry Technology Transfer Before and After the Bayh-Dole Act.
Mustar, P., Renault, M., Colombo, M.G., Piva, E., Fontes, M., Locket., A., Wright, M., Clarysse, B., Moray, and N., (2006) Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy. *Research Policy*, 35 (2), 289-308.
Myers, S.C. (1984) The Capital Structure Puzzle. *The Journal of Finance*, 39, 574–592.
Myers, S.C., Majluf, N.S. (1984) Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics*, 13(2), 187-221.
Nooteboom, B. (2009) *A Cognitive Theory of the Firm. Learning, Governance and Dynamic Capabilities.* Cheltenham: Edward Elgar.
Pelled, L. H. (1996). Demographic diversity, conflict and work group outcomes: An intervening process theory. *Organization Science*, 7(6) 615-631.
Pro Inno Europe (2011) *European Innovation Scoreboard*. Maastricht: MERIT
Rasmussen, E., Moen, Ø., and Gulbrandsen, M. (2006) Initiatives to promote commercialization of university knowledge, *Technovation*, 26 (4), 518-533.
Reagans, R. E. and B. McEvily (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly*, 48, 240-267.
Rickne, A. (2006). Connectivity and Performance of Science-based Firms. *Small Business Economics* 26, 393-408.
Robbins, S. P. and Judge, T. A. (2011). *Essentials of Organizational Behavior* (11th ed.). Essex: Pearson.
Rothaermel, F.T., Thursby, M., 2005. Incubator firm failure or graduation?: The role of university linkages. *Research Policy*, 34(7), 1076-1090.
Pérez, M.P. and Sánchez, A.M. (2003) The development of university spin-offs: early dynamics of technology transfer and networking. *Technovation*, 23(10) 823-831.
Pirnay, F., Surlemont, B., Nlemvo, F. (2003) Toward a Typology of University Spin-offs. *Small Business Economics*, 21(4), 355-369.
PRO INNO EUROPE (2011) The Innovation Union's Performance scoreboard for Research and Innovation, (online) http://ec.europa.eu/enterprise/policies/innovation/files/ius-2011_en.pdf, accessed on 01/10/2012.
Saetre, A., Atkinson, O., Ellerås, B. (2006) University Spin-offs and Technology Commercialization, A comparative study between Norway, Sweden and the United States, Trondheim: NTNU.
Semadeni, M. and Cannella, A.A. (2011) Examining the performance effects of post spin-off links to parent firms: should the apron strings be cut? *Strategic Management Journal*, 32, 1083-1098.
Shane, S. (2004) *Academic Entrepreneurship. University Spin-offs and Wealth Creation*. Northhampton (MA): Edward Elgar.

Shane, S. and Stuart, T., (2002). Organizational endowments and the performance of university start-ups. *Management Science* 48 (1), 154–171.
Siegel, D.S., Waldman, DA., Atwater, L.E. and Link, A.N, (2003) Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. *Journal of High Technology Management Research*, 14(1), 111-133.
Simsek, Z. (2009). Organizational ambidexterity: Towards a multilevel understanding. *Journal of Management Studies*, 46(4), 597-624.
Sorenson, P. and Waguespack, D.M. (2005) Research on social networks and the organization of research and development: an introductory essay. *Journal of Engineering and Technology Management*, 22(1/2), 1-7.
Stinchcombe, A.L. (1965). Social structure and organizations, in J. March (ed) *Handbook of Organizations*, Rand McNally, Chicago, 142–193.
Taheri, M. (2013) From Mind to Market at University. PhD dissertation, TPM, TU Delft.
Thorgren, S., Wincent, J. and Eriksson, J. (2011) Too small or too large to trust your partners in multipartner alliances? The role of effort in initiating generalized exchanges. *Scandinavian Journal of Management*, 27(1), 99-112.
Tidd, J., Bessant, J. (2009) *Managing Innovations. Integrating Technological, Market and Organizational Change*, 4th edition, John Wiley.
Ulhøi, J.P. (2005). The social dimensions of entrepreneurship. Technovation, 25, 939-946.
Utterback, J. (1996) *Mastering the Dynamics of Innovation*. Harvard Business School Press.
Vanaelst, I., B. Clarysse, M. Wright, A. Lockett, et al. (2006). Entrepreneurial Team Development in Academic Spinouts: An Examination of Team Heterogeneity. *Entrepreneurship Theory and Practice*: 1042-2587.
Villena, V.H., Revilla, E., and Choi, T.Y. (2011) The dark side of buyer–supplier relationships: A social capital perspective. *Journal of Operations Management*, 29(6), 561-576.
Walter, A., Auer, M. and Ritter, T. (2006) The impact of network capabilities and entrepreneurial orientation on university spin-off performance. *Journal of Business Venturing* 21, 541–567.
Wernerfelt, B. (1984) A Resource-Based View of the Firm. *Strategic Management Journal*, 5 (2): 171-180.
Wiklund, J., Patzelt, H. and Shepherd, D. (2009). Building an integrative model of small business growth. *Small Business Economics*, 32(4), 351-374.
Williams, K. Y. and O'Reilly III, C. A. (1998) Demography and diversity in organizations: A review of 40 years of research. In B. M. Staw & L. L. Cummings (Eds), *Research in Organizational Behavior*, 20, 77–140.
Wright, M., Piva, E., Mosey, S. and Lockett, A. (2009) Academic entrepreneurship and business schools, *The Journal of Technology Transfer*, 34 (6), 560-587.

Appendix 1

We apply augmented regression test (DWH test) to test for endogeneity in the *employment growth* model, using diversity through international networks as instrument variable. Accordingly, we first perform the original regression model and then include the residuals in an augmented regression. If the coefficient of the residual is not significantly different from zero, OLS is not consistent. In this case, $F(1,86)=0.00$ and $Prob > F=0.95$, we conclude that the OLS results are consistent and there is no problem of endogeneity. Because we also assume that employment growth may influence diversity from social networks, we again check for the existence of endogeneity. Using Durbin-Wu-Hausman test, the outcome, $F(1,86)=1.90$, $Prob > F=0.171$, indicates that OLS results are consistent with absence of endogeneity problem. We also check for endogeneity in the *turnover growth* model, taking diversity through international networks into account. Because the residual is found to be different from zero at 10% level, $F(1,85)=3.40$, $Prob>F=0.068$, we conclude that the estimates are consistent at 5% test level.