International knowledge gaining: challenges and barriers among young university spin-off firms

Mozhdeh Taheri* and Marina van Geenhuizen**

*Researcher at the Faculty of Technology, Policy and Management, Delft University of Technology.
Contact: m.taheri@tudelft.nl
**Professor of Innovation and Innovation Policy in Urban Economies at the same faculty.
Contact: m.s.vangeenhuizen@tudelft.nl

Abstract
Industrial competence is increasingly dispersed across the globe, urging young high-technology firms to build knowledge relationships across national and continental boundaries. However, building such relationships is hampered by numerous barriers following from short in experience and education of founders of these firms. In this paper, we examine the role of absorptive capacity of a specific category of firms, university spin-offs, in building knowledge networks, specially the spatial reach involved. In a sample of 105 spin-offs, in the Netherlands and Norway, we find that around 60 per cent of the firms employ knowledge relationships abroad, almost 35 per cent of them outside of Europe. The main underlying absorptive capacity factors are a high education level (PhD), participation in market/business-related training, and low newness of realized innovations, the last indicating support from an established market position in knowledge networking with a larger reach. A final result is that international knowledge networks associates with higher levels of firm growth regarding employment.

Keywords: university spin-off firms, absorptive capacity, barriers, knowledge networks, spatial reach.

1. Great challenges but low absorptive capacity

Being embedded in networks of inter-firm and inter-organizational knowledge relationships is generally seen as challenging as it enables firms to absorb a wide range of specialized knowledge and, as a result, to perform better compared to firms without such embedding (Grant, 1996; Powell et al., 1996; Malerba and Orsenigo, 2000; Tether, 2002). In particular, a considerable body of literature supports the idea that openness to external knowledge sources helps boosting innovation performance (Leiponen and Helfat, 2010; Love et al., 2013).

Since the early 1990s, the increased global competition has produced a continuous pressure on
high technology firms to improve their technological, organizational and market-related knowledge, and to do this in part through collaborative networks. In addition, various studies indicate the importance of knowledge collaboration on a global level (Kuemmerle, 2002; Clercq et al., 2012); this is because industrial competence and innovative economic activity are now widely dispersed all over the globe, whereas increased specialization has limited the availability of specialized knowledge to only a few places in the world (Teece, 1992; Amin and Cohendet, 2006). The OECD (2011) observes an increased role in international research activity for countries like China, Korea, Brazil and India. In R&D investment, the US is still in first position but is followed by China, just ahead of Japan, whereas Korea equals the UK (OECD, 2012). This changing landscape of R&D and related innovative businesses may thus be a large challenge among young high-technology firms and drive them to increasingly cross larger distances to acquire the knowledge needed. However, in the practice-oriented literature, numerous practical barriers have been identified among young high-technology firms hampering the development of international activity, like cultural barriers and information and network barriers (OECD, 2009; BIC, 2010), and these are often related to limits in absorptive capacity.

Knowledge gaining from external partners is seen in this paper as being active in achieving new, often complementary, knowledge through a process of interaction and information processing in identifying and selecting appropriate partners, developing routines to interact with them and constructing management systems to monitor and manage the relationships. Given these activities, knowledge gaining from external partners is subject to a learning process in which absorptive capacity plays an important role. Developing absorptive capacity is seen as highly important for young firms as they suffer in general from liability of newness and consequently from an increased propensity to fail compared to more established firms (Stinchcombe, 1965; Unger et al., 2011). Higher levels of absorptive capacity enable young firms to better select and absorb information about new external situations and translate that into decisions and actions (Sapienza et al. 2005; West and Noel, 2009). This particularly holds for building networks abroad, in terms of searching, selecting and maintaining the most beneficial relationships. In studies on absorptive capacity, firms are viewed as units that encompass the process of signaling, interpreting and using information from their changing environment. Absorptive capacity is the dynamic capacity enabling firms to create value and gain competitive advantage, particularly to respond in a timely fashion to changes in the business environment (Freeman, 1982; Cohen and Levinthal, 1989; Zahra and George, 2002; Lane et al., 2006; McAdam et al., 2011).

Despite the fact that increasing absorptive capacity has been recognized as one of the main options in overcoming difficulties in changing situations (Escribano et al., 2009; Yu et al., 2011), it has been studied in relation to international knowledge networking only in a few empirical works, like de Jong and Freel (2010), whereas the measurement of absorptive capacity has often been limited to a few indicators - R&D based - disregarding the difference between potential and realized absorptive capacity (Zahra and George, 2002). The aim of this paper is therefore to elucidate international knowledge networking among young high-tech firms and the extent in which differences in the reach in this networking is determined by absorptive capacity, measured in an extended way.

The focal firms in the current paper are university spin-offs, which we define as relatively young firms and independently established by university staff and/or graduates in order to develop and
commercialize knowledge created at universities (Pirnay et al., 2003; Shane, 2004). Attention to this type of firm has increased in general and in the regional/national innovation policies since the early 1980s, especially since the early 2000s (Djokovic and Soutaris, 2008; Huggins and Johnston, 2009). In this context, university spin-offs are viewed as developers of university inventions towards market application or application in society, as contributors to a wider diffusion of university knowledge, as promoters of entrepreneurship in the region and as supporters of high-technology infrastructures (Shane, 2004; Debackere and Veugelers, 2005). What makes spin-offs different from many other small high-technology firms is that they originate from a non-commercial environment, in many cases, a technology research environment, which implies that the entrepreneur is basically in need of complementary knowledge to develop a marketable product and knowledge regarding customer requirements, changing market demands, pricing, etc. (Lockett et al., 2005).

With regard to absorptive capacity, we found three knowledge gaps in the literature. There is the already addressed gap regarding the role of absorptive capacity in knowledge gaining abroad, including distances, which has only recently been included in research agenda’s (Xia and Roper, 2008; de Jong and Freel, 2010; Clercq et al., 2012; Fletcher and Harris, 2012; Liu, 2012). In more detail, there is a need for an extended approach and measurement of absorptive capacity which often have been limited to R&D indicators (Escribano et al., 2009; de Jong and Freel, 2010; Murovec and Prodan, 2009). Also, to our knowledge, the absorptive capacity of the focal category of firms in this paper, university spin-offs, and its influence on their ability to build knowledge relationships abroad, has not yet been studied. Against this backdrop the research questions are as follows: 1) What is the pattern of international knowledge networking and its spatial reach? 2) To what extent can the differences in spatial reach be attributed to a diverse absorptive capacity? In addition, at the background plays the question of growth: 3) to what extent does international knowledge gaining has a positive influence on firm growth?

Drawing on interview data on 105 spin-off firms in Western Europe, the paper makes the following contribution to the empirical literature. First, it provides a deeper view on international knowledge gaining, namely, insight into spatial reach in knowledge networks, given the need to cross larger distances seen from Europe. Secondly, based upon a key role for absorptive capacity, the paper provides an explanation of differences in spatial reach in knowledge networks. The explanatory power turns out to be modest, but not below levels in the few other studies. It also provides an extended approach to absorptive capacity including a distinction between potential and realized absorptive capacity, with the first conceived as more than merely R&D. And thirdly, the paper provides an extension of empirical research on absorptive capacity and knowledge relationships abroad to the category of university spin-off firms, which is entirely new. Lastly, the paper contributes to the literature by confirming the relevance of international knowledge networks, in that these networks go along with a stronger growth of the firms.

The paper unfolds as follows. Theoretical and empirical perspectives as well as model development are discussed in Section 2. The methodological steps, including data collection, are explained in Section 3. This is followed by a brief analysis of internationalization of firm growth, and a descriptive analysis and multivariate analysis of spatial reach in knowledge networking, highlighting the role of absorptive capacity factors, in Section 4. The paper ends with a discussion and conclusions.
2. Model design with a focus on absorptive capacity

2.1 Barriers
In the practice-oriented literature, the emphasis is laid on various barriers among innovative small firms (BIS, 2010; OECD, 2009) preventing a quick internationalization among them. Given some overlap between categories of barriers, we may distinguish between (1) resource barriers, such as short in investment capital, management time and skills, reputation and accountability; (2) information and network barriers, such as lack of knowledge on foreign markets and difficulty to contact potential partners abroad to identify business opportunities, (3) cultural barriers, as exemplified by difficulty to adjust to local cultural norms in doing business, and to languages and cultural differences in product specification/preferences, and finally (4) legal/regulatory barriers, like in dealing with different financial and tax regulation, ownership issues, product standards, certification and intellectual property protection (Oviatt and McDougall, 1994; Prashantham, 2005).

Another, more theoretical, starting point for analysis of small firm internationalization has been different types of stage- and process models, dwelling upon changing influence of resource and network barriers. Gaining sufficient resources to ‘invest’ in internationalization over time is at the heart of the model of incremental internationalization, also named the Uppsala model (Johanson and Vahlne, 1977), in which small firms first establish domestic markets and then turn to markets abroad. This stepwise approach to accessing foreign trade markets is also connected with the use of complementary social networks (Johansson and Mattson, 1998; Johansson and Vahlne, 2003). By contrast, the born-global model assumes an immediate entry into foreign markets, namely at firm establishment or shortly after, this as a different way of internationalization (e.g., Oviatt and McDougall, 1994; Andersson and Wictor, 2003; Knight et al., 2004; Fernhaber et al., 2007). The processes that make new ventures born-global, are seen to be connected to pre-existing networks (Johansson and Vahlne, 2003) eventually coupled with newly established ones allowing for a rapid and pro-active learning (e.g. Freeman et al., 2010), all increasing absorptive capacity.

2.2 Absorptive capacity
Absorptive capacity as the ability of firms to recognize, acquire and to assimilate and exploit external knowledge, can be seen as one of the major resources of firms (Cohen and Levinthal, 1989). In the concept of absorptive capacity it is recognized that firms are in the position to understand, adopt and integrate new knowledge generated elsewhere, meaning that various strategy options are open. Accordingly, a higher level of absorptive capacity enables a wider and more diverse knowledge search strategy and access to and integration of highly specific sets of new knowledge, potentially leading to higher levels of innovation and firm performance, including internationalization (Freeman, 1982; March, 1991; Nelson and Winter, 1982; Teece, 2007; West and Noel, 2009).

Zahra and George (2002) distinguish between two dimensions in absorptive capacity, potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP). PACAP makes firms eager to acquire new knowledge and allows them to acquire and assimilate external knowledge (Lubatkin and Lane, 1998) while RACAP allows the firms to leverage their knowledge by using the knowledge it has absorbed. This distinction puts a strong emphasis on the idea that firms may
acquire and assimilate knowledge, but may lack the ability to transform and exploit it for innovation or profit generation. By adopting the previous conceptualization of absorptive capacity, we may argue that firms with greater absorptive capacity are better equipped to identify and exploit external knowledge that is useful, bridging larger distances in internationalization if necessary (Escribano et al., 2009; Huber, 1991). We thus assume that several characteristics of founding entrepreneurs or founding teams, such as pre-start working experience and level of education, are important dimensions of absorptive capacity, as skills, expertise, understanding, etc. that have been gathered previously (e.g. Colombo and Grilli, 2005, 2010), thereby referring to potential absorptive capacity. An additional component of potential absorptive capacity is cross-cultural experience in the founding team, through living experience and/or family ties abroad. Cross-cultural experience can reduce cultural distances between partners in different countries, leading to a higher degree of involvement in firms abroad (Boschma, 2005; Hart and Acs, 2011; Liu, 2012).

In addition, realized absorptive capacity refers to the ability to leverage existing knowledge and make particular choices. This may be evidenced by the actual stage in product development, like having brought new products to market as evidenced by new product announcements (Zahra and George, 2002), and by the level of newness of innovations (Nooteboom et al., 2005; Fabrizio, 2009). Young high-technology firms are involved in different phases of new product development, including the early development stage, pilot stage, market access stage and established market position, each indicating different components of absorptive capacity. Similarly, having responded to important external changes, can be seen as a manifestation of realized absorptive capacity (Debrulle et al., 2013).

2.3 Model building
We built a model to explore influences on internationalization and its spatial reach among university spin-off firms. Young and small firms are subject to what is called ‘liability of newness’, and the associated lack of reputation and accountability often persuades them to connect with high status stakeholders, at the expense of relationships elsewhere (Stinchcombe, 1965; Baum and Oliver, 1996; Autio et al., 2010). For this reason and the idea that with older age and larger firm size the chance to own more resources increases, we include the age and size of spin-off firms as control variables in the model, assuming that the older the firm and the larger its size, the larger the reach in knowledge relationships may be. However, some university spin-off firms behave like ‘born globals’ and employ knowledge relations at far distances abroad from establishment, already at a small size (Madsen and Servais, 1997; Andersson and Wictor, 2003; Freeman et al., 2010). In addition to this, spin-off firms operate in economic sectors and industry types where innovation and the associated learning processes are different, like between science-based sectors and market-based sectors (Pavitt, 1984; Tidd et al., 2005). Due to the universal nature of science, science-based firms tend to be globally oriented in terms of learning, except for the first stages. By contrast, in sectors pushed by market demand and market context, adaptive learning is important and this type of learning tends to benefit more from local face-to-face interactions in solving problems (Asheim et al., 2007; Nemet, 2009). In addition, science-based firms are faced with stronger turbulence in their environment compared to non-science-based firms, especially with respect to constantly evolving information on new technology, gaining venture capital in various rounds, patenting issues, regulation, as well as fierce competition, requiring more specialized knowledge gaining, most probably over larger distances.
(Miller and Friesen, 1983; Liao et al., 2003). In other studies, similar differences are seen between high-technology firms and lower technology firms, and often a high-technology level has been associated with ‘born-globals’ (Crick and Jones, 2000; Andersson and Wictor, 2003). For these reasons, industry is included in the model as a control variable, with an emphasis on the difference between science-based and market-based activities.

The above argument connects with studies suggesting that the spatial orientation in the (potential) customer market influences the reach in knowledge relationships. De Jong and Freel (2010) confirm that operating in export markets is associated with a larger reach in knowledge relationships, which is why we also take market orientation in our model as a control variable. In addition, to distinguish the influence of a different supply of knowledge in the region (city) of location, we include location in our model as a control variable, and assume that firms in peripheral regions go abroad more quickly, looking for knowledge that is lacking locally (de Jong and Freel, 2010).

As the core of the model, we include the following potential absorptive capacity factors: R&D expenditure, size of the founding team, and especially, because often neglected in potential absorptive capacity, various founder or team characteristics, including PhD level, multidisciplinary education, participation in training, pre-start working experience and cross-cultural experience (Becker, 1993; Wiklund and Shepherd, 2003; Bosma et al., 2004; Colombo and Grilli, 2005, 2010; Zhang et al., 2006; Jansen et al., 2011). Realized absorptive capacity is included in our model through ‘newness of innovations’ and ‘stage in product development’. Reasons for these selections were not only theoretical but also practical, namely availability in the dataset and the need to avoid sources of bias, but we are aware of the fact that these are clear approximations.

3. Data and methods

3.1 Data collection

We draw on data from two university cities in Europe (Note 1). The two countries involved (the Netherlands and Norway) share a similar, somewhat risk-avoiding entrepreneurship culture (GEM, 2010), gain similar scores on the main European Innovation Scoreboard indicators (ProInno Europe, 2011), and both have relatively small domestic markets, making them export-orientated with a relatively large chance for adoption of the born-global model. This pattern indicates that we mainly measure differences between the two cities, Delft and Trondheim, and not between countries (Note 2). Delft is a part of the Randstad metropolitan area in the Province of South Holland and the major industry in this area is commercial and service industry (Statistics Netherlands, 2010), while the major industry in the Trøndelag area, where Trondheim is located, is mining, agriculture including farmed fish and processed wood, with oil and gas production as the fastest growing sector (Statistics Norway, 2010). The economy of South Holland is eight times bigger than that of Trøndelag, indicating potentially huge differences in the intensity of local/regional knowledge spill-overs and in opportunities for local networking with useful partners.

In constructing the database, the population of spin-offs needed to satisfy various conditions: all
commercializing knowledge created at the universities, survived to 2006/7 with an age not older than 10 years and having enjoyed at least one type of support from their incubation organization/university. All the firms in this population (150) were invited – using email and mediation by the incubator manager in Trondheim - for an interview, leading altogether to an overall response rate of 70 per cent (105 firms) (Note 3). The data were collected using a semi-structured questionnaire in personal face-to-face interviews with the principal manager, in all but three cases a member of the founding team. To analyze spatial reach in knowledge relationships, we collected cross-section data in 2006/7 and also asked questions about several characteristics of the firms during the start-up phase at the time, while we went back to the firms by e-mail or website to determine their growth up to 2011.

3.2 Measuring variables

In the literature, absorptive capacity is a construct that is measured in highly diverse and mostly indirect ways using different proxies.

Only a few studies have dealt with absorptive capacity addressing its underlying complex nature by taking a broad set of indicators into account both on potential and realized absorptive capacity, including the strategic response to market change (Lane et al., 2006; Debrulle et al., 2013). The current study also has limitations in covering the huge complexity of absorptive capacity, mainly due to data availability, and is confined to eight indicators (Table 1).

<table>
<thead>
<tr>
<th>Category Description</th>
<th>Measurement in literature (main examples)</th>
<th>Measured in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential absorptive capacity</td>
<td>-Years of experience of R&amp;D section (Murovec &amp; Prodan, 2009; de Jong &amp; Freel, 2010)</td>
<td>-No data available</td>
</tr>
<tr>
<td></td>
<td>-Training (investment) of personnel related to innovative projects (Escribano et al., 2009; Murovec &amp; Prodan, 2009)</td>
<td>-Business and market training/consultation</td>
</tr>
<tr>
<td></td>
<td>-Share of scientists in total number of employees (Escribano et al., 2009)</td>
<td>-No data available</td>
</tr>
<tr>
<td></td>
<td>-Fully staffed R&amp;D department (Veugelers, 1997; Escribano et al., 2009)</td>
<td>-Not used because not applicable for young spin-off firms</td>
</tr>
<tr>
<td></td>
<td>-R&amp;D expenditure/intensity (Nooteboom et al., 2005; Murovec &amp; Prodan, 2009; Escribano et al., 2009; de Jong &amp; Freel, 2010; Bishop et al., 2011; Xia, 2013)</td>
<td>-R&amp;D expenditure</td>
</tr>
<tr>
<td></td>
<td>-Continuous R&amp;D (Bishop et al., 2011; Xia, 2013)</td>
<td>-No data available</td>
</tr>
<tr>
<td></td>
<td>-Market-oriented meetings (Debrulle et al., 2013)</td>
<td>-No data available</td>
</tr>
<tr>
<td></td>
<td>-Accumulated knowledge in the firm (Murovec &amp; Prodan, 2009; Schewns and Kabst, 2009; de Jong &amp; Freel, 2010; Colombo &amp; Grilli, 2010; Xia, 2013)</td>
<td>-Organizational age and size</td>
</tr>
<tr>
<td></td>
<td>-Number of cross-firm patent citation (Fabrizio, 2009)</td>
<td>-Size of founding team</td>
</tr>
<tr>
<td></td>
<td>-Number of citations in a firm’s publications to research developed in other firms (Cockburn &amp; Henderson, 1998; Fabrizio, 2009)</td>
<td>-Work experience of founders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-PhD level among founders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Multidisciplinary education</td>
</tr>
<tr>
<td>Potential absorptive capacity</td>
<td>-No data available</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Not used because only small part of the spin-off firms in this study is involved in publications</td>
<td></td>
</tr>
</tbody>
</table>
Realized absorptive capacity  
- New research projects initiated and number of new product ideas (Zara & George, 2002)  
- Not used because counting of new research projects and product ideas causes bias, due to different ideas about newness and a different level of detail adopted in counting

Realized absorptive capacity  
- Number of patents (Nooteboom et al., 2005; Fabrizio, 2009; Xia, 2013)  
- New product announcements (Zahra and George, 2002)  
- Length of product development cycle (Keller, 1996; Nooteboom et al., 2005; Gilsing and Duysters, 2008)  
- Number of publications (Fabrizio, 2009)  
- Response to changes in market environment (e.g. on product development) (Debrulle et al., 2013)  
- Not used as a single indicator because of bias due to different patenting cultures between industries  
- Newness in terms of breakthrough and patent involvement  
- Stage in new product development (exploration or exploitation)  
- Not used because only small part of spin-off firms in this study is involved in publication  
- No data available

Table 2 shows the measurement of the model variables. The dependent variable, spatial reach in knowledge relationships, is derived from asking the respondents about which knowledge sources (partners) they felt had been important to the growth of their firm, including the location of these partners. With regard to location, it turns out to be impossible to reach the level of detail of cities because many spin-offs are reluctant to mention a city as information that is apparently highly sensitive. That is the reason why we cover countries and present the dependent variable as an ordinal variable indicating reach in four broad categories: no international knowledge relationships, only countries in Europe, only Europe and North America, only Europe and Asia, and three or more continents.

We measure the control variables as follows. The firms’ organizational age as the number of years since a firm was founded, and firm size as the number of employees at the time the survey was conducted. Using the categorization of industry and associated learning proposed by Tidd et al. (2005), we distinguish between two industries: 1) science-based, dealing with basics in chemistry, life-sciences, nanotechnology, etc., and 2) market-based, including specialized supplier firms providing input to complex production systems, e.g. machinery and instruments, and information processing particularly servicing finance, retailing and transport, all reflecting demand-pull learning. Furthermore, market orientation is measured as ‘most important actual or envisaged customer market’, using the categories regional/national and international, included in the model as a dummy variable. Our final control variable (location) is measured in two categories as a dummy variable, Trondheim as a town in a peripheral and low-density region, and Delft as part of a core metropolitan area.

With regard to potential absorptive capacity, R&D expenditure is measured as a percentage of average firm turnover over the past three years. A small minority of the firms (15 per cent) had no turnover because the firms did not sell their product yet, but they received substantial national research subsidies or grants from large firms (based on collaborative agreements). In those cases, we take income from these sources, as indicated by the respondent. Further, the variables used to indicate amount and diversity in accumulated knowledge in the founding team are measured as
follows: the number of team members, pre-start working experience as the average number of working years of the first three founders, education level in terms of the number of doctorate degrees in the founding team, and multidisciplinary education, by including two classes, single technology and multiple technology/disciplines. Next, cross-cultural experience among the founding team members is measured by using the country of birth of the team members or their parent(s). Note that, because of limitations in our database and some doubt as to the validity of some indicators (Kleinknecht et al., 2002), the years of experience of the R&D department and various indicators of knowledge assimilation cannot be measured (Table 1).

With regard to realized absorptive capacity, some indicators that are mentioned in literature are not present in our database due to the difficulty of grasping them without bias. Firstly, some respondents were reluctant to answer questions on new research projects and new product ideas for reasons of secrecy, and secondly, counting new product ideas would have allowed bias to enter, because the result would depend on the level of detail provided by the respondent (Zahra and George, 2002). With regard to knowledge exploitation, we include certain aspects of the indicators mentioned in literature in two variables, i.e. newness of the innovation and stage in new product development. Newness is measured in three categories, based on whether the product was perceived as a breakthrough and/or new to the sector, and on whether patent(s) were involved. We avoid simply counting the number of patents, for the reason mentioned that different sectors have different patenting cultures (Kleinknecht et al., 2002; Mann and Sager, 2007). Furthermore, the stage of new product development is measured as a rank variable with two categories: early development, including pilot and testing, and the later stages, including market introduction and related consultancy.

### 3.3 Ordered regression analysis

To understand the spatial distribution of phenomena, usually spatial analysis or spatial network analysis are used (e.g., Maggioni et al., 2007), which take the phenomena as points in space. However, as indicated previously, this level of detail (cities) could not be achieved in our dataset, reason why we focus on regression analysis. We use Ordered Logistic regression, based on the assumption that the levels of spatial reach have a natural ordering. Ordered logistic regression uses maximum likelihood estimation as an iterative process.

The common checks and considerations are performed, i.e. checking for multicollinearity and looking at the endogeneity issue. Thus, correlations between the independent variables are examined to check for multicollinearity (Appendix 1). The strongest single correlation is between firm age and firm size (0.58), and there is also strong correlation between firm age and stage of new product/process development (0.56) and between firm age and R&D spending, however, with a negative sign, namely -0.47, referring to lower R&D expenditure among older firms, which make us decide to exclude firm age from further analysis. This step does not result in omitted variable bias, due to its very weak correlation with the dependent variable (see Appendix 1). The remaining correlations (below 0.50) do not indicate serious concern for multicollinearity (Hair et al., 1995). With regard to the endogeneity issue, we mention the following. While potential absorptive capacity is measured mainly in terms of team characteristics at the time of the firm start, a couple of years ago before the interviews, including founding team size, pre-start working experience, PhD level and education of founding team members, internationalization and its range is measured as the situation of firms at time of the
survey (2006/7), thus excluding reverse causality and simultaneous bias. However, we need to test four other independent variables in our model for endogeneity: R&D activity, international market orientation, business/market training and level of newness. For example, spatial reach in knowledge relationships could have enhanced the level of innovativeness or could cause a firm to increase its investment in market training. In our analysis, all four variables are found to be exogenous (Note 4).

4. Results

4.1 Level and reach of international knowledge networks
A majority of the spin-offs in our sample (62 per cent) employs knowledge relationships abroad, almost 34 per cent of them outside of Europe which is slightly more than the share within Europe (29 per cent) (Table 2). The category with the largest reach is ‘various continents’, at a level of 28 per cent. The overall share of 62 per cent of having knowledge relationships abroad is somewhat smaller compared with another survey among university spin-off firms in various European countries, indicating a level of 72 per cent (van Geenhuizen and Ye, 2012). The difference may be caused by the economic downturn at the time of the last survey, ‘pushing’ market-oriented spin-offs to markets outside the small domestic one which is suffering from budget cuts.

The above spin-off studies show a clearly contrasting pattern compared to the findings by de Jong and Freel (2010), in which only 22 per cent of the network partners are abroad. This considerable difference can be attributed to our decision to focus specifically on university spin-off firms, namely, while the other study looks at a broader category of high-technology SMEs, and, secondly, by the type of knowledge relationships, where the relatively limited knowledge sourcing activity in the spin-off studies contrasts with the more comprehensive approach adopted in the other study.

The spin-offs in our sample that employed knowledge relationships abroad were mostly at product/service sales stage and had developed knowledge relationships with customers, while a smaller group was working, on site, in foreign countries on a project basis, including civil engineering works and construction in the oil sector, tailoring their activities in intensive knowledge interaction to meet the needs of local customers. The relatively large segment of spin-offs that is already present in the market (63 per cent) indicates that market-related sources, mainly customers and suppliers, are the most important source of knowledge relationships abroad (41 per cent), with relationships at annual exhibitions/fairs coming in second place (23 per cent). Knowledge acquisition from universities and research institutes abroad occurs much less often (6 per cent). For other descriptive statistics we refer to Table 2.
### Table 2 Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>N university spin-offs</td>
<td>105</td>
</tr>
</tbody>
</table>
| Reach in knowledge relationships a)           | Not internationalized (38.0%)  
Internationalized within Europe only (28.5%)  
Internationalized in North America or Asia (5.8%)  
Worldwide (27.7%)  |
| Firm age                                      | Average: 5.1; s.d.: 3.03; Min-max: 0-10                                          |
| Firm size (employees)                         | Average: 7.4; s.d.: 7.06; Min-max: 0.5-51                                        |
| Industry-science-based (dummy)                | Science-based (26.7%)  
Market-based (73.3%)  |
| Market orientation (dummy)                   | Regional/national (36.2%)  
International (63.8%)  |
| Location-peripheral region (dummy)            | Peripheral (41.0%)  
Core metropolitan (59.0%)  |
| R&D expenditure (%)                           | Average: 39.8; s.d.: 23.07; Min-max: 0-100                                      |
| Size of founding team                         | Average: 2.3; s.d.: 1.16; Min-max: 1-5                                           |
| Working experience (years)                    | Average: 2.6; s.d.: 4.05; Min-max: 0–21                                         |
| Multidisciplinary education                  | Single technology (65.7%)  
Multiple studies (34.3%)  |
| PhD level                                     | Average: 0.6; s.d.: 0.86; Min-max: 0-3                                           |
| Participation in training (dummy)             | Yes (31.4%)  
No (68.6%)  |
| Cross-cultural experience (dummy) b)          | Yes (15.2%)  
No (82.8%)  |
| Level of newness (product/service)            | Low level (22.8%)  
Medium level without patents (35.2%)  
High level with patents (42.0%)  |
| Stage in product development                  | Development/pilot/testing (37.2%)  
Introduced to market (62.8%)  |

a. In the modelling part, aggregation to three was necessary for statistical reasons.
b. Missing data: 2%

### 4.2 Absorptive capacity and reach in international knowledge networks

We conduct a stepwise regression analysis by adding various new variables to the model at each step, thereby estimating the improvement of the models (Table 3). In Model 1, we included four control variables that led to a rather weak result (Pseudo $R^2$ of 0.10). All four coefficients, industry (science-based activity), firm size, market orientation and location in a peripheral region, are found to be positive and significant. Next we add six variables to the model, representing potential absorptive capacity, which increases the model power by 0.05 in Model 2. In Model 3, we add three variables representing realized absorptive capacity to the control variables, which causes the model power to increase by 0.02 (compared to Model 1). Next, by
including all the variables in Model 4, we reach a Pseudo $R^2$ of 0.17. Out of eight absorptive capacity indicators, the three coefficients, namely, PhD education, participation in training and newness (low level) are positive and significant. In a final step, we explore various interaction terms within the model to see whether they increase the model power, which is only true for the interaction term of location and participation in training (Model 5). Accordingly, the model improves to a Pseudo $R^2$ of 0.19.

The results confirm a positive and significant influence of international experience, through PhD studies, on the spatial reach of knowledge relationships, which is in line with a broader observation with regard to higher education as a characteristic of high-technology entrepreneurs or teams being linked to a higher level of international openness (Cavusgil, 1984; Lane et al., 2001; Liu, 2012; Xia, 2013). In addition, the positive role of participation in training on spatial reach can be understood given the lack of market knowledge in most spin-off teams (van Geenhuizen and Soetanto, 2009). A positive influence of training on a firm's ability to recognize and exploit knowledge opportunities worldwide is confirmed in other studies, for instance Murovec and Prodan (2009) and Escribano et al. (2009).

The geographical location of the spin-offs is also found to be a significant factor: firms in relatively small cities in peripheral regions, exemplified by Trondheim, are more likely to bridge larger distances in acquiring knowledge from abroad than firms in a core metropolitan area (Delft). Following Feldman (1994) and de Jong and Freel (2010), distant collaboration tends to be a response to resource deficiencies in the local/regional area, in this case, a remote non-metropolitan location in Norway urges the firms to look further afield, often outside Scandinavia. However, this may also be due to the existing international orientation of the energy sector, which has a strong presence in the Trondheim region. Although we aim to exclude national differences in terms of innovation systems, size of the economy, etc., by comparing Norway and the Netherlands, there is one factor we do not take into account and may contribute to the significant result of location in a peripheral region, and that is a different perception of distance between the two countries, leading to a different network building behavior, with a willingness to travel over larger distance in the larger of the two countries (Norway). In particular, derived from the interaction effect, spin-off firms with a higher absorptive capacity through training while facing shortage in knowledge in their city/region tend to bridge larger distances to acquire new knowledge.

Furthermore, science-based spin-offs are found to be more likely to cross larger geographical distances to establish knowledge relationships, which is in line with the spatial dimension connected to the learning concepts posed by Asheim et al. (2007). Accordingly, science-based firms tend to be globally oriented in their knowledge acquisition due to the universal character of science but also need for specialized knowledge to deal with environmental turbulence, thereby exemplifying ‘born-globals’, while adaptive learning pushed by demand and market context tends to benefit more from local face-to-face knowledge interaction. Also, larger firms are found to be more likely to establish distant knowledge relationships, probably due to the loosening of ties of growing firms with their territories (Torré, 2008) and an increase in the financial and human resources as firms grow enabling the stretching of knowledge gaining over larger distances.
With regard to realized absorptive capacity, the coefficient of low newness is positive and significant. This surprising result can be explained as follows. Firms engaged in lower levels of newness (n=23) are active in market-oriented sectors, mostly in later stages of development. Accordingly, they have already gained established market positions and participate in knowledge relationships abroad through market-based sources in the shape of customers and suppliers in different countries worldwide.

Table 3 Ordered logistic regression analysis of spatial reach in knowledge relationships

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry—science-based (dummy, yes=1)</td>
<td>1.25 (0.47) ***</td>
<td>1.48 (0.51) †</td>
<td>1.38 (0.50) ***</td>
<td>1.57 (0.53) †</td>
<td>1.63 (0.54) †</td>
</tr>
<tr>
<td>Log firm size</td>
<td>0.58 (0.24) **</td>
<td>0.78 (0.29) ***</td>
<td>0.51 (0.25) **</td>
<td>0.75 (0.31) **</td>
<td>0.77 (0.32) **</td>
</tr>
<tr>
<td>(International) market orientation (dummy, yes=1)</td>
<td>0.85 (0.43) **</td>
<td>0.74 (0.46)</td>
<td>0.98 (0.47) **</td>
<td>0.83 (0.50) *</td>
<td>0.77 (0.50)</td>
</tr>
<tr>
<td>Location (dummy, Trondheim=1)</td>
<td>0.73 (0.40) *</td>
<td>1.05 (0.47) **</td>
<td>1.03 (0.43) **</td>
<td>1.28 (0.49) ***</td>
<td>0.87 (0.54)</td>
</tr>
<tr>
<td><strong>PACAP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D expenditure</td>
<td>-</td>
<td>-0.08 (0.10)</td>
<td>-</td>
<td>-0.05 (0.11)</td>
<td>-0.03 (0.11)</td>
</tr>
<tr>
<td>Working experience</td>
<td>-</td>
<td>0.00 (0.19)</td>
<td>-</td>
<td>0.01 (0.20)</td>
<td>0.09 (0.20)</td>
</tr>
<tr>
<td>PhD level</td>
<td>-</td>
<td>0.83 (0.37) **</td>
<td>-</td>
<td>0.82 (0.39) **</td>
<td>0.78 (0.39) **</td>
</tr>
<tr>
<td>Size of founding team</td>
<td>-0.29 (0.18)</td>
<td>-</td>
<td>-0.29 (0.18)</td>
<td>-0.28 (0.19)</td>
<td></td>
</tr>
<tr>
<td>Multidisciplinary education (dummy, yes=1)</td>
<td>-</td>
<td>-0.42 (0.47)</td>
<td>-</td>
<td>-0.39 (0.48)</td>
<td>-0.56 (0.50)</td>
</tr>
<tr>
<td>Participation in training (dummy, yes=1)</td>
<td>0.84 (0.48)*</td>
<td>-</td>
<td>0.95 (0.49)*</td>
<td>0.55 (0.55)</td>
<td></td>
</tr>
<tr>
<td><strong>RACAP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newness – low level (dummy)</td>
<td>-</td>
<td>-</td>
<td>1.12 (0.57) *</td>
<td>1.23 (0.60) **</td>
<td>1.49 (0.63) **</td>
</tr>
<tr>
<td>Newness – high level (dummy)</td>
<td>-</td>
<td>-</td>
<td>0.69 (0.48)</td>
<td>0.65 (0.52)</td>
<td>0.84 (0.54)</td>
</tr>
<tr>
<td>Stage in product/process development</td>
<td>-</td>
<td>-</td>
<td>0.42 (0.44)</td>
<td>0.02 (0.7)</td>
<td>0.01 (0.48)</td>
</tr>
<tr>
<td>Location*Participation in training</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.95 (1.11)*</td>
</tr>
<tr>
<td>LR Chi square</td>
<td>22.15†</td>
<td>33.80 †</td>
<td>27.29 †</td>
<td>38.37 †</td>
<td>41.58 †</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.10</td>
<td>0.15</td>
<td>0.12</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-100.53</td>
<td>-94.71</td>
<td>-97.96</td>
<td>-92.42</td>
<td>-90.81</td>
</tr>
</tbody>
</table>

* P<0.1, ** P<0.05, *** P<0.01, †P<0.005

Among all relevant factors, there is a strong dependency on the part of spatial reach on three absorptive capacity indicators, i.e. PhD experience, participation in training and lower levels of newness. The first two may clearly help in preventing or reducing barriers in partner search and
language and cultural barriers, while the last indicator, specifically of a limited realized absorptive capacity, reflects the customer market for already accepted innovations as a driving force of increasing spatial reach in knowledge networking. Contrary to our expectations, the coefficients of R&D expenditure, size of founding team and multidisciplinary education in this team are negative and non-significant.

4.3 International knowledge relations and firm growth
As often suggested in the practical literature on SMEs development, an international orientation, be-it imports, outsourcing, exports, knowledge relations, etc. is a condition for growth (e.g. BIS, 2010). As a final step we, therefore, explore the extent in which international knowledge relationships go along with a stronger growth of the spin-off firms. Spin-offs employing international knowledge relationships tend indeed to grow stronger compared to spin-offs without such relationships. In terms of job growth, there is a significant difference between the averages, namely 1.7 fte per year and 0.5 fte per year, respectively (Table 4). Similarly, with regard to turnover, spin-offs employing international knowledge relationships encompass a larger share of the highest turnover classes (>300.000 Euro per year), at a share of 65 per cent, compared to a share of 46 per cent among their counterparts. From the previous analysis, we may understand this pattern as following from the stronger market introduction among the first category.

Table 4 International knowledge relationships and growth among spin-off firms

<table>
<thead>
<tr>
<th>Knowledge relations</th>
<th>Average annual employment growth (from start to 2010) (fte) (sd) a)</th>
<th>Turnover (Euro) in 2010 b)</th>
<th>Totals spin-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>International knowledge relations</td>
<td>1.66 (3.09)</td>
<td>&lt; 100,000: 13 (20.0%)</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>100,000-300,000: 10 (15.4%)</td>
<td>&gt;300,000: 42 (64.6%)</td>
<td></td>
</tr>
<tr>
<td>No such relations</td>
<td>0.46 (1.05)</td>
<td>&lt; 100,000: 17 (43.6%)</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>100,000-300,000: 4 (10.2%)</td>
<td>&gt;300,000: 18 (46.2%)</td>
<td></td>
</tr>
</tbody>
</table>

a) T-test results significant at P<0.05
b) Pearson chi² = 5.7, P<0.05.

5. Discussion and conclusions
Small high-tech firms that employ international knowledge networks tend to grow stronger, among them the university spin-off firms in this study. Extending knowledge acquisition in other continents is increasingly compelling for such firms in Western Europe, as new countries are emerging as centres of R&D and innovative economic activity, like China, Korea and Brazil. However, spin-offs have different amounts of absorptive capacity available in their search of new knowledge and in benefiting from this knowledge. A majority of spin-offs in this study (62 per cent) was found to be engaged in international knowledge networking, including substantial
differences in reach, witness one third outside Europe (34 per cent).

We explored these differences on the basis of two sets of factors: a set of absorptive capacity indicators that encompassed potential and realized absorptive capacity, and a set of firm-related factors, including location. Using ordered logistic regression in testing a model of spatial reach in knowledge relationships on 105 firms in the Netherlands and Norway, seven important factors were identified, which, in terms of absorptive capacity indicators, included PhD education, participation in training/coaching, and a relatively low level of newness of innovation, and which, in terms of firm-related factors used as control variables, included firm location in Trondheim, firm size, international market orientation and industry as science-based activity.

To date, a small number of studies on innovative SMEs (as a broader category) deals with spatial patterns of knowledge relationships (e.g., de Jong and Freel, 2010; Laursen and Salter, 2004). In both studies, the focus is on R&D factors covering one dimension of potential absorptive capacity, aside from some structural firm characteristics. Accordingly, the current paper was different and extended the literature in five important ways. *First*, we added to the insights into (inter)continental reach of firms in knowledge networking given an increasing need to cross larger distances to connect with new global players in innovation and economic activity, which has only recently been included in research agenda’s. A majority of young spin-off firms (62 per cent) turned out to employ knowledge relationships abroad, of which one third was active in countries outside Europe. *Secondly*, we used absorptive capacity as a key in learning processes of firms faced by changing situations, and found that a PhD education and participation in training/coaching by founders or founding teams do support the establishment of knowledge networks over large distances, while having gained an established market position connected with somewhat older innovations at a lower level of newness, gives the same effect. *Thirdly*, we used a more comprehensive measurement of absorptive capacity by extending the scope which has often been limited to R&D indicators, with various individual quality factors of founders or founding teams, which found to be significant in the model results, and with two knowledge exploitation indicators, of which one turned out to be significant in these results (lower levels of newness). *Fourthly*, the absorptive capacity of university spin-offs has not yet been studied. The results confirm studies of a broader category of firms (innovative SMEs) as far as influence of the firm size, science-based activity and international orientation are concerned (de Jong and Freel, 2010), but the spatial reach among spin-offs turned out to be much larger than among the more comprehensive category of innovative SMEs. The results also ‘challenged’ the influence of newness of innovations among spin-off firms, as apparently low levels of newness are associated with a large amount of absorptive capacity in knowledge relations, which could be caused by activity of the sampled firms in oil (energy) production, improving utilities, civil engineering projects and software projects on site abroad, and likeliness to establish international knowledge relationships with customers/partners after having passed market introduction already for some years. Moreover, knowledge relationships over large distances with universities and research institutes turned out to be rare.

And as a *final* contribution, while location turned out to be a significant factor in spatial reach in knowledge acquisition and we could confirm a wider reach among spin-off firms in Trondheim, as found by de Jong and Freel (2010), we had to draw attention to two influences, namely, the character of the regional economy in Trondheim, with impacts from the highly globalized energy
sector and maritime sector and a potentially higher willingness to cross large distances in countries that are large in size, all potentially part of the explanation.

With regard to generalization of the results of the current study, the following can be stated. Both countries involved, the Netherlands and Norway, share a somewhat risk-avoiding entrepreneurial culture in a small and open national economy, and specialize in new technology in seashore activities, mainly transport and energy, which indicates that the results may have implications for technical universities in only a limited number of similar countries, such as Denmark, Sweden and northern parts of the United Kingdom, also taking the role of willingness to cross large distances into account. Nevertheless, our modelling results were one of the first of its kind in covering a relatively broad range of absorptive capacity indicators, including both potential and realized absorptive capacity, as distinguished by Zahra and George (2002). We were able to produce good results on three of the eight indicators, while the overall power of the models remained relatively weak, albeit comparable to similar studies (see Note 5), which supports the finding that absorptive capacity works differently under diverse circumstances, while as a construct it is also difficult to measure (Zahra and George, 2002; Lane et al., 2006; Murovec and Prodan, 2009; Schmidt, 2010). The explanatory power of the presented models, however, could be increased by examining several variables in greater detail, e.g. working experience of the founding team which in our model and measurement found to be important (Schewns and Kabst, 2009). In particular, more attention could be paid to the dynamics within the founding team, with different sizes and with heterogeneity in terms of the present disciplines. Also, attempts could be made to move from using proxies in measurement to more direct measures of absorptive capacity (Debrulle et al., 2013).

The findings may also have some practical implications. As an advice aimed to enhance growth of spin-off firms and knowledge relationships abroad among spin-offs that are not involved in international networks (almost 40 per cent of the sample), mainly addressed at the management of incubators and/or universities, we recommend founding teams to include members holding a PhD or collaborate with external consultants/specialists with international experience, since the last’s experience support firms to operate in international networks and to prevent barriers like in finding the right partner and in communicating in different languages and culture, and they may utilize pre-existing networks.
Note 1 Using data on university-related incubators in various countries, 40 incubators were selected representing particular growth patterns. Employing rough-set analysis, it was found that two factors determine growth of incubators, i.e. stakeholder involvement in managing the incubator and level of urbanization of the location. Next, using a framework to select two incubators with contrasting positions with regard to these factors NTNU Trondheim in Norway and TU Delft in Netherlands were chosen.

Note 2 We also checked for significant differences in accounting systems between the Netherlands and Norway, but we found a harmonized accounting legislation for small enterprises and this holds true for non-listed limited liability companies, which is the legal status of most spin-off firms (EC, 2011).

Note 3 A previous study found that around 80% of the spin-offs in Delft managed to survive the first ten years. Using simulation studies, it appeared that firms that have failed in this period do not differ significantly from the ones that survived which is the reason why major selection bias in the results from not-surviving can be excluded.

Note 4 We tested the endogeneity of international knowledge relationships taking four explanatory variables in the model. These variables were R&D activity, market orientation, business and market training and newness. First, using two stage conditional maximum likelihood (2SCML) suggested by Alvarez and Glasgow (1999) to deal with endogenous dichotomous variable X (international knowledge relationships) and continuous explanatory variable (R&D activity), R&D activity was found not to be endogeneous. Second, we used probit model for endogenous regressors in STATA to test for endogeneity while both endogenous variable and explanatory variables were dichotomous. Using IV Wald test of exogeneity, first we assumed that variable X (international knowledge relationships) was endogenous, and we accounted for it using variable Z (market orientation) (Rivers & Vuong, 1988; Wooldridge, 2002). Next, we assumed that variable X (international knowledge relationships) was endogenous, and we accounted for it by using variable Z (newness). Wald Test checked whether X was endogenous or not, on the basis of whether the error terms in the structural equation and the reduced-form equation for the endogenous variable were correlated. The outcome of the first test Chi2(1)= 5.99 (Prob > Chi2= 0.014) and second test Chi2(1)= 3.30 (Prob > Chi2= 0.069) confirmed that ‘market orientation’ and ‘newness’ were exogenous. In the same way, endogeneity of variable X (international knowledge relationships) was checked, instrumenting for variable Z (business and market training). The outcome of the first test Chi2(1)= 3.07 (Prob > Chi2= 0.079) confirmed that ‘business and market training’ was exogenous. The previous tests were performed for a binary variable ‘international knowledge relationships’ (Taheri and van Geenhuizen, 2011). Due to a high correlation between this variable and spatial reach in knowledge relationships (0.90), we expected that the negative results of the endogeneity test for international knowledge relations also hold true for spatial reach in knowledge relationships, confirmed that R&D activity, market orientation, business and market training and newness were not endogenous in the model in this paper.

Note 5 De Jong and Freel (2010), using multilevel regression model to explain reach of collaboration in high technology small firms, do not reach a Pseudo $R^2$ higher than 0.20. Escribano et al. (2009), using a logit model to explain managing knowledge flow and innovative outcomes, reach a $R^2$ of 0.19 in their best model, and Murovec and Prodan (2009), using structural equations to measure innovation output, do not reach a $R^2$ higher than 0.25.
### Appendix 1- Correlation matrix (n=105) a)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 International knowledge relationships</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Spatial reach in knowledge relationships</td>
<td>0.90</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Firm age</td>
<td>0.05</td>
<td>0.08</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Location</td>
<td>-0.04</td>
<td>-0.15</td>
<td>0.24</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Firm size</td>
<td>0.05</td>
<td>0.16</td>
<td>0.58</td>
<td>**</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Market-orientation</td>
<td>0.28</td>
<td>**</td>
<td>0.30</td>
<td>**</td>
<td>-0.06</td>
<td>-0.17</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Industry - science-based</td>
<td>0.24</td>
<td>**</td>
<td>-0.32</td>
<td>**</td>
<td>-0.08</td>
<td>-0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Cross-cultural background</td>
<td>-0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 R&amp;D expenditure</td>
<td>0.16</td>
<td>0.07</td>
<td>-0.47</td>
<td>**</td>
<td>-0.16</td>
<td>-0.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Work experience</td>
<td>0.20</td>
<td>0.19</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Size of founding team</td>
<td>-0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 PhD education</td>
<td>0.25</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Multidisciplinary education</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Newness - high</td>
<td>0.26</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Newness - low</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Participation in training</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Stage in new product development</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P<0.05, **P<0.01,
a) Spearman correlation coefficients.
References


Australia.


Statistics Netherland 2010: www.cbs.nl
Statistics Norway 2010: http://www.ssb.no/english/
GEM 2010: http://www.gemconsortium.org/docs/266/gem-2010-global-report