Determinants of University Spin-offs' Growth: Do Socioeconomic Networks and Support Matter?

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Abstract

As the resources of university spin-offs (USOs) are often not sufficient, growth opportunities critically depend on their socioeconomic networks and on support received from incubator organizations. This paper aims to analyses the role of socioeconomic networks (i.e. tightness, strength of relationships, heterogeneity in partners' background, and spatial proximity) and various support measures in determining growth of USOs. Using spin-offs from the Technical University of Delft, the Netherlands as a case study, a set of hypothesis is tested by using linear regression (LR) and hierarchical moderated multiple regression analysis (HMMR). The results confirm that loose networks, weak relationships and interaction with partners of diverse backgrounds are enhancing spin-offs' growth, while a positive influence of close spatial proximity with network partners could not be confirmed. On the other hand, the results indicated that spatial proximity has interaction effects with other characteristics of socioeconomic network in determining growth. With regard to support from incubator organizations, the results indicated that the idea of receiving a combination of conventional and added value support has a more positive influence on spin-offs' growth than receiving only conventional support. Overall, the results revealed that socioeconomic network characteristics tend to influence growth much stronger than various support measures do.

Keywords: *university spin-offs, resources, network, linear regression analysis, hierarchical moderated multiple regression analysis, TU Delft (The Netherlands).*

1. Setting the Scene

University spin-offs (USOs) aim to transfer scientific and technological knowledge from universities to the market place (Chiesa and Piccaluga, 200l). University spin-offs may appear small in terms of aggregate employment, but they significantly contribute to the creation of new jobs and innovation of the regional economy (Rothwell and Zegveld, 1985, Mansfield, 1991). Having new technology as the core of their business and provided that they are clustered in space, these firms increase the competitive edge of regions (e.g. Keeble and Wilkinson, 1999). In more detail, USOs offer benefits such as:

- To promote technological entrepreneurship in regions as they base their business mostly on high technology development, rely on high-tech skills, and pay good wages.
- To stimulate other business support and infrastructures that in turn provide benefits to other start ups (Lockett *et al*. 2003).
- In the context of the university, to strengthen the relationships with the business community, improve the image of universities, fulfill commitment to society, and generate income from patents (e.g. Heydebreck *et al,* 2002)

Over the years, these advantages have been widely recognized and fostering spin-offs has become part of most universities and research centers policy to commercialize research results. Among the many ways to accelerate the growth of USOs, perhaps the most captivating one is establishing incubator organizations. The infrastructure of incubators was built gradually in industrial countries such as the United States and Western Europe in the last two decades. Incubators have evolved and now appear to reach maturity (Lalkaka, 2001). The first generation of incubators in the 1980s essentially only offered affordable office facilities to potential new firms. As time progressed, it was realized that the needs of spin-offs include more than just physical support (e.g. office and administrative support) and financial support. This situation has challenged various incubators to respond to the necessity of providing "value added support", like business skills training and connecting the entrepreneur with different networks.

However, after several years of spin-offs euphoria, some studies have started to look critically at the entrepreneurial output of universities. A recent study points out that even though some successful spin-out companies have been created, the mechanism has been overemphasized and it is still doubted that spin-offs will survive in the long term (Lambert, 2003). Other studies have also examined the impact and high transaction costs of spinning out in a critical way (Bozeman, 2000; Lerner, 2005). In spite of these critics**,** the creation of university spin-offs still represents a potentially important innovation mechanism. Therefore, it seems necessary to reconsider the kind of support and to aim at the creation of better performing spin-offs. This means the design of policies that focus on the quality of spin-offs instead of the quantity (Clarysee *et al*., 2004).

In this paper, we look at the growth of USOs as a process in which these companies try to acquire vital resources for their survival. However, in reality resources available to USOs are often not sufficient. Some USOs receive support from incubator organizations even though not all resources can be covered, while other USOs have to strive for acquiring resources on their own. Thus, the chance to grow depends critically on the environment of spin-offs and on the nature of the interaction with 'external partners' including friends, family, colleagues, and former lecturers or professors that provide access to important resources (Birley, 1985). In this respect, networks as an essential factor influencing the survival of USOs should receive considerable attention by incubator organizations in designing support policies. Unfortunately,

little attention has been paid to ways to improve the network structures of USOs. Although networking is seen by various authors as a key feature in explaining the nature of newly established firms and in predicting their future success (Larson and Starr, 1993), very few studies (except for Perez and Sanchez, 2003) focus on the early years of USOs' networks development. Moreover, with some exceptions (e.g. Nicolaou and Birley, 2003) relatively few empirical studies have attempted to use statistical analysis. Most research on USOs' networks draws on case studies. Thus, so far the influence of socioeconomic networks on early growth of spin-offs is still unexplored on the basis of large and medium scale surveys (Markman *et al*., 2005).

This study is undertaken in response to the lack of attention given to factors underlying the growth of USOs. We address the following question: what is the influence of different socioeconomic networks and different support measures on the growth of USOs? In particular, we focus on whether spatial proximity and network building support interact with other network characteristics in determining the growth of USOs. Following Cooper (1992), our approach uses multi-factors as a predictor for firm performance, instead of focusing only on one particular factor, because the former approach is more comprehensive in predicting the USOs' performance. Accordingly, we develop a causal model and test this model by applying regression analysis. The paper is presented in the following structure. First, we provide a brief overview of Resource-Based theory and this is followed by the development of hypotheses. In the next section, the research design is discussed. An examination of the regression results follows. The paper concludes with a summary and evaluation of the modeling results.

2. Resource-Based Theory

To understand the growth of firms, many scholars have developed various theoretical viewpoints, including knowledge-based theory, the dynamic capability perspective, business networks, and strategic alliances. Basically, all of these approaches are rooted in the Resource Based View (RBV) introduced by Penrose (1959). Penrose's seminal work has been instrumental to the on-going development of modern resource-based theory that is applied in many fields such as strategic management, organization studies and marketing.

According to the RBV, firms are conceptualized as heterogeneous bundles of assets or resources tied to the firms' management. Firms acquire or search for resources as an input and convert these into products or services for which revenue can be obtained. The resource based view suggests that heterogeneity of resources is necessary but not sufficient for a sustainable advantage. It suggests that resources have to be unique to firms in order to create competitive advantage. Resources should also be difficult to imitate, otherwise, competitors can easily obtain these resources and neutralize the competitive advantage (Barney, 1991).

In reality, firms frequently lack critical resources during their early development. Apart from the lack of *basic resources* such as initial investment and office facilities, new and small firms may also desire what are called *added value resources* such as the ability to identify business opportunities, learning to manage the firm, business guidance or advice, and mental endorsement. Such resources can be acquired; e.g. through the networks of these firms (Pisano, 1990).

Organizations, whether established firms or start-ups, are part of a network and are dependent on external actors (Pfeffer and Salancik, 1978). Studies on small firm growth indicate that developed networks of strong relationships with various partners may be an advantage to gain

resources (Hoang and Antoncic, 2003). Networks provide entrepreneurs with avenues for negotiation and persuasion, enabling them to gather a variety of resources (e.g., market information, problem solving, social support, venture funding, and other financial resources) held by other actors (Nicolaou and Birley, 2003). Birley (1985) observes the extensive use of social networks in the early stages of a venture generation process. Starr and MacMillan (1990) document the use of social and economic exchange mechanisms to acquire resources and to gain legitimacy during the early stages of ventures.

The literature (e.g. Birley, 1985) tends to distinguish between two types of networks on which firms can draw: formal and informal. Formal networks include financial institutions, accountants, lawyers, the chamber of commerce, small business administrators, etc. These are the people/institution who are directly connected with business matters. Informal networks may include family, friends, previous colleagues or previous employers, and former professors or lecturers. Conversations with them may range from hobby, family to business. Some of the relationships have been established long before entrepreneur launched their business. However, such networks are not static but dynamic from time to time. For instance, informal networks with friends may become formal ones when friends turn into customers. Moreover, there is no clear boundary between formal and informal. A person can be a tax consultant and friend at the same time.

In this study networks are defined as a socioeconomic network of important '*partners*' that potentially provide valuable resources for firm growth. As USOs frequently lack critical resources during their early development, especially entrepreneurial knowledge and skills (Geenhuizen and Soetanto, 2003). Accordingly, USOs may attempt to manage obstacles by seeking a solution through their '*partners*' (e.g. friends, colleagues, former professor, etc). These relationships with '*partners*' are may be essential in order to gather relevant knowledge, to get external support and service, to access external resources not available in-house, and to look for business advice (Birley, 1985). Thus, in the early years of USOs' establishment, socioeconomic networks may be important and cannot be neglected.

Another possibility for gaining resources is through incubator organizations. As an *organization*, incubators aim to accelerate the development of start-ups by providing an array of targeted resources and services. Incubators traditionally merge the concept of fostering new business development with the concept of technology transfer and commercialization (Phillips, 2002). They can be seen as entrepreneurial (non-profit) organizations in performing a bridging function between promising spin-offs and resources required by these spin-offs while protecting them against any potential failure (Hackett and Dilts, 2004). Incubators may also act as a link between start-ups and other partners that provide resources, such as venture capitalists, governments, financial institutions, and other business practitioners. In fact, incubators perform as a mechanism for a wide range of networking while encouraging the development of small businesses.

Many incubators employ large buildings, in which they offer customized rooms and supporting services. However, there are also examples of decentralized facilities, e.g. rooms spreading over different faculty buildings of universities. Generally, incubators support start-ups only on a temporary basis, e.g. three or four years, after which the start-ups are forced to leave the incubator and support will end. Some incubator organizations also try to provide access to business networks such as trade organizations. USOs can make use of these types of support below market price, and thus they enjoy a cost reduction and enhance their competitive advantage.

3. Model Development and Hypotheses

The central proposition of resource-based theory is that a firm has to build on and maintain their set of resources in order to survive and stay competitive. As the resources do not reside exclusively within firms, we argue that there are two ways that USOs can use to gain their resources that are through (1) socio-economic network and (2) incubators' support. The following sections will discuss each of the two factors and will present various hypotheses built base on them.

3.1 Socioeconomic Network

Although many empirical studies have proven benefits of socioeconomic networks for firm growth, little is known about the mechanism or structures inside socioeconomic networks between USOs and their partners. In reality, not all firms possess comparable levels of network resources. Firms' socioeconomic networks vary in terms of structure, pattern of relationship, and the variation in the mix of contacts. Therefore, the first part of our model serves to investigate the contribution of this factor in USOs' growth. In our study socioeconomic networks are examined by focusing on network characteristics: structural, strength of relationship, social, and spatial characteristics. The structural characteristic refers to the degree of tightness among partner networks of USOs. The strength of relationship refers to the length of time and emotion invested on relationships. A social characteristic refers to the difference of social status among partners in networks. A spatial characteristic refers to the geographical location of partners.

3.1.1 Tight or Loose Networks

In the literature of small business development, the importance of dense or tight networks is emphasized as being one of the factors influencing the survival of new and small firms. Tight networks are described as networks where everyone is connected to each other. Because people know and interact with each other, they are more likely to convey and reinforce norms of exchange and more easily able to monitor their observance and enforce sanctions. In business, such networks will reduce risk and enhance the opportunity to build cooperation and get access to resources from other people connected in the network. People on this kind of network are familiar with each other's interest, making the transfer of knowledge less difficult. They also build trust and credibility on each other. Therefore, tight networks are beneficial for the transfer of complex and tacit knowledge, development of trust and comfort, legitimacy or reputation, and joint problem solving (Coleman, 1990; Uzzi, 1996).

In contrast with the above argument, Grannovetter (1992) suggests that people who are connected in sparsely networks will enjoy more advantages. Accordingly, a loose network structure causes benefits from the diversity of information and the brokerage opportunities created by the lack of connection between separate clusters in social networks. This leads into a concept called *Structural Hole* Theory (by Burt, 1992). The persons who occupy brokerage positions between those clusters have better access to information. Structural holes separate non redundant sources of information, sources that are more additive than overlapping. By being connected in a network which is rich of new information and opportunities, entrepreneurs have benefits in terms of : (1) enhancing business opportunities, (2) getting access to resources that could not otherwise be obtained, which often constitute the linking knot between seemingly unrelated resources, (3) getting references from partners that may lead entrepreneurs to a new business network.

Studies of the role of structural characteristics of networks on the performance of new firms are not conclusive. Several studies have stressed that linkages with tight networks are more advantageous for the early growth of firms (Gulati, 1995), while others emphasize the importance of being connected to loose networks (McEvily and Zaheer, 1999). This consideration leads to our first hypotheses:

Hypothesis 1a The performance of USOs is positively affected by tight networks.
Hypothesis 1b The performance of USOs is positively affected by loose networks.

3.1.2 Strong or Weak Relationships

Whereas the above characteristics, tightness refers to structure of the networks. Strength of the relationship refers to the quality of relationship. The strength of relationships between USOs and their partners varies based on the time invested in the relationships. Usually, strong relationships are based on long-term and intense interactions. Typical examples of strong relationships include friendship and family ties. However, Granovetter (1995) defines the strength of relationships based on time and emotions invested in a relationship, as well as the reciprocity involved between participating actors. As people know each other more and become emotionally involved, they will develop a relationship in which they put their trust, commitment and willingness to support each other reciprocally. This type of relationship is important for entrepreneurs that try to market an unproven product and have limited resources. In such situations characterized by a high level of uncertainty, entrepreneurs will heavily rely on close friends or family members for learning, protection and support.

The concept of social networks presents a contradictory argument. Although initially developed by sociologists, this concept has been increasingly used to explain economic actions (e.g Larson and Starr, 1993). Granovetter (1973) argues that new information is obtained through casual acquaintances rather than through strong personal relationships. Since the strongly connected actors are likely to interact frequently, much of information that circulates in this social system is the same. Conversely, *weak ties* often include links with actors who move in social circles other than those of the focal actors. It is suggested that weak ties are an important source of information about activities, resources, and opportunities in distant parts of social system. Weak ties are often more important in spreading information or resources because they tend to serve as a bridge between otherwise disconnected social networks. In attempts to obtain resources for growth, weak ties may be are essential for USOs. It is through weak ties that USOs can recognize novel information which leads them to new resources and enabling to exploit a new business opportunities. Because of the contradiction the above argument, we formulate the following hypotheses:

Hypothesis 2a The performance of USOs is positively affected by strong relationships.
Hypothesis 2b The performance of USOs is positively affected by weak relationships.

3.1.3 Heterogeneity of Contact Background

The third hypothesis is about the social characteristics of networks. Marsden (1987) shows that diverse partners integrating several spheres of society often facilitate more beneficial actions to individuals than similar partners. With regards to USOs' development, partners that come from a different environment of USOs have more variety in their perceptions and give access to a wider range of resources. The more heterogonous partners USOs have, the more variety of resources such as know-how, information and expertise to USOs can access. Hence, heterogeneity of partners' backgrounds increases the likelihood of obtaining valuable

information, knowledge, and guides spin-offs to different resources. Therefore, we hypothesize as follows:

Hypothesis 3 The performance of USOs is positively affected by a large heterogeneity of partners' backgrounds.

3.1.4 Spatial Proximity

In the study of network creation, it is assumed that networks do not randomly link individuals. Rather, people interact most frequently with those in close geographical proximity and with whom they share common backgrounds, interests and affiliations (Gertler, 2003). Because both physical and social locations strongly influence people's activities, proximity on these dimensions increases the likelihood of interaction and communication (Blau, 1977). More specifically, spatial proximity decreases direct costs associated with frequent and extended interaction necessary for maintaining social relationships (Zipf, 1949), particularly close personal networks. As the geographical distance between spin-offs and their partners increases, the opportunity for meeting in person and face-to-face interaction is lower and it is more difficult to maintain an effective relationship. In contrast, a network of partners that is clustered provides a greater opportunity to interact actively (face-to-face interaction) with partners and to benefit from knowledge spillovers (e.g. Audretch, 1998; Camagni, 1991). Accordingly, we argue that a close spatial proximity between USOs and their partners will have a positive influence on USOs' performance.

Hypothesis 4 The performance of USOs is positively affected by a close spatial proximity to network partners.

In this study, socioeconomic networks are defined in multi-facet characteristics such as tightness, strength of relationship, heterogeneity and spatial proximity. Researchers (e.g. Howells, 2002; Boschma, 2005) have started to recognize that spatial proximity has a complementary role that is building and strengthening the other characteristics of socioeconomic networks. For instance, close proximity between spin-offs and their partners will facilitate more frequent face-to-face interactions, which in turn can lead to tight and strong relationships. On the contrary, distant proximity will lead to loose and weak relationship (Harrison, 1992; Audretsch and Stephan, 1996). This argument comes close to what Howells (2002) calls as 'a more indirect and subtle impact of spatial proximity'. In this respect, we then assume that spatial proximity not only directly influences USOs' performance, but also will moderate the relationship between the characteristics of socioeconomic networks (i.e. tightness, strength of relationship, heterogeneity) and USOs' performance. This consideration leads to our hypotheses:

Hypothesis 5 Spatial proximity to network partners will moderate the relationship between socioeconomic network characteristics and the performance of USOs.

3.2 Support from Incubation Organizations

The last hypothesis is related with the nature of support provided by incubator organizations. The nature of support may vary considerably, dependent upon the perceived needs of start-ups and the competence and resources of incubators. Conventional support is oriented towards the provision of '*basic resources*', e.g. office, administration and financial support. However, there has been an important evolution in the kinds of support, from conventional to added value support; the latter includes support such as entrepreneurial courses for enhancing business skills, business mentoring and networking services. Overall, the types of support provided by incubator organizations can be grouped into two following categories:

1. Conventional support (e.g loan, grant, venture capital, office facilities, shared administration facilities)
2. Added value support (e.g. business counseling, consultation, entrepreneurial training, networking possibility, equipment and research facilities)

In this study, we assume that conventional support only fulfill the basic need of USOs. It may help USOs to overcome their first obstacles in terms of initial investment and office. However, for further development, USOs may need more added value support as well. Therefore, we propose the following hypothesis:

Hypothesis 6 USOs which receive conventional support plus value-added support perform better than USOs that receive only conventional support.

Related with socioeconomic networks of USOs, we assume that added value support; especially support such as network building support, will moderate the relationship between socio economic networks and performance. Therefore, we hypothesize as follows:

Hypothesis 7 Network building support will moderate the relationship between socioeconomic network characteristics and the performance of USO.

Besides the hypothesis developed above, we also consider about the role of age in influencing the network characteristics as well as spin-offs' performance. In managing a small and technology-based firm, having previous experiences will help entrepreneurs in building a network. As they climb on the learning curve, their capability is improved that they could better identify the most essential partners and participate in their network. Although learning is not a linear process, it increases with age. Therefore, we use age as a control variable in this study. Figure 1 shows the framework of this study which includes seven hypothesis and age as control variable.

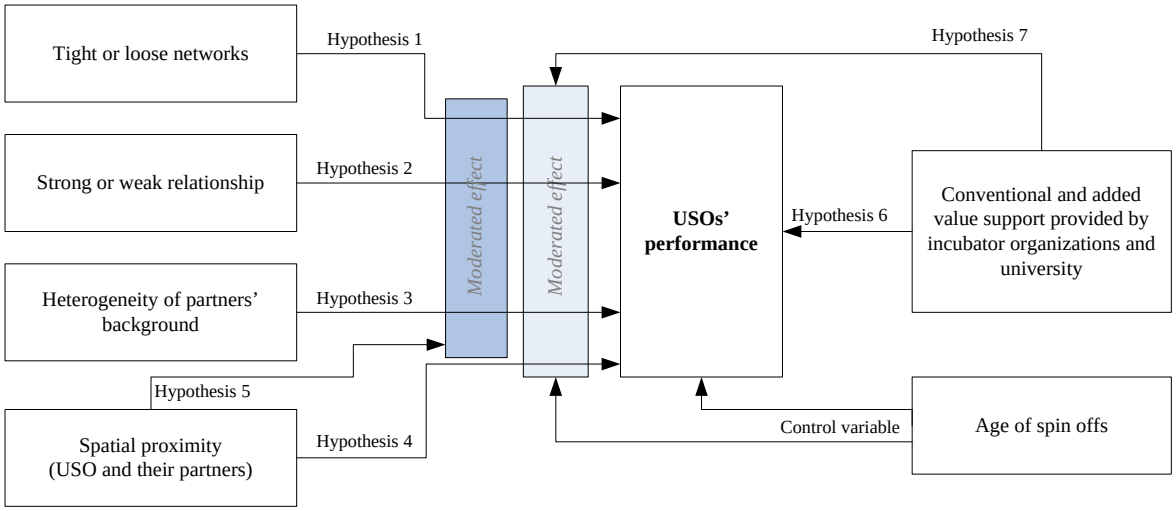

Figure 1. Determinant factors of USOs'performance

4. Research Design

The study draws on a survey of university spin-offs of TU Delft, the Netherlands. In total the population includes 61 spin-offs, defined by two criteria, that is age not older than 10 years

and having received support at least one type of support from TU Delft. The response rate was 67% leading to 41 valid interviews.

In this study, an Ordinary Least Square (OLS) regression analysis was used (see appendix 1 for the explanation of the variables). To test the hypotheses, five models were estimated. In each model, we include age variable as a control variable that could affect the dependent variable. Model 1 tested the hypotheses about socio-economic networks of the USOs. The impact of support was tested in model 2 and 3. Model 2 include a single variable explaining whether the USOs received only conventional support and/or added value support. In the next model (model 3), we examined the roles of each type of support in determining the USOs' performance. Moreover, we also conducted a regression analysis by combining the factors of the socioeconomic network and support from incubators in one model (model 4 and 5).

In the next step, we used hierarchical moderated multiple regression (Cohen and Cohen, 1983) to test our hypothesis of the interaction effect caused by single support, i.e. network building support, spatial proximity and age. There were three steps in the hierarchical moderated multiple regression (HMMR) analysis. In the first step, the variables of socioeconomic network characteristics were entered as a block. Entered in the second step were the moderated variables, in this case the network building support (model 6-9), spatial proximity (model 10-12) or age (model 13-16). The cross-product term of moderated variables and network characteristics was entered in the final step. In hierarchical HMMR, the statistical significance of the increment in R^2 (ΔR^2) with the addition of the cross-product term is used as a criterion for the effect size of the interaction (see appendix 2 for the models' equation).

One of the pitfalls in estimating regression models is the existence of multicollinearity among independent variables. To check for multicollinearity, the so-called variance inflation factor (VIF) was used, which is the reciprocal of tolerance. Large VIFs are an indication for the presence of multicollinearity. For the linear regression, the VIFs found in the estimates ranged from 1.24 to 1.58, meaning that no multicollinearity problems occurred. With regards to HMMR analysis, the main complaint against the use of multiplicative terms in regression analysis is related with the issues of multicollinearity (e.g. Althauser, 1971). This leads to the introduction of '*inflated*' standard errors for the regression coefficient. However, following the suggestion from Jaccard *et al*. (1990) this problem can be solved by centering the variables prior to the formation of multiplicative terms. Such a transformation is likely to yield a low correlation between product terms and component parts of terms. In this study, we use the transformation techniques suggested by Cronbach (1987).

5. Empirical results

5.1 Descriptive statistics

In this section we provide descriptive statistics. Table 1 shows a brief description of our sample. The number of firms in each age category has the same proportion. TU Delft's spin-offs are relatively small firms, most of them have less than 5 employees (44%) and almost one third have between 5 and 10 employees (37%). Most of the spin-offs can be seen as strongly innovative. They have in-house R&D (92%) and invest quite a large amount in R&D. Around 70 % of the spin-offs spend more than 10 percent of annual turnover in this activity. The USOs produce turn over from different sources, including selling products, consultation, and development and design. In some cases, the spin-offs have more than one source of income.

Table 1. Descriptive Statistics of sample

Characteristics	Absolute	Percentage
Age		
- Less than 4 years old	14	34.15
- 4-6 years	14	34.15
- More than 6 years	13	31.71
Size (fte)		
- Less than 5 fte	18	43.90
- 5-10 fte	15	36.59
- More than 10 fte	8	19.51
In-house research and development	38	92.00
R&D (per cent of annual turnover)		
- None	5	12.20
- Less than 10 per cent	7	17.07
- 10-30 per cent	18	43.90
- More than 30 per cent	11	26.83
Source of turnover[a]		
- Product sale	22	31.43
- Consultation	24	34.29
- Development and design	24	34.29

Note: [a] → more than one category possible per firm.

Table 2 shows obstacles faced by the USOs during their development. It appears that knowledge (skills) is the most problematic need, especially marketing knowledge and sales skills. Dealing with future uncertainty together with a lack of capability in forecasting future markets is one of the problems faced by most of the USOs. Next important is a shortage in skills to handle management overload. Half of the spin-offs also report that they face financial problems. Other issues, such as accommodation and the availability of research infrastructure appear to be of minor importance. The previous findings are similar with the findings of a study of problematic needs experienced by TU Delft spin-offs in 2002 (Van Geenhuizen and Soetanto, 2003)

Table 2. Problematic obstacles

Obstacles	Specification	Total	%	Rank
Market-related knowledge	Lack of marketing knowledge	22	15.71	1
	Lack of sales skills	20	14.29	2
	Lack of forecasting capability about future markets	18	12.86	4
Management-skills	Difficulty in dealing with uncertainty	19	13.57	3
	Too many managerial tasks to handle	12	8.57	5
Market	Lack of market demand	10	7.14	6
Financial	Lack of investment capital	9	6.43	7
	Lack of cash flow	6	4.29	8
Physical	Lack of adequate accommodation	5	3.57	9
	Lack of research and testing facilities	4	2.86	10

Note: more than one obstacle possible per firm.

It is not surprising that shortages in market- and management-related knowledge and skills are the major obstacles, since USOs evolve from an initial idea in a non-commercial environment to a competitive profit generating firm, a stage in which new and completely different knowledge and routines are required (Vohora *et al*., 2004). To overcome these obstacles, it is assumed that USOs seek external support through their socioeconomic networks.

Table 3. Descriptive statistics of variables used in analysis

Dependent variable	**Mean**	**S.D**
Job growth (1996-2005)	1.10 (fte)	1.02 (fte)
Independent variables		
Characteristics of network	**Mean**	**S.D**
Age	5.07 (year)	2.70 (year)
Number of partners (2005)	3.75 (persons)	.965 (persons)
Frequency of interaction with partner (2005)	2.28 (per month)	1.26 (per month)
Duration of relationship with partner	6.00 (year)	2.73 (year)
Heterogeneity index	0.58	0.13
Spatial proximity of partners	20.11 (minutes by car)	7.39 (minutes by car)
Type of support	**Absolute**	**Percentage**
Office and services	19	46.34%
Grant, loan or venture capital	21	51.22%
Marketing-related support	15	36.59%
Managerial consultation	15	36.59%
Network building	14	34.15%
Training/seminar	26	63.41%
Access to research results from university	10	24.39%
Access to research facilities at the university	16	39.02%

Table 3 shows the descriptive statistics of some network characteristics (see also appendix). We have measured network characteristics by using the name-generator technique. This technique is conducted by asking the respondent to name individuals with whom they mainly interact concerning exchange of information about business problems and opportunities and concerning other types of resources. Consistent with other studies, TU Delft's spin-offs have 3.75 partners on average. The study by Renzulli *et al*. (2001) reported that spin-offs have an average of 4.8 external partners. McEvily and Zaheer found the number of 3.5 connected partners per spin-offs. According to the entrepreneurs, they meet their partners in face to face interactions 2.28 times per month on average. Our respondents reported that they have known the contacts for 6.00 years on average. Related with support, most of the respondents reported that they received support such as training or seminar (63.41%) and loan or grant (51.15%).

5.2 Regression analysis

In this section, we examine to what extent the previously discussed socioeconomic networks influence the growth of USOs. In addition, we examine the influence of various support measures that USOs have received from the incubator and/or directly from the university. To these purposes, a linear regression analysis was performed. Table 4 reports the results of five models generated in the regression analysis. We start with a discussion about the statistical significance of each variable followed by the interpretation of the sign of the regression coefficient of each variable. Next, we will discuss the results from the moderated hierarchical regression analysis. At the end of this section, we will draw conclusions on the hypotheses.

Table 4. Results of ordinary least squares regression

Job growth as a dependent variable **Independent variables**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	β	β	β	β	β
Control variable					
Age of spin-off	.322**	.426**	.378**	.314**	.369**
Socio-economic networks					
Tightness	-.260**			-.241**	-.274**
Strength of relationship	-.375*			-.308**	-.277**
Heterogeneity in partners' background	-.273**			-.206**	-.436**
Spatial proximity (of network partners)	.349**			.316**	.310**
Mix of support Mixed conventional and added value support		.588**		.196*	
Type of support					
Conventional support					
Office and services			-.180		-.056
Grant, loan or venture capital			-.205		-.023
Added value support					
Marketing-related support			.337**		.075
Managerial consultation			.049		-.110
Network building			.366**		.059
Training/seminar			.022		.082
Access to research results from university			.140		.084
Access to research facilities in university			.037		-.009
F	29.25	20.99	3.04	28.25	9.97
Significance of F (Prob<F)	0.00	0.00	0.01	0.00	0.00
R2	0.8069	.5249	.4688	0.8329	0.8276
Adjusted R2	0.7793	.4999	.3145	0.8035	0.7446

* p < 0.10 * *p<0.05 *** p<0.01

Table 4 shows that age is significant in all models. All variables concerning the network characteristics are consistently significant throughout model 1, 4 and 5 and so is the variable concerning a mix of conventional and added value support in model 2 and 4. With regard to the different types of support (model 3), only two variables (e.g. marketing-related support, and network building) are significant. As this model shows relatively low accuracy in predicting the dependent variable (R^2=.4688), we need to be cautious in interpreting the result. Model 4 shows, however, that a mix of support is only marginally significant (p<0.10). In model 5, all support variables are not significant. We may conclude that network characteristic variables dominate as influence on performance of USOs.

Our next discussion will focus on the direction (*sign*) of the regression coefficients. With regards to age, the result shows that USOs' performance is positively influenced by age of firms. Model 1 presents the influence of socio-economic networks. The literature shows the ambiguous pattern of a positive relationship being either tight or loose. However, our results reveal that a loose network is essential. This implies that having partners in different networks (loose networks) tends to increase USOs' performance. With regard to hypothesis 2, employing weak relationships appears to be important for growth of the spin-offs. Further, the hypothesis about a positive relationship between USOs' performance and heterogeneity of contacts' background is confirmed. In addition, the results fail to prove the positive impact of nearby partners in determining USOs' performance. Apparently, local knowledge spillovers have no positive impact on USOs' growth. With regard to the kind of support (hypothesis 5), the regression results (model 2) indicate that a combination of conventional and added value

support tends to enhance growth. The results point out that the more diverse the added value support received by USOs is, the better USOs' performance is.

The regression model (model 3) reveals different findings concerning the hypothesis about the role of individual support measures. Some support such as marketing-related support and network building are found to positively influence the USOs' performance. The two types of conventional support show a negative sign. This would mean that USOs who receive such support do not perform well. Probably, this is caused by the fact that our sample includes a relatively large share of young spin-offs that have received this support but could not grow yet because of their young age (34%- 2-4 years old). This result once more confirms that USOs which receive a combination of conventional and added value support perform better.

On the last part of this section, we present the result of the analysis using a hierarchical moderated multiply regression. There are three variables that are assumed to have a moderated effect on the relationship between the characteristics of socioeconomic networks and the performance of USOs. These variables are network building support, spatial proximity and age which will be explained below.

The previous analysis indicates positive relationships between the characteristics of networks, that is loose networks, weak relationships, heterogeneous contacts and a large distance to partners and the performance of USOs. Therefore, it is important for policy perspective to identify whether network building support plays a role in moderating these relationships. The results (table 5) show that a significant influence only appears with regard to heterogeneity of the partners' backgrounds. Interaction between network support and other socioeconomic network characteristics is not significant. Apparently, socioeconomic networks develop and grow under the influence of other factors, such as the entrepreneurs' capability in establishing networks, location history, or relationships already present before the companies started.

Table 5. Results of HMMR analysis (network building support)

Step		**1**	**2**	**3**			
Model		**Socioeconomic network (A, B, C, D)**	**Network building support (E)**	**Interaction variables**			
				A x E	**B x E**	**C x E**	**D x E**
6	R2	0.716	0.746	0.747			
	ΔR		0.031	0.001			
	F		4.237**	0.098			
7	R2	0.716	0.746		0.747		
	ΔR		0.031		0.001		
	F		4.237**		0.160		
8	R2	0.716	0.746			0.783	
	ΔR		0.031			0.037	
	F		4.237**			5.727**	
9	R2	0.716	0.746				0.746
	ΔR		0.031				0.000
	F		4.237**				0.026

Note: A: Tightness; B: Strength of relationship; C: Heterogeneity in partners background; D: Spatial proximity; E: Network building support

Interaction	**Coefficient**
Tightness x Network building support (A x E)	-0.050
Strength of relationship x Network building support (B x E)	-0.020
Heterogeneity in partner's background x Network building support (C x E)	-0.228**
Spatial proximity x Network building support (D x E)	0.010

* p < 0.10 * *p<0.05 *** p<0.01

With regards to spatial proximity, the result shows that spatial proximity shows a significant interaction effect with all the socioeconomic network characteristics (tightness, strength of relationship, and heterogeneity of partners' background). The interaction between spatial proximity and strength of relationship has the strongest significance level on the performance of the USOs. In this case, the spin-offs which have partners in a relatively distant proximity tend to have a loose network and weak relationship.

Table 6. Results of HMMR analysis (spatial proximity)

Step		**1**	**2**	**3**		
Model		**Socio economic network (A, B, C)**	**Spatial Proximity (D)**	**Interaction variables**		
				A x D	**B x D**	**C x D**
10	R2	0.556	0.670	0.701		
	ΔR		0.114	0.031		
	ΔF		12.755**	3.723*		
11	R2	0.546	0.654		0.696	
	ΔR		0.107		0.043	
	ΔF		11.471**		5.058**	
12	R2	0.331	0.570			0.612
	ΔR		0.240			0.042
	ΔF		20.652**			3.851*

Note: A: Tightness; B: Strength of relationship; C: Heterogeneity in partners background; D: Spatial proximity

Interaction	**Coefficient**
Tightness x Spatial proximity (A x D)	0.002*
Strength of relationship x Spatial proximity (B x D)	0.006**
Heterogeneity in partner's background Spatial proximity (C x D)	0.023*

* p < 0.10 * *p<0.05 *** p<0.01

Note: the sign of coefficient is positive; it is because we apply the two-steps transformation on the spatial proximity variable (see appendix 3 for more explanation)

Table 7 shows the result of HMMR by placing age of spin offs as a moderator variable. Although, the level of significance is relatively low (<0.10), we consider that the result confirms our assumption that age has an influence on the characteristics of socioeconomic networks. The only insignificant result is related with the heterogeneity of contacts' background.

Table 7. Results of HMMR analysis (Age of spin-offs)

Step		**1**	**2**	**3**			
Model		**Socioeconomic network (A, B, C, D)**	**Age of spin-off (F)**	**Interaction variables**			
				A x F	**B x F**	**C x F**	**D x F**
13	R2	0.427	0.556	0.595			
	ΔR		0.129	0.039			
	F		11.045**	3.560*			
14	R2	0.317	0.546		0.588		
	ΔR		0.229		0.042		
	F		19.153**		3.776*		
15	R2	0.127	0.331			0.334	
	ΔR		0.204			0.003	
	F		11.579**			0.172	
16	R2	0.492	0.530				0.564
	ΔR		0.038				0.034
	F		3.044**				2.845*

Note: A: Tightness; B: Strength of relationship; C: Heterogeneity in partners background; D: Spatial proximity; E: Network building support

Interaction	Coefficient
Tightness x Age of spin-off (A x F)	-0.003*
Strength of relationship x Age of spin-off (B x F)	-0.018*
Heterogeneity in partner's background x Age of spin-off (C x F)	-0.002
Spatial proximity x Age of spin-off (D x F)	-0.032*

* p < 0.10 * *p<0.05 *** p<0.01

The results reported here indicate a lack of support for the hypotheses that predicted the relationship between support received from incubator organization and the performance of the USOs. It also reveals that the network building support has a modest influence in determining the relationship between the characteristics of socioeconomic networks and the performance of the USOs. On the other hand, socioeconomic networks seem to be essential in determining the performance of USOs. Furthermore, it was also proven that spatial proximity has played a moderate effect on the relationship between the characteristics of socioeconomic network and the performance of the USOs. Regarding age, the result also found a significance level on both regression analyses. We may summarize our results in terms of rejecting or accepting the hypotheses in table 7.

Table 8. Summary of hypothesis

Hypotheses	Description	Conclusion
Hypothesis 1a	Performance of USOs is positively affected by tight networks.	Rejected
Hypothesis 1b	Performance of USOs is positively affected by loose networks.	Accepted
Hypothesis 2a	Performance of USOs is positively affected by strong relationships.	Rejected
Hypothesis 2b	Performance of USOs is positively affected by weak relationships.	Accepted
Hypothesis 3	Performance of USOs is positively affected by strong heterogeneity of partners' backgrounds.	Accepted
Hypothesis 4	Performance of USOs is positively affected by close spatial proximity between USOs and their partners.	Rejected
Hypothesis 5	The spatial proximity to network partners will moderate the relationship between socioeconomic network characteristics and the performance of USO.	Accepted
Hypothesis 6	USOs which receive conventional support plus value-added support perform better than USOs that receive only conventional support.	Accepted
Hypothesis 7	The network building support will moderate the relationship between socioeconomic network characteristics and the performance of USO.	Mostly rejected

6. Conclusion

The aim of this paper was to explore the influence of socio-economic networks and of various support measures on USOs' performance. The results from the regression analysis indicated that spin-offs facing networks rich in loose and weak relationships are in a better position to grow compared to spin-offs facing tight and strong relationships. In addition, a large diversity in the background of partners appeared to be essential. The previous results all pointed into the same direction that is, relatively open information (knowledge) sources and flow tend to have a positive influence on growth of innovative companies. In contrast with our expectation, the findings could not prove that a close spatial proximity of partners has a positive influence on growth. We may understand the latter result in the sense that close spatial proximity leads to network characteristics that prevent an open information and knowledge flow. However, the idea that a close proximity apparently does not lead to cost advantages, like in achieving new knowledge (knowledge spillovers), is more difficult to understand. Moreover, the results also revealed that spatial proximity interacts with the other characteristics of socioeconomic

networks in determining the performance of USOs. These findings on interaction supported the argument that spatial proximity has 'an indirect role' in determining the nature of socioeconomic networks. With regard to support provided by incubator organizations and/or directly by the university, the results showed that conventional support is effective if combined with added value support. We may conclude that the overall findings confirm the ongoing discussion in the literature about the need to improve the support provided to USOs. We propose to put a greater emphasis on added value support, particularly on the capacity of USOs in network building that leads to loose and weak networks and a large diversity in partners' background.

We believe that our case study of TU Delft's spin-offs can be generalized to some extend, namely to technical universities and technical faculties at general universities in Western Europe, particularly in countries facing a relatively weak entrepreneurial (risk-taking) culture. However, there are two things to consider. First, from the perspective of the type of incubation policy. TU Delft's incubation policy is specific as it represents the so-called low selective model (Clarysse *et al*., 2005). This model aims to create as many start-ups as possible and focuses on providing conventional support. Second, from the location perspective, TU Delft's spin-offs are located at a close distance of two important large cities, The Hague and Rotterdam. This poly-centric pattern of cities may lead to different spatial networks compared with spin-offs located in single cities.

Despite the interesting results, we acknowledge that there are some limitations in our study. The limitations are methodological in nature. First, we were not able to exclude certain fuzziness in the data on personal networks with regard to spin-offs managed by more than one entrepreneur. This is a common situation in network study using so-called ego-centric technique (Brewer and Webster, 1999). In addition, a certain bias has entered the measurement of openness of the networks with regard to weak relationships. It was difficult to identify whether network partners in a weak relationship interact with each other independent of the ego.

In conclusion, this study is to be viewed as a first effort to identify broad patterns of socioeconomic networks experienced by USOs and the influence of these patterns on growth. In a next step, this study can be extended by conducting research that may lead to a more refined understanding of the factors which show relatively low levels of significance in the regression analysis particularly in measuring the interaction effect. We admit that the relatively low levels of significance of the interaction effects may be caused by our relatively sample size (Jaccard *et al*., 1990). Therefore, in the next step in the research, we will increase the sample size.

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Appendix 1

Regression	Variables	Description
Linear regression and moderated hierarchical regression	Job growth	Measured by average annual growth in full-time equivalents.
	Tightness	Measured by the number of existing relationship divided by the number of potential relationship. The value of this variable is between 0 and 1. A low value indicates a loose network and a high value indicates a tight network.
	Strength of relationship	Measured by two criteria: the average frequency of interaction and the number of years the relationships have lasted. =(#frequency of interaction/#partner)+(#number of years the relationship /#partners) A low value indicates a weak relationship and a high value indicates a strong relationship.
	Heterogeneity	Measured by the sum of the outcomes of the heterogeneity index of each type of partners' background (e.g. academic, business). The index is calculated on the basis of the square of the number of partners from a similar background divided by the total number of partners. A high value indicates that many partners come from the same background and a low value indicates that partners have diverse background.
	Spatial proximity	Measured by the average travel time to partners. =(#travel time/#partner) A low value indicates a close proximity and a high value indicates a large distance.
	Network building support	The variable is a dummy variable for the network building support received by the USOs. (1=received support; 0=did not receive support)
Linear regression	Mixed support	The variable is a rank variable for the types of support. The codification is as follows : Rank 1: Only conventional support. Rank 2: Conventional and 20% added value support or only 60% and more added value support. Rank 3: Conventional and 40% - 60% added value support. Rank 4: Conventional and 60% and more added value support.
	Type of support (8 types)	Each variable is a dummy variable (1=received support; 0=did not receive support)

Appendix 2

By applying the hierarchical moderated multiple regression analysis, we developed two models. The first model is as follows:

Job growth = $b0$ + b1(NET1) + $b2$(SUP) + $b3$(NET1 x SUP)

where $b0$ is the intercept; $b1$ is the regression coefficient associated with the characteristics of socioeconomic networks (tightness, strength of relationship, heterogeneity, and spatial proximity); $b2$ is the coefficient associated with dummy variable whether spin offs receive a network building support or not; b3 is the coefficient associated with the interaction effect, which is the multiplicative product of the two variables (Network building support and the characteristics of socioeconomic network). In total there are four models representing each of the characteristics of socioeconomic networks.

The second equation is as follows:

Job growth = $b0$ + $b1$(NET2) + $b3$(PRO) + $b4$(NET2 x PRO)

where $b0$ is the intercept; $b1$ is the regression coefficient associated with the characteristics of socioeconomic network (tightness, strength of relationship, and heterogeneity); $b2$ is the coefficient associated with spatial proximity; $b3$ is the coefficient associated with the interaction effect, which is the multiplicative product of spatial proximity and the other characteristics of socioeconomic networks.

In total there are three models that represent the characteristics of socioeconomic networks (tightness, strength of relationship, and heterogeneity.
The third equation is as follows:
Job growth = *b0* + b*1*(NET3) + *b2*(AGE) + *b3*(NET3 x AGE)
where *b0* is the intercept; *b1* is the regression coefficient associated with the characteristics of socioeconomic networks (tightness, strength of relationship, heterogeneity, and spatial proximity); *b2* is the coefficient associated with age of spin-offs; b*3* is the coefficient associated with the interaction effect, which is the multiplicative product of the two variables (age and the characteristics of socioeconomic network). In total there are four models representing each of the characteristics of socioeconomic networks.

Appendix 3

The failure to detect the interaction effects may due to some problems. The main problem is related with multicollinearity. To counteract this problem Jaccard *et al*. (1990) suggested centering the variable prior to the formation of product terms. However, this step may lead to some difficulties in interpreting the result. For instance, in our case, the previous analysis (liner regression analysis) shows that spatial proximity has a reverse direction compared with other socioeconomic network characteristics. Therefore, by centering the spatial proximity variable and applying the moderated regression analysis, it will cause a 'scale coarseness' problem (Bobko and Russel, 1994, Aguinis, 1995). To solve this problem, effort should be made to maximize the reliability of the measures involved in the analysis, especially caused by product term. Therefore, we performed an additional transformation aiming to overturn the direction of spatial proximity variable (formula: 1/spatial proximity). The aim of this step is then make the expected direction (sign) of spatial proximity is the same with other characteristics of socioeconomic network. Finally, we performed a 'centering' transformation on this variable by subtracting it with their mean (Cronbach, 1987). This transformation did not change the value of spatial proximity variable, but altered the value (and standard errors) of this variable and the intercept.