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How far may academic spin-offs go to learn? A focus on absorptive capacity

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**HOW FAR MAY ACADEMIC SPIN-OFFS GO TO LEARN?
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 of these firms, the relationship is explored between absorptive capacity and international learning, alongside other factors. International learning is measured in two ways, i.e. 1) adoption of the strategy and 2) scale involved (close and far). A majority of spin-off firms is engaged in international learning and – based on exploring two types of models - the most powerful influences tend to be international market orientation and level of education of the founding team. Overall the explanatory power of the models turns out to be weak, but this is inherent in models including absorptive capacity. It is a capacity of firms that may work differently under diverse circumstances and it is also difficult to measure. Implications of the results and future research steps are discussed.

1. Setting the Scene

The production and utilization of new knowledge is a major distinctive factor between regions and their economies today. In the development of the regional knowledge-based economy, 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 it is defined as local, regional or international. 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). The latter outcomes may suggest that young firms with a limited absorptive capacity (or capacity to learn) are bound to mainly learn locally and that this situation is most adequate.

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 expenditure 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 of absorptive capacity. 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 causal 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 present the outcomes of an exploration of the causal background of international learning taken as presence/absence of the strategy and taken as the reach in learning (close versus at a distance). The paper closes with a summary and a brief indication of implications of the outcomes and further analysis.

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 spatial 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 Feldman 1996); 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 ‘supply of knowledge’ like complementary knowledge to the core invention and knowledge from launching customers, etc. differ between urban places. These places may run from centrally located large metropolitan areas (like Randstad in the Netherlands) to rather isolated towns in the periphery of Europe. It is plausible that firms in the last towns feel themselves urged to go abroad more quickly, looking for the knowledge they need. Distant collaboration may be a response to knowledge shortages in the local area.

The last viewpoint comes close to what is emphasized in management and entrepreneurship studies, i.e. the character of the learning needs of young high-tech firms and the match with the supply of learning sources and networks on a local-global scale in open systems (Bathelt et al. 2004; Simmie 2003). Thus, the dominant learning may have a different reach, i. e. local (regional), national and international and, within the latter, learning at close distance or at larger distances, dependent among others on the specialization level needed (van Geenhuizen, 2008).

All in all, there are some contradictory theoretical viewpoints, but increasingly empirical studies point to a large differentiation in the spatial reach of learning.

2.2 Firm characteristic, markets and technology

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.

As previously indicated, the literature also suggests that there is a large differentiation between firms in spatial reach in learning. This may originate from different levels of 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 firm 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, and the market (uncertainty and orientation) in our causal model. We also add the character of technology use. As previously indicated, Asheim et al. (2007) distinguish between science-driven and market-driven technology use, with science-driven learning networks unfolding more often on a global level.

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 multi-disciplinarily 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 can 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).

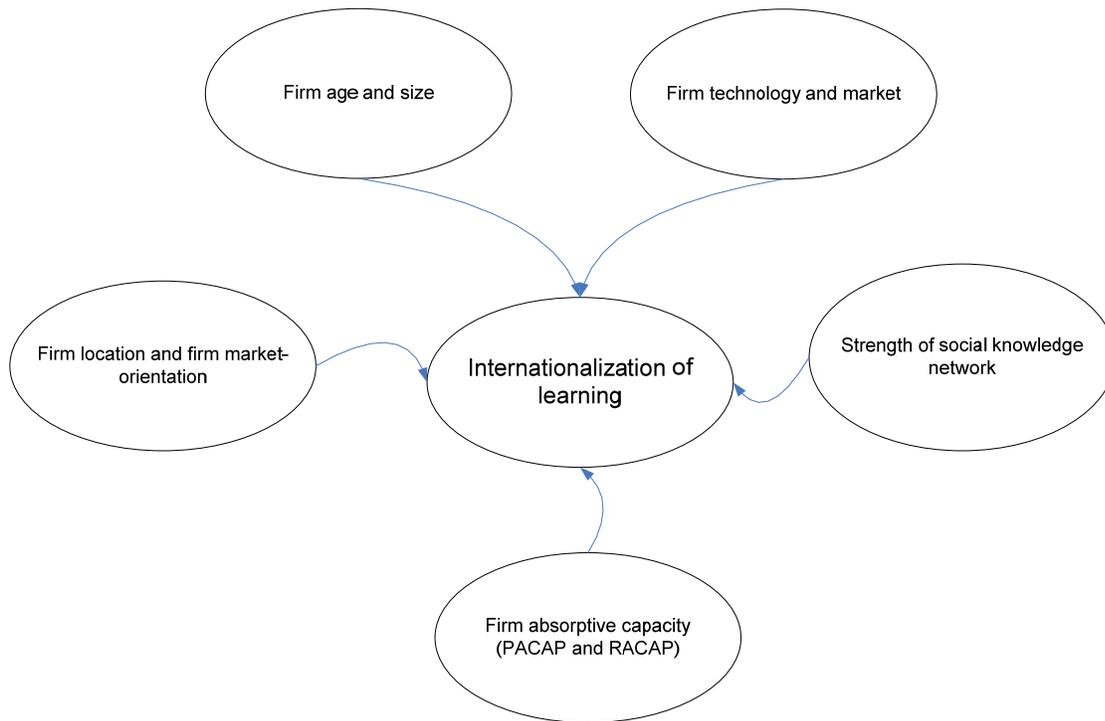
2.4 Role of social networks in a stepwise development

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). Thus, in their early years, high-tech firms seem to elaborate relatively strong (dense) personal networks. Such a development would mean that international learning as a next step goes along with existing social learning networks that are quite strong. 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. Causal model

Given the above inventory of influences on international learning, we use a division into five (1) the firm's location and market-orientation, (2) firm size and age, (3) the firm's strategy in terms of technology use and market, (4) firm's absorptive capacity including PACAP and RACAP, and (5) firm's social network characteristics, focusing on strength (Figure 1).

Figure 1- Causal diagram of firm's internationalization



3. Methodological Aspects

3.1. Steps and variables

The analysis in this paper follows three steps: 1) a descriptive analysis of international learning and of absorptive capacity, 2) a broad exploration of the causal model based on bivariate correlation analysis, and 3) based on the outcomes of the previous step, a preliminary model construction and testing of the model using multiple regression analysis. First, we 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 details 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 in two ways: a) as a dichotomous variable indicating whether the spin-off expands its learning activity using more formal knowledge sources abroad (yes/no), and b) as a variable indicating the geographic scale involved in the learning networks. Learning may be extended into neighboring countries only, all over Europe and/or the world. Scale is defined as an ordinal variable using three categories: far, close 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, but with a quite high position in the national urban hierarchy and national knowledge system. 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 of rejecting innovations 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 classified 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. In measuring (potential) absorptive capacity of spin-offs (Table 1), we include R&D spending (R&D expenditure as a percentage of income) 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 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 the composite variable "newness" in three categories, based on whether the product is a breakthrough and/or

new to the sector and on whether patent application and granted patent(s) are involved. Further, development stage indicates the stage of technology development (a rank variable with two categories: early development stage including pilot and testing stage, and later stage including introduced to market and consultancy).

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 - Size of founding team
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)	<i>Our database does not allow measuring this</i>
Realized absorptive capacity	Knowledge transformation	-Number of new product ideas -New research projects initiated (Zara and George 2002)	- Newness of innovation through breakthrough character and patents (applied/granted involved)
Realized absorptive capacity	Knowledge exploitation	-Number of patents -New product announcements -Length of product development cycle (Zara and George 2002)	- Development stage of new products/processes

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” (note 1), 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.

3.3 Multiple regression analysis

Since we take both dependent variables - internationalization of learning- and – spatial reach in learning – as dichotomous variables, 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, in the first model internationalization of learning and in the second one spatial reach). Thus in a simple logistic regression with one predictor variable (X): $\text{Ln}(\text{ODDS}) = \text{Ln}(Y/1-Y) = a + bX$ (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 correlations are between firm age and product development stage (0.66) and high level of newness and medium level of newness (-0.65). The reported correlations (most are below 0.50) do not indicate serious concern for multicollinearity (Hair et al., 1995).

As a first step, we include only those variables which are significantly correlated with internationalization of learning according to the previous bivariate analysis (Table 3 and Table 4). To improve model parameters (pseudo R^2 and LR test); we add variables systematically into the model to have the maximum increase of model fitness at each step. We end this procedure at the point of a trade off between fitness and number of (significant) variables, where adding more variables cannot produce a considerable improvement of the parameters anymore.

4. Absorptive Capacity and Internationalization: Descriptive Analysis

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 variation. 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 the 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 and other fields such as management. 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 43% of the entrepreneurs qualify their innovation as new (breakthrough and/or new to the sector) while they are involved in patent application or granted patents at least once. Some of the firms qualify their invention at the medium level and never applied for or dealt with a granted patent (35%), advanced software/hardware application firms are mostly in this group. The remaining firms have a low level of newness being mainly active in less advanced software industry (21%).

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: small experience (<=3 yrs) and larger experience (>3)**	Small experience (54.5%) Larger experience (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 based on disciplinary background (single and multiple technology, multidisciplinary)	Technology (64.6%) Multiple technologies (22.2%) Management (3.1%) Mixed (10.1%)			
Level of education	Three categories based on presence of knowledge on the PhD level	No PhD (61.6%) One PhD (24.2%) More than one PhD (14.2%)			
Development stage	Two categories	Early development stage or pilot and testing (36.5%) Introduction to market, including consultancy as main activity (63.5%)			
Newness	Three categories based on the entrepreneur's perception of the innovation: a breakthrough and/or new to the sector or not, and number of patents applied for and/or granted	High level (43.5%) Medium level (35.5%) Low level (21%)			

* Average in the last three years.

** Years of experience has a mean of 7.5; S.D: 11.8, min:0, max: 62.

We may conclude that even in a small segment of high-technology small firms – university spin-offs – there is a large differentiation in the various dimensions of absorptive capacity.

As far as internationalization is concerned, a majority of the spin-off firms in our database (61%) has adopted the strategy of international learning. Among these firms, 16% have expanded their reach in learning merely in a neighboring country, while most of them (44%) have internationalized globally (Appendix 2).

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).

5. Exploring Influences on International Learning

5.1 Strategy of international learning

We first broadly explore the relationship between the strategy of international learning and the factors of influence as shown in Figure 1. This step serves to select independent variables facing a high correlation with international learning.

On the basis of bivariate correlation analysis, we find significant relationships between internationalization of learning and four characteristics of absorptive capacity: R&D spending, number of team members at start, education level of founding team and newness of innovation. Looking for a significant cut-point in R&D spending, we observe that firms with higher R&D expenditure (more than 20% of revenues) face a higher level of internationalization. In addition, a higher education level of the founders tends to be positively correlated with internationalization. In contrast, a small starting team seems to be correlated with internationalization of learning, not a large starting team. The last, somewhat contradictory, result may be explained as follows: smaller teams need more external knowledge in increasing their innovativeness, including international learning.

Further, a high level of newness within firms often protected by a patent shows positive correlation with internationalization of learning while medium level of newness within firms that is not protected by a patent tend to be negatively correlated with internationalization of learning. An explanation for this result could be that firms are reluctant to share knowledge and learn internationally when their internal innovations are not well protected well. The outcomes are

partly in line with the idea that prior knowledge accumulation within firms will increase their ability to search for international learning and to coordinate it. Further, we find a positive correlation between international market orientation of firms and international learning (see Appendix 3).

We now proceed with the exploration of influences on international learning using logistic regression analysis (Table 3). As a first step, in Model 1, we include all variables which are significantly correlated with international learning according to the previous bivariate analysis. 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 and 3 represent these steps. In Model 2, by adding firm size we further improve the model fitness and the coefficients of international market orientation, R&D spending, founder team members, education level of founding team and medium level of newness remain significant but high level of newness becomes insignificant. In Model 3, including eight variables and adding technology to the model, the number of significant variables does not change. Adding more variables doesn't produce considerable improvements. Choosing the strongest model as a trade off between fitness and number of (significant) variables, Model 2 qualifies best. International market orientation, R&D spending, size of founding team, education level of founding team and medium level of newness turn out to be important factors according to this model.

In more detail, the interpretation of Model 2 is as follows: for firms with a larger size (versus firms with smaller size), the log odds of being internationalized increases by 0.80 but the coefficient is not significant. For firms with international market orientation, the log odds of being internationalized increases by 0.99 and for firms with a larger amount of R&D spending, the log odds of being internationalized increases by 1.29. Subsequently, for firms with smaller size of founding team, the log odds of being internationalized increases by 0.62 and for firms with higher level of education of founding team, the log odds of being internationalized increases by 0.63. Firms facing a low level of newness (versus firms with medium level of newness) have a higher chance to learn internationally (the log odds of being internationalized increases by 1.51 in this case). In the same way, firms with a low level of newness have a higher chance to learn internationally compared with firms with a high level of newness, but the latter coefficient is significant.

Table 3- Logistic regression analysis - dependent variable: strategy of international learning (yes/no)

Variables	1	2	3	4
	Logit coef.(s.e.)	Logit coef.(s.e.)	Logit coef.(s.e.)	Logit coef.(s.e.)
Firm age	-	-	-	
Firm size	-	0.80 (0.51)	0.84 (0.51)	
International market orientation	1.16 (0.55) ††	0.99 (0.56) †††	1.02 (0.56) †††	
Technology	-	-	0.61 (0.64)	
<i>Absorptive capacity indicators</i>				
R&D spending	1.22 (0.63) †††	1.29 (0.64) ††	1.37 (0.66) ††	
Team members at start	-0.55 (0.24) ††	-0.62 (0.25) ††	-0.63 (0.25) ††	
Level of education(founder team)	0.59 (0.31) †††	0.63 (0.32) †††	0.61 (0.33) †††	
Type of education(founder team)	-	-	-	
Newness-high level	-1.35 (0.8) †††	-1.13 (0.8)	-1.38 (0.86)	
Newness- medium level	-1.59 (0.67) ††	-1.51 (0.68) ††	-1.81 (0.76) ††	
Development stage	-	-	-	
N	99	99	99	
LR Chi square	25.45†	28.01†	28.92†	
Pseudo R Square	0.19	0.21	0.217	
Log likelihood	-53.65	-52.37	-51.91	

†P<0.005, ††P<0.05, †††P<0.1

In addition, note that all signs in Model 2 are positive as expected, except for two. The size of the founding team and high/medium level of newness of the innovation tend to have a negative impact on internationalization, but the coefficient of high level of newness of the innovation is 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 losing IP rights in sharing highly new knowledge abroad. This is particularly apparent in Model 2 in which newness on the medium level indicates that inventions are not protected by a patent.

Overall, the models remain rather weak, but five of the variables show consistently a significant coefficient across all models: international market-orientation, R&D expenditure, education level

of founding team size of founding team and medium level of newness (all three models). With these rather robust results, our study confirms outcomes of some recent empirical studies (e.g. de Jong and Freel, 2010).

5.2 Spatial reach in learning

In the remaining part of this section we focus on the spatial reach in learning in the frame of internationalization. The dependent variable is measured using two classes: close and far reach. Based on correlation analysis as a first step, we also find significant positive relationships between the dependent variable and four characteristics of absorptive capacity: R&D spending, R&D employees, education level of founding team and high level of newness. Also, we observe a positive relationship between firm size and spatial reach. The same holds for international market orientation (details are in Appendix 3).

In Model 1 we first include variables which are significantly correlated with spatial reach. The variables R&D employees and high level of newness show up in the model with very small coefficients. Therefore we decide to exclude them in Model 2 which does not change the model fitness considerably. The model parameters (pseudo R^2 and LR test) further are improved by adding variables systematically into the model to have the maximum increase in model parameters at each step (Models 3 to 5). Adding more variables doesn't improve the model considerably. Given the outcomes, we qualify Model 4 as the best model describing spatial reach in learning as a trade off between model fitness and number of (significant) variables in the model.

Model 4 includes six variables four of which are significant: firm size, international market orientation, education level of founding team and development stage found significant in this model. Three variables, i.e. firm size, international market orientation and education level of founding team are consistently significant in all five models, aside from development stage in three models. The model suggests that larger firms, firms who are engaged in exports, firms facing a higher education level of founders and firms in an earlier stage of invention development are more likely to learn crossing larger geographical distances.

Table 4- Logistic regression analysis - dependent variable: spatial reach in learning (close/far)

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.)
Firm size	1.30 (0.59) ††	1.37 (0.51) †	1.96 (0.62) †	2.14 (0.66) †	2.24 (0.67) †
International market orientation	1.05 (0.58) †††	0.99 (0.53) †††	0.93 (0.54) †††	1.09 (0.57) †††	1.13 (0.58) †††
Market (uncertainty)	-	-	-	0.86 (0.53)	0.78 (0.54)
<i>Absorptive capacity indicators</i>					
R&D spending	0.91 (0.66)	0.86 (0.57)	0.46 (0.62)	0.37 (0.63)	0.32 (0.63)
R&D employees	0.09 (0.6)	-	-	-	-
Level of education (founder team)	1.06 (0.37) †	1.04 (0.37) †	1.23 (0.39) †	1.28 (0.40) †	1.31 (0.40) †
Type of education (founder team)	-	-	-	-	-
Newness- high level	-0.18 (0.6)	-	-	-	-
Development stage	-	-	-1.26 (0.62) ††	-1.28 (0.64) ††	-1.40 (0.66) ††
<i>Social network characteristics</i>					
Frequency of meetings	-	-	-	-	0.78 (0.72)
N	99	99	99	99	99
LR Chi square	30.90*	30.77*	35.23*	37.92*	39.13*
Pseudo R Square	0.227	0.226	0.259	0.278	0.287
Log likelihood	-52.56	-52.62	-50.39	-49.04	-48.44

*P<0.005, †P<0.01, ††P<0.05, †††P<0.1

Comparing the two ‘best’ models (Model 2 for international learning strategy and Model 4 for spatial reach) reveals the following results: (1) the strategy of international learning tends to be stronger dependent on absorptive capacity than the spatial reach in learning, and (2) international market orientation and level of education of the founding team are relatively strong influences on both the strategy of international learning and spatial reach in learning.

6. 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 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 a scan of the literature and the exploration of this model using multiple regression analysis (logistic regression, forward stepwise method). We included three types of factors in the causal model: firm-related factors (location, age, size, market-orientation, market (uncertainty) 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. The best model of the strategy of international learning - as a trade-off between model size and model fitness - includes five variables showing significant coefficients: international market orientation, R&D spending, size and level of education of the founding team and a medium level of newness, four of them representing absorptive capacity. Thus, firms engaged in exports, firms facing high R&D expenditure, firms with a smaller size at start, firms with a higher level of education of founders and firms with a low level of innovativeness have a relatively large chance to adopt the strategy of international learning.

The best model of spatial reach in learning includes four variables showing significant coefficients: firm size, international market orientation, education level of the founding team, and

development stage. The two 'best' models indicate the following: the strategy of international learning tends to be stronger dependent on absorptive capacity than the spatial reach in learning. In addition, international market orientation and level of education of the founding team are relatively strong influences on both the strategy of international learning and spatial reach in learning. Overall, the explanatory power of the models turns out to be weak. This is however inherent in models including absorptive capacity. Absorptive capacity is a capacity of firms that may work differently under diverse circumstances and it is also difficult to measure. 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 the variables concerning absorptive capacity, and secondly we could continue our research to identify some more not yet identified indicators of absorptive capacity.

Note 1

In a previous study it was found - using simulation studies- that firms that have died do not differ significantly from the ones that survived in some main respects (Soetanto, 2009).

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 and is defined in three categories: very well, somehow and very little.

c. Newness is initially defined in five categories:

Code	5	4	3	2	1	Total
Frequencies	15	28	12	23	21	99

5: Highly innovative firms with high R&D spending and more than one applied or granted patent

4: Highly innovative firms with at least one applied or granted patent (breakthrough and/or new to the sector)

3: Innovative firms with rather high spending on R&D with usually no applied or granted patent

2: Medium-level innovative firms usually with rather low R&D spending (more advanced innovative software firms are mostly in this category)

1: Low-level innovative firms usually with quite low R&D spending (simple non-innovative software firms are mostly in this category)

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
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%			
Strategy of international learning	two categories	0: Not Internationalized (39.5%) 1: Internationalized (60%)			
Spatial reach in learning	three categories	0: Not Internationalized (39.4%) 1: Small reach in internationalization (16.2%) 2: Large reach in internationalization (44.5%)			

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

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 Firm age	1	0.57**	-0.11	-0.18	-0.004	-0.13	-0.32**	0.24*	-0.03	-0.13	-0.06	0.04	-0.32**	0.09	0.66**	0.07	-0.25*	0.05	0.03
2 Firm size		1	0.13	-0.14	-0.07	-0.15	-0.05	0.50**	-0.10	0.10	-0.11	0.34*	-0.10	0.02	0.38**	0.23*	-0.08	0.14	0.25*
3 International market-orientation			1	0.17	0.04	-0.11	0.24*	0.18	0.14	-0.07	0.30**	0.16	0.45**	-0.19	-0.09	0.07	-0.07	0.29**	0.34**
4 Urban location				1	0.06	0.11	0.15	-0.05	0.26**	0.14	0.11	0.12	0.05	0.15	-0.22*	-0.13	-0.09	0.05	0.15
5 Technology					1	-0.18	0.03	-0.03	0.1	0.05	0.08	0.02	0.08	0.21*	-0.01	-0.005	0.08	0.006	-0.005
6 Market (uncertainty)						1	0.05	-0.03	-0.12	0.05	-0.09	0.05	-0.09	-0.09	-0.11	0.15	0.11	0.067	0.06
7 R&D expenditure							1	0.26**	0.15	0.16	0.20*	0.13	0.49**	-0.21*	-0.32**	0.11	0.02	0.20*	0.23*
8 R&D employees								1	-0.11	0.14	-0.06	0.41**	-0.02	-0.02	0.13	0.11	0.008	0.09	0.20*
9 Previous working experience (founding team)									1	-0.21*	0.36**	-0.07	0.26**	-0.12	-0.03	-0.13	-0.23*	0.20	0.16
10 Size of founding team at start										1	-0.05	0.30**	-0.04	0.10	-0.12	0.08	0.16	-0.21*	0.04
11 Education level (founder team)											1	-0.03	0.32**	-0.15	0.05	0.05	-0.05	0.26**	0.36**
12 Education type (founder team)												1	0.05	-0.01	0.12	0.27**	0.16	0.07	0.12
13 High level of newness of innovation													1	-0.65**	-0.31*	0.11	0.002	0.21*	0.20*
14 Medium level of newness of innovation														1	0.16	-0.10	0.02	-0.27**	-0.15
15 Product development stage															1	0.16	0.04	0.07	-0.08
16 Tightness of social networks																1	0.22*	0.14	0.13
17 Frequency of network meetings																	1	0.02	0.05
18 Strategy of international learning																		1	0.72**
19 Spatial reach in learning***																			1

*P<0.05, **P<0.01,

*** In two categories: close (including not internationalized) and far reach

a) Spearman correlation coefficients

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