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SPATIAL REACH IN LEARNING OF ACADEMIC SPIN-OFFS – A FOCUS ON ABSORPTIVE CAPACITY

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Abstract
The current paper explores the extent of international learning among university spin-off firms and enhancing factors of this learning. Drawing on survey data of 100 university spin-off firms, the relationship is explored between absorptive capacity and international learning, alongside other factors. A small majority of spin-off firms is engaged in international learning and the most powerful influences tend to be R&D expenditure and international market orientation. The implications of the results and future research steps are discussed.

1. Introduction

In the development of regional innovation systems, universities are recognized as a main source of new knowledge and innovations. By introducing commercialization of university knowledge among others through "university spin-offs" (McQueen and Wallmark 1982) universities have claimed a new role in regions' and countries' economies since the early 1980s and even more strongly since the early 2000s. Spin-off firms not only develop university inventions towards application in the market; they also contribute to a wider diffusion of university knowledge into the business community, to the enhancement of entrepreneurship in the region, and to an improvement of infrastructures supporting high-tech entrepreneurship (e.g. Shane, 2004; Benneworth et al., 2009). Spin-off firms provide places for university students to gain experience (internships) and if quickly growing and in need for new knowledge, these firms on their turn may finance specific research projects at the university.

A central issue in the discussion on innovation systems is "space" and whether we bound it in local, regional or international context. As discussed by Autio (1998), a firm may link with different partners such as universities, research institutes, customers, suppliers, etc. both nationally and internationally, dependent upon the need for specialized knowledge. Nevertheless, many empirical studies embracing the idea of agglomeration economies (cities) or cluster economies, have shown that small high-tech firms benefit from knowledge spillovers and collaboration with partners in close physical proximity (Audretsch and Feldman 1996; Braunerhjelm et al. 2000).

Since the increased popularity of network analysis picturing real-life knowledge relationships, however, some doubt has arisen about the importance of local learning, and the idea has emerged of some differentiation between high-tech firms in this respect (van Geenhuizen, 2008). By nature, small high-tech firms are in short of specialized knowledge and sophisticated services, most likely not all available in their local environment (Torre 2008). Dependent upon their specific technology and market, these firms may need to connect with partners who possess additional (core or complementary) knowledge and information which help them in developing products, designing prototypes, testing them, and introducing the products to market, etc. Dependent upon the strength of the own R&D intensity and related investments, and on previous knowledge and experience, they acquire and exploit the external knowledge more or less efficiently. The differentiation among high-tech firms does not only hold for the spatial reach in learning but also for the type of knowledge sources involved, research-related or market-related.

The utilization of external knowledge resources is increasingly seen as a key condition for the performance of small high-technology firms. With the grown specialization in research and development across the globe, it is particularly the utilization of international knowledge sources and collaboration that is seen as one of the most important processes underlying firms' innovative activities (Kafouros et al. 2008; Pittiglio et al. 2009). It is precisely for these reasons that absorptive capacity has become a popular construct in the past two decades. Absorptive capacity is the dynamic capacity that enables firms to create value and to gain and sustain competitive advantage through the management of external knowledge. Following Zahra and George (2002) and according to our conceptualization of absorptive capacity, a distinction is made between four components, i.e. acquisition and assimilation (as potential absorptive capacity), and transformation and application (as realized absorptive capacity).

What has rarely been studied so far is how internationalization of learning links with different components of small firms' absorptive capacity. Establishing (and maintaining) learning networks abroad is unlikely to be an easy task, and most probably requires various investments by the firms, among others in absorptive capacity. A recent study shows that it is absorptive capacity that contributes to an explanation of internationalization processes in a broad sense (Sedoglavich et al. 2009), whereas another recent study shows that a higher level of potential absorptive capacity positively relates with learning collaboration with more distant partners (de Jong and Freel 2010).The last study however uses a limited approximation of absorptive capacity, namely through R&D expenditures and R&D intensity. Therefore, this study attempts to broaden the scope of absorptive capacity by using indicators with a larger coverage of the four components. The following questions will be addressed:
1. In which respects is absorptive capacity different between small high-tech firms?
2. How are various components of absorptive capacity, alongside other factors, related to patterns of international learning?

Our study draws on a sample of 100 spin-off firms from two universities, Delft University of Technology in Delft, The Netherlands, and National Technical University of Norway in Trondheim, Norway. The paper is structured as follows. Relevant theory on distance in learning, absorptive capacity and firm characteristics is examined in section 2, and serves as an underpinning of a conceptual model of internationalization in learning. In section 3, the methodological steps in the study are discussed, including data description. This is followed by section 4, that presents a descriptive analysis of absorptive capacity and of internationalization in learning, and section 5 that presents the outcomes of a first exploration of the causal background of international learning. Implications of the outcomes and further analysis are addressed in the final section.

2. Theoretical views

2.1. Learning and distance

Knowledge and information - whether it is technical or non-technical - are a valuable source of competitive advantage for firms at different development stages (Grant 1997). Young technology firms by nature have a limited set of internal knowledge available, and particularly young spin-off firms in technology fields are in short of market-related and management-related knowledge

(van Geenhuizen and Soetanto 2009). Therefore, such firms need to acquire external knowledge and information to survive and grow. Firms may learn through their science-based channels such as universities and research institutes, and through market-based relations such as with customers and suppliers.

Learning can be described as the ways in which firms build, supplement and organize knowledge and routines around their activities and within their cultures, and adapt and develop organizational efficiency by improving the use of broad skills of their workforce (Dodgson, 1992). There are two main types of learning, i.e. learning to solve particular problems on a day-to-day basis and learning to learn, i.e. the capability to learn in an efficient and effective way. The latter type connects with the concept of absorptive capacity. As defined by Zahra and George (2002) absorptive capacity is a set of organizational routines and processes by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organizational capability. Learning as developing capacity to acquire and later assimilate existing knowledge (Cohen and Levinthal 1990), may be different between the scientific fields concerned. Asheim et al. (2007) presented different forms of learning: science-based and adaptive learning (market-based). Science-based learning is close to knowledge exploration and usually related with radical innovations. Life science and material science (nanotechnology) are in this category. Laws of nature and know why are key in this type of learning. While adaptive learning (know how) is more about finding applications and solutions based on market demand and stands on the exploitation side of knowledge. Mechatronics in which customer relations are important in firm's learning is in this category. In addition to these features, Asheim et al.(2007) also suggest a difference in spatial orientation. While science-based learning tends to be globally oriented (except for the first stages) due to its universal character, adaptive learning is context specific, deals more with tacit knowledge and tends to benefit from face-to-face interaction, eventually in local clusters. This idea motivates us to include *technology* in our exploratory model of internationalization in learning.

Boschma (2005) describes proximity in five dimensions; among them are cognitive proximity and geographical proximity. He posits that geographical proximity is neither a necessary nor a sufficient condition for inter-organizational learning and effective innovative collaboration, but it may facilitate innovation through strengthening other dimensions of proximity. According to Boschma, cognitive proximity exists if organizations are similar in terms of their knowledge base, a situation that determines whether these organizations can interact effectively in a learning process. This suggests that cognitive proximity could be a trade-off for geographical proximity. In other words, organizations with higher cognitive proximity could collaborate more effectively even within a geographical distant context.

In innovation studies, much attention has been paid to the supply/exchange of new knowledge in urban places. Many authors take for granted that high-tech firms benefit from a location in large cities and metropolitan areas due to a relatively large availability of information (knowledge spillovers) and large pools of specialized workers and talented people (e.g. Audretsch and Feldman1996); this as opposed to small cities and rural and peripheral places . In most of these views, importance is attached to cultural and social proximity that goes along with spatial proximity. Accordingly, a common history/culture connected with spatial proximity facilitates trust in interaction and social networks allowing for tacit knowledge transfer (e.g. Maskell and

Malmberg, 1999). Given these ideas we include *location* of the firm in our exploratory analysis, because 'availability of knowledge' like complementary knowledge to the core invention, knowledge from launching customers, etc. differs between the urban places in our study. Delft is part of the large metropolitan area of Randstad in the Netherlands, whereas Trondheim is a rather isolated town in the middle of Norway. It seems plausible that firms in Trondheim feel themselves urged to go abroad more quickly than the ones in Delft, looking for the knowledge they need. Distant collaboration may be a response to knowledge shortages in the local area.

2.2 Firm characteristics and market

It is suggested in the literature that young and small firms are more tied to local places due to limited human and financial resources for searching and coordinating the acquisition of knowledge in wider areas, particularly abroad. This would explain the phenomenon that younger and smaller firms locate more close to organizations with which they are familiar (for example, through their origin) and wish to collaborate with. For these reasons, we include *age* and *size* of firms in our analysis.

However, the literature indicates that there is more differentiation between firms in spatial reach in learning. This holds for uncertainty in the market, for example when the invention turns out to be a breakthrough without a market or when access to the market is heavily regulated (trials and tests in medical science). A strong uncertainty may drive the firms abroad in search for even more specialized knowledge. In addition, what is already proven in some empirical research is that the spatial orientation in the customer market influences the reach in learning. There is a clear link between the reach in product markets and innovation collaboration (Arndt and Sternberg, 2000). In addition, de Jong and Freel (2010) confirm that operating in export markets is associated with a greater reach in learning activity. Given the above insights, we include age and size, market (uncertainty) and market-orientation in our conceptual model.

2.3 Absorptive capacity

A quite recent study shows that it is absorptive capacity that contributes to an explanation of internationalization processes (Sedoglavich et al. 2009). Accordingly, high-tech small and medium-sized enterprises possess technological absorptive capacity which influences their strategies including internationalization (mainly export). Cohen and Levinthal (1990) perceive a firm's absorptive capacity as its ability to value, assimilate and apply external knowledge which depends on its prior related knowledge. Here we could bridge cognitive proximity with "absorptive capacity" concept. Both claim that organizational search for new knowledge is limited by its existing inventory of knowledge and experience. Therefore, learning is seen to be a collective and path dependent process for which prior knowledge will facilitate new knowledge acquisition, assimilation and later exploitation. Thus, several characteristics of founding entrepreneurs (or teams), such as previous working experience and level and multidisciplinarity of education, seem important as dimensions of absorptive capacity in the role of prior knowledge accumulation within firms.

Zahra and George (2002) define absorptive capacity as a set of organizational routines and processes by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organizational capability. The authors make a distinction between two dimensions: potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP). PACAP

makes the firm interested to acquiring and assimilating external knowledge (Lubatkin and Lane 1998) while RACAP makes a firm capable of leveraging its knowledge by using the absorbed knowledge. Therefore, a firm may acquire and assimilate knowledge but might not have the capability to transform and exploit it for innovation or profit generation. So, high potential absorptive capacity does not necessarily imply a better performance. Distinguishing between potential and realized absorptive capacity helps to explain why some firms are more efficient than others in using absorptive capacity. Zahra and George (2002) mention that most studies on absorptive capacity reflect a firm's realized capacity comprising knowledge transformation and exploitation while focusing on innovative outcomes in measurement (Cohen and Levinthal 1990). Thus, potential capacity, including knowledge acquisition and assimilation capabilities, has received less attention in empirical scrutiny.

University spin-off firms are usually small firms in short of (highly) specialized knowledge, be-it technical or market-related. These specialized firms may have a different *potential* absorptive capacity, for example dependent on a team/single start and if a team, on the composition of the team. If a strong potential absorptive capacity, these firms tend to connect with external sources of knowledge concerning the same technology or complementary technology. In this sense, spin-off firms find themselves cognitively close to other firms with strong technical absorptive capacity (Torre 2008). It could also be claimed that a strong absorptive capacity enables firms to increase their cognitive proximity with potential partners even across geographical distances. Although small high-tech firms prefer fairly close partners for innovative collaboration (Jong and Freel 2010), costs of overcoming distance could be compensated by acquiring highly specialized knowledge or sophisticated services in places across the globe (Drejer and Vinding 2005).

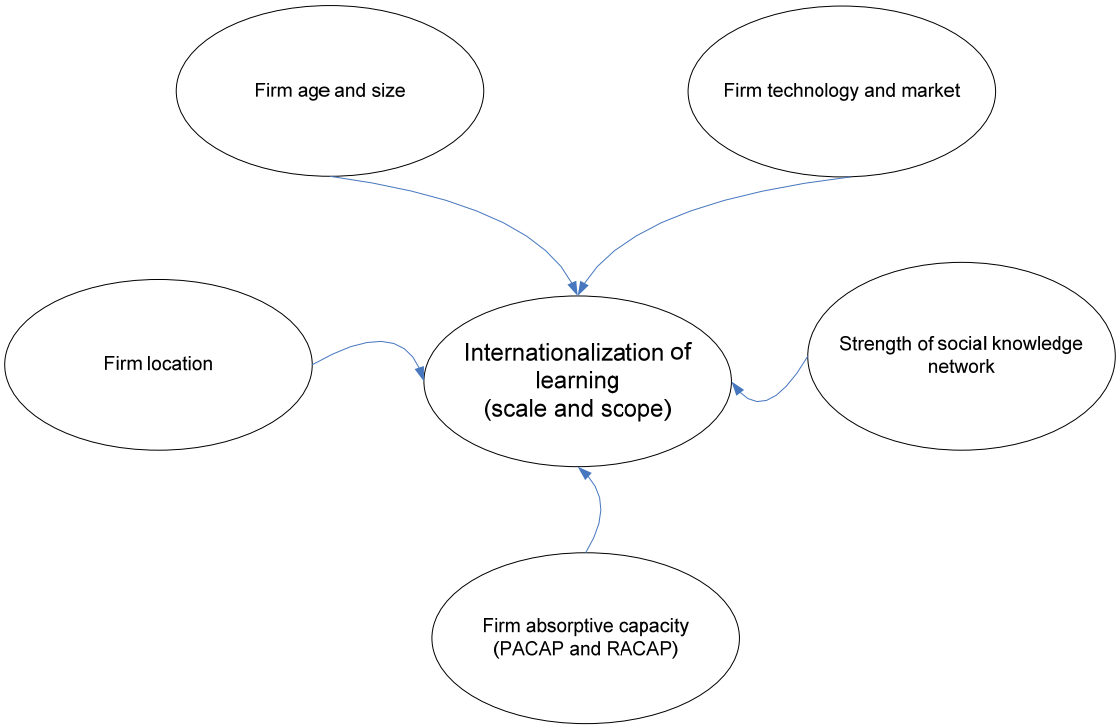
2.4 Social network profile

In the literature, the step to go international in learning is also connected with the role of social (personal) networks. The idea is a stage-based development model in which young high-tech firms first build a relatively strong and 'safe' social network at their home base/region, before they to go abroad for accessing more formal learning relations (e.g. Johannisson, 1998). In their early years, high-tech firms seem to elaborate relatively strong (dense) personal networks. Such a development would mean that international learning goes along with strong social learning networks. However, there is no consensus in the literature. According to the born-global literature particular segments of high-tech firms step into global networking immediately after their inception or shortly after, rejecting the idea of a stepwise development (e.g. Madsen and Servais, 1997; Andersson and Wictor, 2003).

2.5. Conceptual model

Given the above inventory of influences on international learning, we use a division into three (1) the firm's characteristics location, firm size and age, firm technology and market, (2) firm's absorptive capacity including PACAP and RACAP, and (3) firm's social network characteristics, focusing on strength (Figure 1).

Figure 1- Causal diagram of explanatory factors of firm's internationalization



3. Methodological Aspects

3.1. Steps and variables

The analysis in this paper unfolds in three steps: 1) a descriptive analysis of international learning and of absorptive capacity, 2) a broad exploration of the conceptual model based on bivariate correlation analysis, and 3) based on the outcomes of the previous step, model construction and testing of the model using multiple regression analysis. First, we need to discuss which variables we select in measuring the concepts and what the characteristics are of the sample of spin-off firms we use. Appendix 1 and Appendix 2 provide more detail on the construction of the variables and on the outcomes of them.

The *dependent* variable in this study is *internationalization of learning.* We measure this as a dichotomous variable showing whether the spin-off expands its learning activity with the use of more formal knowledge sources abroad (yes/no). In addition, we distinguish between two variables of internationalization, i.e. scale and scope (van Geenhuizen, 2008). *International scale* refers to the geographical pattern of actors in knowledge networks. Knowledge acquisition may be extended into neighboring countries only, all over Europe and/or the world. Scale is defined as an ordinal variable using three categories: high, low and no internationalization. *International scope* is an indicator for the number of different knowledge sources to which a firm is connected internationally and for the differentiation within these sources given knowledge oriented sources

(e.g. universities, government research center) and business oriented sources (e.g. customers, commercial laboratories). Accordingly, scope is defined as an ordinal variable using three categories: high, low and no internationalization.

Firm characteristics. Location is measured in two classes: Delft or Trondheim. Delft represents a city in a large metropolitan area close to the urban heartland of Europe, whereas Trondheim represents a city in an isolated region in the periphery of Europe. As firm characteristics, we have taken firm age (number of years since a firm's foundation), firm size (number of employees) and firm market (including the type of market in terms of uncertainty and national/international output markets). Markets are divided into two categories: relatively certain markets and relatively uncertain markets. Uncertain markets are defined as: highly regulated markets with high risks or not yet existing markets (in case of radical innovations). Also sectors which are highly sensitive to economic downturns e.g. related to the chips industry are defined as uncertain. Based on the categorization of technology and concomitant learning by Asheim et al. (2007), we distinguish two main categories of firms: science-driven ones, dealing with some basics of chemistry, life-sciences, nanotechnology, flow mechanics, optics, etc., and remaining ones dealing with adaptive learning in response to user needs.

Absorptive capacity. Measuring (potential) absorptive capacity of spin-offs (Table 1), we include R&D spending (R&D expenditure as a percentage of revenues) and number of R&D employees as the main source of technical knowledge acquisition in firms. We also include several variables representing the initial state of knowledge accumulation, such as entrepreneur's previous working experience, level of education of founders (by the degree they hold), type of education of founders (whether the team composition is just technical or is multidisciplinary), type of business start (team or single) and number of team members as dimensions of potential absorptive capacity. In order to measure realized absorptive capacity, we use variable "newness" in two categories based on the entrepreneur's evaluation on whether his/her product is a breakthrough and/or new to the sector. Development stage indicates the stage of technology development at the time of the interview (a rank variable including two categories: early development stage including pilot and testing stage, and later stage including introduced to market and consultancy). Whether a spin-off is involved in patenting (applied/granted) is also included as a measure for realized absorptive capacity.

Strength in social networks. We have selected two characteristics that represent aspects of support, i.e. tightness of the network (as amount of existing versus potential relations), and strength of relationships (as three variables: frequency of face-to-face contact, duration of the relationship and acquaintance level with partners).

Table 1- Absorptive capacity, dimensions and operationalization

Main category	Dimension	Operationalization in the literature	Operationalization in this study
Potential absorptive capacity	Knowledge acquisition	-Years of experience of the R&D department -R&D intensity (Zahra & George 2002; Murovec & Prodan 2009; Jong & Freel 2010)	- Amount of R&D investment - Number of R&D employees - Working experience of founders - Level of education of founders - Type of education of founders - Team versus single start -Number of team members at start
Potential absorptive capacity	Knowledge assimilation	-Number of cross-firm patent citation -Number of citations made in a firm's publication to research developed in other firms (Zara and George 2002)	Our database does not allow measuring this.
Realized absorptive capacity	Knowledge transformation	-Number of new product ideas -New research projects initiated (Zara and George 2002)	- Newness of innovation
Realized absorptive capacity	Knowledge exploitation	-Number of patents -New product announcements -Length of product development cycle (Zara and George 2002)	-Applied/granted patent - Development stage

3.2. Data description

The study draws on a given survey of spin-offs of the Technical University (TU) Delft, Delft, the Netherlands and the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. The population of spin-offs from these universities was delineated on the basis of the following criteria. First, the firms needed to satisfy the condition of commercializing knowledge created at the university. Further, the firms had to satisfy the condition of "survived in 2006", not older than 10 years, and enjoy at least one type of support from the incubation organization/university. All firms in this population (150) were approached leading to an overall response rate of 66.7% (100 firms). Data were collected using a semi-structured questionnaire in personal face-to-face interviews with entrepreneurs. If necessary the information was supplemented by website analysis.

4. Absorptive Capacity among Spin-off Firms

As presented in table 2, spin-off firms in this study spend an average of 38% of their revenues on R&D related activities. On average, they employ four R&D employees. Both indicators show a relatively high standard deviation and a min-max range indicating quite some differentiation. The type of start shows that 21% of the spin-offs have started based on a single entrepreneur while 37% have started with two members and 41% with three or more members. With regard to team's knowledge composition, most spin-offs have just technical backgrounds in one field (65%) whereas 32% have a background in more than one technology or a combination of

technology with gamma/alpha. In addition, most spin-offs have no knowledge at the PhD level (62%), but 38% do have such knowledge.

With regard to development stage, most spin-offs (64%) are in the stage of having introduced their product/process into the market or supply consultancy services. A minority (37%) is still in an early development stage or stage of pilot production and various testing. In terms of newness of the products/processes, about 74% of the entrepreneurs qualify their invention as new (breakthrough and/or new to the sector) while 26% qualify their invention not as new in this sense. Also, nearly half of the spin-offs in the database has applied for or has been granted at least one patent, while patent application does not apply for 31% of firms (mainly active in software industry).

Table 2- Absorptive capacity

Variables	**Measure**	**Mean**	**S.D.**	**Min**	**Max**
R&D spending	Percentage of turnover or income*	38.59	21.22	0	100
R&D employees	Number of R&D employees	4.23	3.78	0	23
Previous working experience	Sum of years of working experience among first three founders grouped into two categories: low experience (<=3 yrs) and experienced (>3)†	Low experience (54.5%) Experienced (45.5%)			
Team-start	Two categories	Yes (78.8%) No (21.2%)			
Number of members in team		One member (21.2%) Two members (37.4%) Three or more members (41.4%)			
Type of education	Four categories: technology, multiple technology, management and technology/management/art/medicine**	Technology (64.6%) Multiple technologies (22.2%) Mixed (10.1%) Management (3.1%)			
Level of education	Three categories: no PhD, one PhD and more than one PhD in the entrepreneurial team	No PhD (61.6%) One PhD (24.2%) More than one PhD (14%)			
Development stage	Two categories	Early development stage or pilot and testing (36.5%) Introduction to market, including consultancy as main activity (63.5%)			
Newness	Two categories based on the entrepreneur's perception of the invention: a breakthrough and/or new to the sector or not	Yes (74%) No (26%)			
Granted or applied patent	Three categories	No applied/granted patent (18.2%) At least one applied or granted patent (50.5%) Not applicable* (31.3%)			

* Average in the last three years

† Experience has a mean of 7.5; S.D: 11.8, min:0, max: 62

5. International Learning among Spin-off Firms

As shown in table 3, a small majority of the spin-off firms in our database (61%) is internationalized in their learning activity. Among these firms, 16% have expanded their reach in learning merely in a neighboring country, while most of them (44%) have internationalized globally.

Table 3. Internationalization scale

Internationalization	Frequency	Percentage share
Not internationalized	39	39.4
Neighboring country (low)	16	16.2
Remaining Europe / World (high)	44	44.4
Total	99	100.0

Concerning the type of sources in international learning, we find that customers and exhibitions are the two most important ones for university spin-offs. Among the 60 firms engaged in international learning, customers account for 48%, whereas exhibitions account for 42%. Altogether, market-based sources (customers, suppliers, etc.) account for 28% of all international knowledge sources, whereas knowledge-based sources (universities, higher educational institutes, research institutes, etc.) account for 5%.

Among firms engaged in international learning, 75% have an international market orientation (selling/export). This finding could indicate links between product-market relations and knowledge collaboration and is in line with previous studies demonstrating links between knowledge relations, innovation collaboration and spatial reach to product-markets and exports (Arndt and Sternberg 2000; Roper and Love 2002).

6. Exploration of Influences on International Learning

In this section we broadly explore the relationship between internationalization of learning and the factors of influence as shown in figure 1. In this stage of the study we limit our self to absence or presence of international learning.

On the basis of cross-tabulation analysis, we find significant relationships between internationalization of learning and four characteristics of absorptive capacity: R&D spending, previous work experience of founder team, number of team members at start, and education level of the founder team. Looking for a significant cut-point in R&D spending, we observe that firms with higher spending in R&D (more than 20% of revenue) face a higher level of internationalization. In addition, years of working experience (founder team) tends to be positively associated with internationalization. The same holds for a higher education level of the founders. In contrast, a small starting team seems to be associated with internationalization of learning, not a large starting team. Except for the last result, the outcomes are in line with our hypothesis that prior knowledge accumulation within firms will increase their ability to search

for international learning and to coordinate it. The last, somewhat contradictory, result may be explained as follows: smaller teams need more external knowledge in increasing their innovativeness, including international learning. Further, we find a positive association between international market orientation of firms and international learning.

Table 4. Analysis of association between variables (cross tabulation analysis)*

Variables	Internationalization of learning
1. Firm age	N.S.
2. Firm size (5 employees as borderline)	N.S.
3. Character of technology	N.S.
4 Market uncertainty	N.S.
5. International market-orientation	**S.** † International market-orientation is positively associated with internationalization
6. Urban location (Delft versus Trondheim)	N.S.
7 R&D spending (20% of revenues as borderline)	**S.** †† R&D expenditure is positively associated with internationalization
8 R&D employees	N.S.
9 Working experience at start (3 years as borderline)	**S.**††† Working experience is positively associated with internationalization
10 Size of team at start (3 members as borderline)	**S.** ††† Number of team members is negatively associated with internationalization
11 Education level (PhD)	**S. ††** Number of PhDs in founder team is positively associated with internationalization
12 Education type (founder team)	N.S.
13 Newness of invention	N.S.
14 Granted or applied patent(s)	N.S.
15 Product development stage	N.S.
16 Frequency of network meetings	N.S.
17 Duration of relationships	N.S.
18 Acquaintance level in relationships	N.S.
19 Tightness	N.S.

*S.: significant, N.S.: not significant; significance level: †P<0.01, ††P<0.5, †††P<0.1; N (spin-offs): 99.

7. Explanatory model

In this section, we first describe the type of regression analysis used, i.e. logistic regression analysis, and then we examine the results of this analysis in identifying a model with the best fit.

Since the dependent variable - internationalization of learning- is a dichotomous variable we use logistic regression analysis. Accordingly, our regression model will predict the logit that is the (natural) log of the odds of having one or the other decision (here, internationalization of learning). Thus in a simple logistic regression with one predictor variable (X): Ln (ODDS) = Ln (Y/1-Y)= a+bX (Y, is the predicted probability of the event and X is a predictor variable).

With the aim to check for multicollinearity, correlation between the independent variables is presented in Appendix 3. The largest single correlation is between firm age and product development stage (0.66). The reported correlations (most are below 0.50) do not indicate serious concern for multicollinearity (Hair et al., 1998).

As a first step, in Model 1, we include all variables which are significantly associated with internationalization of learning according to the previous bivariate analysis (table 5). The results of this model show quite weak model parameters. To improve model parameters (pseudo R^2 and LR test); we add variables systematically into the model in order to have the maximum increase of model fitness at each step. Models 2 to 4 represent these steps. In Model 2, by adding 'newness' there is a significant improvement in model parameters, not only because its coefficient is significant but also the coefficient of R&D expenditure becomes significant, while the coefficient of international market orientation remains significant. In Model 3, by adding firm size we further improve the model fitness and the coefficients of international market orientation, R&D spending and newness remain significant. In Model 4, including eight variables and adding market (uncertainty) to the model, firm size becomes significant but newness becomes insignificant. In Model 5, by including nine variables we reach almost no better model by fitness. Adding more variables doesn't produce considerable improvements. Choosing the strongest model as a trade off between fitness and number of (significant) variables, Model 4 qualifies best. Firm size, international market orientation and R&D spending turn out to be important factors according to this model.

In more detail, the interpretation of Model 4 is as follows: for firms with a larger size (versus. firms with smaller size), the log odds of being internationalized increases by 0.89. For firms with international market orientation, the log odds of being internationalized increases by 1.04 and for firms with a larger amount of R&D spending, the log odds of being internationalized increases by 1.06. In addition, note that all signs in Model 4 are positive as expected, except for two. The size of the founding team and newness of the invention tend to have a negative impact on internationalization, but the coefficients are not significant. A negative impact of size of the founding team may be explained by the strategy of small teams to learn internationally to compensate for small size. Similarly, a negative impact of newness on internationalization may be due to a trend that firms facing a low level of newness are more eager to learn by internationalization and that firms facing a high level of newness feel hampered in international learning due a danger of loosing IP rights in sharing highly new knowledge abroad.

Table 5- Logistic regression analysis - dependent variable: internationalization of learning (yes/no)

Variables	1	2	3	4	5
	Logit coef.(s.e.)	Logit coef.(s.e.)	Logit coef.(s.e.)	Logit coef.(s.e.)	Logit coef.(s.e.)
Control variables					
Firm age	-	-	-		
Firm size	-	-	0.76 (0.49)	0.89 (0.51) ††	0.95 (0.52) ††
International market orientation	0.86 (0.47) ††	1.18 (0.52) †	1.02 (0.53)††	1.04 (0.55)††	1.08 (0.54) †
Location	-	-	-	-	-
Technology	-	-	-	-	-
Market (uncertainty)	-	-	-	0.65 (0.52)	0.61 (0.52)
Absorptive capacity					
R&D expenditure	0.72 (0.5)	1.08 (0.57)††	1.15 (0.58)††	1.06 (0.54)††	1.05 (0.59)††
R&D employees	-	-	-	-	-
Previous working experience	0.41 (0.48)	0.41 (0.49)	0.48 (0.5)	0.58 (0.51)	0.72 (0.53)
Size of founding team	-0.99 (0.67)	-1.00 (0.68)	-1.08 (0.7)	-1.12 (0.71)	-1.19 (0.73)
Education level (founding team)	0.59 (0.52)	0.67 (0.53)	0.83 (0.55)	0.86 (0.55)	0.84 (0.56)
Education type (founding team)	-	-	-	-	-
Newness of innovation	-	-1.12 (0.61) ††	-1.03 (0.62) ††	-0.89 (0.63)	-0.94 (0.63)
Granted or applied patent(s)	-	-	-	-	-
Product development stage	-	-	-	-	-
Social network					
Tightness	-	-	-	-	-
Frequency of network meetings	-	-	-	-	0.72 (0.72)
N	99	99	99	99	99
LR Chi-square	16.41*	20.06*	22.52*	24.12*	25.17*
Pseudo R Square	0.12	0.15	0.169	0.181	0.189
Log likelihood **	-58.17	-56.34	-55.11	-54.31	-53.79

*P<0.005, †P<0.01, ††P<0.05, †††P<0.1

Overall, the models remain rather weak, but two of the variables show consistently a significant coefficient: international market-orientation (all five models) and R&D expenditure (four models). With these rather robust results, our study confirms outcomes of some recent empirical studies (e.g. de Jong and Freel, 2010).

8. Conclusion

This paper is concerned with the first results of an exploratory study of the extent and causes of learning abroad among technology-based spin-off firms. The study is relevant because the high levels of specialization in technology inventions call for highly specialized knowledge, most probably not (all) available in the local environment of spin-off firms. However, as theory

indicates, spin-off firms have different capabilities for learning, depending on their absorptive capacity. The idea is that firms must first invest in their absorptive capacity before they are able to coordinate and learn from their knowledge partners abroad, potentially reflected in the amount of knowledge and experience in the founding team, as well as R&D expenditure. In addition, previous studies indicate that international learning goes along with an international market orientation. It appeared that most spin-offs in the current study (60%) are engaged in international learning, with customers as the most important category of partners.

The study included various steps: design of a causal model of international learning based on the literature, a broad exploration of the relation between the concomitant variables with presence of international learning (using bivariate analysis) and the exploration of a multiple regression model of international learning (using logistic regression). We included three types of factors in the causal model: firm-related factors (location, age, size and market-orientation, and market and technology features), absorptive capacity (based on R&D indicators and knowledge available at start, the latter both in level and richness) and strength of the social network. Bivariate analysis has revealed a significant relation of international learning with international market-orientation, R&D expenditure, working experience at start, number of team members at start and education level of the founding teams. We used these outcomes to construct a first model followed by the forward stepwise method (adding variables) in logistic regression analysis. The best model as a trade-off between the size of the model and model fitness remains rather weak, with three variables showing significant coefficients: firm size, international market orientation and R&D spending, the last as the only one representing absorptive capacity. Thus, larger firms, firms engaged in export and firms facing high R&D expenditure face a relatively large chance for international learning. The explored models are robust in the sense that two variables are consistently significant: international market orientation (all five models) and R&D expenditure (four models). The level of newness of the invention (significant in two models) shows surprisingly a negative relationship, possibly indicating that a low newness urges firms to learn internationally; but it could also mean that firms facing a high level of newness tend to avoid international learning because of danger of loss of intellectual property. All in all, we may conclude that so far absorptive capacity did not turn out to be a major influence in international learning, except for R&D expenditure and level of newness of innovations.

The relative weakness of the model outcomes has implications for further research. First, some of the variables could be examined in the model in more detail of measurement (refinement), in particular this holds for the variables on absorptive capacity, and secondly we could continue our research to identify some more not yet identified indicators of absorptive capacity.

Appendix 1

a. Tightness of network: refers to proportion of partners who are tied in a network measured as 2t / (n(n-1)) , where (t) is the total number of the network relations and (n) is the total number of partners (Borgatti et al. 1998). A high value indicates a relatively tight network; min:0, max:1. For example, if a spin-off has 5 partners but 3 three of them connect to each other, then the density of network would be (2*3)/(5*(5-1))=0.3

b. Strength of relationships: Granovetter (1973 pg. 1361) argued that the strength of a social tie is a function of its duration, emotional intensity, intimacy, and exchange of services. Accordingly, we measure the strength of relationship through three variables: *Duration of relationship* which presents the number of months/years two partners have been in contact with each other – *Frequency of face to face contacts* which represents the frequency of interactions between two partners in a specific period of time (e.g. how many times two partners may meet and have a face to face meeting?) – *Acquaintance level of relationship* which shows a person's assessment of closeness of the relationship.

Appendix 2

Variables and descriptive statistics (N=99)

Variables	Measure	Mean	S.D.	Min	Max
Firm age	# years since foundation	5.11	3.03	1	10
Firm size	#employees	7.43	7.06	0	51
Frequency of network meetings	# meeting per month	1.03	0.60	0.2	4
Duration of relationships	# years	4.25	2.13	1	13
Acquaintance level in relationships	three categories See Appendix 1	1.5	0.55	0.4	2.8
Tightness of networks	see Appendix 1	0.49	0.3	0.1	1
External orientation	see Appendix 1	-0.29	0.52	-1	1
Market orientation	two categories	International (63.5%) Non-international (36.5%)			
Firm market	two categories	Uncertain: 37% Not uncertain: 63%			
Firm technology	two categories	Science driven: 20% Market driven: 80%			
International learning	two categories	0: Not Internationalized (39.5%) 1: Internationalized (60%)			
Internationalization scale	three categories	0: Not Internationalized (39.4%) 1: Low scale of internationalization (16.2%) 2: High scale of internationalization (44.5%)			
Internationalization scope	three categories	0: Not Internationalized (39.4%) 1: Low scope of internationalization (50.5%) 2: High scope of internationalization (10.1%)			

Appendix 3- Correlation matrix (n=99) a)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Firm age	1	0.57**	-0.10	-0.18	-0.004	-0.13	** -0.32	0.24*	-0.03	-0.22	-0.11	0.04	** -0.30	-0.22*	0.66**	0.07	-0.25*
2 Firm size		1	0.13	-0.14	-0.07	-0.14	-0.05	0.50**	-0.09	-0.01	-0.16	0.33*	-0.12	-0.05	0.38**	0.23*	-0.08
3 International market-orientation			1	0.16	0.03	-0.11	0.24*	0.18	0.14	-0.14	0.29**	0.16	0.36**	0.4**	-0.09	0.07	-0.06
4 Urban location				1	0.06	0.11	0.14	-0.05	0.26**	0.03	0.09	0.12	0.22*	-0.005	-0.21*	-0.13	-0.009
5 Technology					1	-0.18	-0.03	-0.03	0.1	-0.02	0.03	0.02	0.27**	0.16	-0.01	-0.005	0.08
6 Market (uncertainty)						1	0.05	-0.03	-0.11	0.07	-0.09	0.04	-0.15	-0.12	-0.11	0.15	0.11
7 R&D expenditure							1	0.26**	0.14	0.17	0.2*	0.13	0.35**	0.40**	-0.32 **	0.10	0.02
8 R&D employees								1	-0.11	0.12	-0.10	0.41**	-0.04	-0.05	0.13	0.11	0.008
9 Previous working experience (founder team)									1	-0.11	0.36**	-0.06	0.08	0.23*	-0.02	-0.13	-0.23*
10 Size of team at start										1	-0.12	0.11	0.02	-0.04	-0.20*	-0.02	0.07
11 Education level (founder team)											1	-0.05	0.18	0.35**	-0.008	0.008	-0.06
12 Education type (founder team)												1	0.07	-0.02	0.11	0.26**	0.16
13 Newness of invention													1	0.43**	-0.21*	0.04	0.07
14 Granted or applied patent(s)														1	-0.23*	0.11	-0.13
15 Product development stage															1	0.16	0.04
16 Tightness of social networks																1	0.22*
17 Frequency of network meetings																	1

*P<0.05, **P<0.01,

a) Spearman correlation coefficients

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