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ABSORPTION OF KNOWLEDGE
SPILLOVERS: STRATEGIC
BOARD AND MANAGERIAL
COMPOSITION FOR COMPETITIVE
ADVANTAGE**

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ABSTRACT

Entrepreneurial Access and Absorption of Knowledge Spillovers: Strategic Board and Managerial Composition for Competitive Advantage

The resource theory of the firm implies that knowledge is a key resource bestowing a competitive advantage for entrepreneurial firms. However, it remains rather unclear up to now, how new ventures and small business can access knowledge resources. The purpose of this paper is to suggest two strategies in particular that facilitate entrepreneurial access to and absorption of external knowledge spillovers: the attraction of managers and directors with an academic background. Based on data on board composition of 295 high technology firms, the results clearly demonstrate the strong link between geographical proximity to research intense universities and board composition.

JEL Classification:

Keywords: board composition, corporate governance, entrepreneurship and university spillover

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1. Introduction

As the resource theory of the firm implies, knowledge is a key resource bestowing a competitive advantage for entrepreneurial firms (Agrawal et al. 2005, Alvarez and Barney, 2004; Kogut and Zander, 1992; Barney, 1986; and Wernerfelt, 1984). However, the paucity of knowledge resources in new ventures and small business has been well documented (Cohen and Klepper, 1992). This raises the question of how new ventures and small business can access knowledge resources. One answer suggested by the knowledge spillover theory of entrepreneurship (Audretsch, 1995, Audretsch and Keilbach (2006) and Audretsch and Lehmann, 2005a) is that new ventures and small businesses generate knowledge resources by accessing external knowledge spillovers. A series of studies has found that location matters for the entrepreneurial access of knowledge spillovers that bestow competitive advantage (Almedia and Kogut, 1997; Powell et al., 1996; Audretsch and Feldman, 1996; Gilbert, 2004; Gilbert, McDougal and Audretsch, 2005; Sorenson and Stuart, 2001).

However, while close geographic proximity may facilitate access to external knowledge spillovers, it does not necessarily guarantee that the entrepreneurial venture can absorb such external knowledge spillovers and transform them into a competitive advantage. An important insight introduced by Cohen and Levinthal (1990) is that firms need to invest in the capacity to access and absorb external knowledge.

The purpose of this paper is to suggest two strategies in particular that facilitate entrepreneurial access to and absorption of external knowledge spillovers. While Cohen and Levinthal (1990) focused on investments in R&D as the mechanism facilitating the

absorption of external knowledge, the size constraint of entrepreneurial startups may also constrain the magnitude of their R&D investments, at least in absolute terms. However, as Audretsch and Stephan (1996) identified, there is a very different mechanism facilitating the access and absorption for entrepreneurial firms in high-technology and science-based industries – board members and firm managers. Audretsch and Stephan (1996) also found compelling evidence implying that geographic proximity is a prerequisite to board members accessing and absorbing external knowledge.

Thus, the *Entrepreneurial Access Hypothesis* suggests a very different role for board members. Rather than the conventional view, which focuses on the function of boards in controlling managers to reduce problems of economic agency, a new role is introduced in the following section, which is to help the entrepreneurial firm access and absorb external knowledge spillovers. The composition of boards is found to be endogenously influenced by the degree to which the firm is in a science-based or high-technology industry, as well as the potential pool of external knowledge spillovers emanating from knowledge sources within close geographic proximity. The results of this paper suggest that a strategy deployed by entrepreneurial firms is to select boards and managers with the human capital and knowledge capabilities to contribute to the access and absorption of external knowledge spillovers.

2. Entrepreneurial Access and Absorption of Knowledge Spillovers

An important assumption inherent in the knowledge spillover theory of entrepreneurship is that the knowledge embedded in a knowledge worker, such as a

scientist or engineer, is exogenous and that, in an effort to appropriate the value of her knowledge endowment, the economic agents endogenously starts a new firm. Strictly considered, such an assumption would seemingly suggest that this initial endowment of knowledge suffices in generating entrepreneurial competitive advantage that should be reflected in a high performance (Gilbert, 2004; and Gilbert, Audretsch and McDougall, 2005 and Audretsch and Lehmann, 2005b).

If such a strict interpretation regarding the exogeneity assumption of entrepreneurial knowledge is valid, then entrepreneurial access to knowledge spillovers subsequent to the startup of the new firm would not be important. This would suggest that a knowledge worker might obtain the requisite knowledge in one location but then subsequently move away to a more preferable location to actually start and grow the new venture. Of course, while this happens in many instances, studies provide compelling evidence suggesting that not only do knowledge-based and technology firms tend to locate within close geographic proximity to a knowledge source, such as a university, but also that geographic proximity bestows the entrepreneur a competitive advantage (Almedia and Kogut, 1997).

In order to start the new venture, the founder need not access external knowledge but rather needs to have a knowledge endowment. As the assumption inherent in the knowledge spillover theory of entrepreneurship suggests, the knowledge was exogenously embodied in the knowledge agent confronting the entrepreneurial decision. The central feature of the model of knowledge spillover entrepreneurship is that the spillover of knowledge is accomplished when the knowledge agent starts the new venture.

However, in order to access knowledge spillovers subsequent to the new venture startup, knowledge that may be external to the entrepreneur needs to be accessed. The location of the entrepreneurial startup can facilitate the access of such external knowledge spillovers. But, as Cohen and Levinthal (1990) pointed out, external knowledge may not be automatically accessed by new ventures, but may rather require investments in what they termed as absorptive capacity. A pre-requisite for the continued post-startup access to knowledge spillovers, is an entrepreneurial capacity for accessing and absorbing ideas generated externally by other firms and knowledge sources, such as universities and research institutions.

How can such external knowledge be accessed and absorbed by entrepreneurial firms? In the seminal article by Cohen and Levinthal (1990), their focus was on the role of investments in R&D as a mechanism for external knowledge access and absorption. As Henderson and Cockburn (1994) showed, there is considerable evidence linking investments in research to the capacity of large, incumbent firms to their capacity to access and absorb external knowledge.

Since new ventures are typically small and consist of a handful of employees, their absorptive capacity generated by investing in scientists and engineers will usually be limited. Even though science-based and high-technology firms may have a high share of employees engaged in R&D activities, and may devote a large share of their budgets to R&D, the small size of the new venture will constrain the absolute magnitude of the R&D investment. Thus, in addition to whatever investments in R&D are made, the entrepreneurial startup may also need mechanisms compensating for inherent size

disadvantages that limit the size, scope and scale of its initial knowledge endowment, which in term constrains the absorptive capacity of the entrepreneurial venture.

Two such mechanisms might include the knowledge capabilities contributed by members of the Board of Directors and by the managers. Why, how, and if these two mechanisms facilitate the absorption of knowledge spillovers into the entrepreneurial venture is explained in the following two sections.

3 Board Composition and Entrepreneurial Access

The role of board members and their contribution to the decision making process and efficiency of firms has a long tradition of scholarly scrutiny, particularly in the field of finance. The focus of this literature is on the role that boards play in exerting control over the firm's managers (Jensen and Meckling, 1976; Hermalin and Weisbach, 1998). This has resulted in a number of valuable insights about the size and scope of boards required to solve the agency problem emerging when corporate control and management are separated into distinct groups. In particular, the number of outsiders and board composition has been found to influence the agency problem concerning corporate control. Because they are less entrenched than insiders, outsiders have a greater incentive to monitor the top managers. However, as Hermalin and Weisbach (2003) report, the empirical evidence supporting the prevailing agency theory approach is mixed. As Hermalin and Weisbach suggest (2003), there is no clear cut empirical evidence suggesting that firm performance is enhanced by the numbers and share of outsiders sitting on boards of U.S. firms.

The composition of boards prevalent throughout continental Europe differs considerably from their counterparts in the United States as well as in the United Kingdom. Board composition in both the United States and United Kingdom is characterized by insiders, managers, and outsiders, who can not legally be involved in managing the firm (Allan and Gale, 1998; Fama and Jensen 1983). The Anglo-American model has been characterized as a one-tier-board.

By contrast, two-tier boards are more prevalent on continental Europe. For example, in Germany, the first tier consists of the board of managers, which includes only top managers of a firm. The second tier consists of the board of directors, which represents members whose task is to control the managers, to inform financiers and to provide advice to the managers (Lehmann and Weigand, 2000; Frick and Lehmann, 2005).

Board size and composition in Germany is dictated by law (Frick and Lehmann, 2005). According to the Co-Determination Laws (*Mitbestimmungsgesetze*), board membership is required to include between one-third and one-half of its representatives to be chosen from the relevant labor unions. This restriction holds only for medium-sized and large firms and for enterprises in traditional sectors such as steel and mining. By contrast, the IPO firms that are analyzed in this chapter have only the restriction that a minimum of three members compose the board of directors. Thus, there is little reason to think that these boards for the IPO firms should play a role that is substantially different from their counterparts serving on boards on Anglo-American style boards.

Thus, for the German IPO ventures, as the prevailing literature for Anglo-American firms suggests, the main role of board members is controlling managers and reducing problems emanating from divergent interests between managers and owners, or the agency problem. In short, the board of directors has ultimate responsibility for ensuring that the firm is run in the best interest of stockholders (Fama and Jensen, 1983).

In view of the demand for decision expertise, coupled with the requirement for detailed firm-specific knowledge, it is natural that boards contain senior managers from within the organisation (Fama and Jensen, 1983). An alternative theory of the role of board membership was posited by Audretsch and Stephan (1996). Rather than focusing on the role of boards in monitoring managers, they instead focused on the role of board members as serving as conduits facilitating and absorbing knowledge spillovers. According to Audretsch and Stephan (1996), board members may have a very different role in addition to control managers, as suggested by agency theory. In science-based and high-technology industries, such as biotechnology, they argue that board members serve to access and absorb external knowledge and therefore require a very different endowment of characteristics and qualifications. In particular, scientific knowledge and other aspects involving knowledge capabilities and human capital may be more important for firms in science-based and high-technology industries, such as biotechnology. In particular, Audretsch and Stephan (1996) examine the geographic relationships of scientists serving on boards of biotechnology firms. Their results suggest that the importance of geographic proximity is clearly shaped by the role played by the scientists on the board. The scientist serving on the board is more likely to be located in the same region as the firm when the relationship involves the transfer of new economic

knowledge. However, when the scientist is providing a service to the company that does not involve knowledge transfer, local proximity becomes much less important. Thus, the results of Audretsch and Stephan (1996) provide compelling evidence that in a science-based or high-technology industry such as biotechnology, board members can serve to promote entrepreneurial competitiveness not just by monitoring costs but also by accessing and absorbing external knowledge.

The *Entrepreneurial Access Hypothesis* suggests that boards will tend to have a greater composition of members with the capabilities to access and absorb external knowledge when the firm is located within close geographic proximity to a knowledge source (Audretsch and Lehmann, 2005b). This leads us to formulate the following proposition:

Proposition 1: *If entrepreneurial access to external knowledge spillovers is sufficiently important in the new venture's strategy to warrant geographic proximity to knowledge sources, then the entrepreneurial venture will also tend to need mechanisms facilitating the access to such external knowledge spillovers, such as board members with high human capital.*

The first empirical test of the *Entrepreneurial Access Hypothesis* therefore involves the composition of boards, and in particular the relationship between the human capital of the board members and the role that external knowledge spillovers play to the venture, as represented by both the geographic proximity to a university as well as the actual spillover mechanisms and output emanating from that university.

To test this hypothesis about entrepreneurial access to knowledge spillovers facilitated by board absorptive capacity, a data base was constructed that consists of German IPO entrepreneurial firms in knowledge and technology industries. There was a total of 295 German firms listed on Germany's equivalent of the United States *NASDAQ*, between 1997 and 2002. From these firms, five banks and nine holding companies were excluded. The dataset was collected combining individual data from the prospectuses of the initial public offering (IPO), along with publicly available information from on-line data sources including the *Deutsche Boerse AG* (www.deutsche-boerse.com). The data base includes highly innovative industries, including biotechnology, medical devices, life sciences, e-commerce and other high-technology industries, all of which are knowledge intensive.

The human capital of the board members is measured as having attained an advanced academic degree, which is the equivalent of having earned a Ph.D.. As Table 1 shows, in 49 ventures, or about 18%, no director has an advanced academic degree (Ph.D or Professor). In 82% of the firms, there is at least one director with an advanced academic degree.

Table 1
Frequency of Directors with an Advanced Degree

Directors with an academic degree	Frequency	Percent	Cumulative Percent
0	49	17.63	17.63
1	88	31.65	49.28
2	84	30.21	79.49
3	38	13.67	93.16
4	11	3.96	97.12
5	8	2.88	100.00

The dependent variable to be explained is the relative importance of human capital in an entrepreneurial board. The explanatory variables should reflect the extent of potential external knowledge spillovers available to the firm. Audretsch and Feldman (1996) identified two important interdependent factors shaping the magnitude of the external spillover pool – geographic proximity to the knowledge source and the knowledge output emanating from that knowledge source. Geographic proximity is measured in terms of kilometres between the closest university and the firm, and the knowledge output is measured in terms of published research in scholarly journals.

Three different estimation methods are used to test the hypothesis that the human capital embodied in directors is influenced by the potential access to absorb external knowledge spillovers. The first method uses the Probit model to estimate the probability that a director holds an academic degree. The second method estimates the share of members serving in the board of directors holding an academic degree. Because this variable is left censored, Tobit-estimation is more appropriate. The third method

estimates the number of board directors holding an academic degree. Since this is a count variable, the negative binomial regression method is appropriate.

The results are shown in Table 2. The first column estimates the likelihood of a given director holding an academic degree and thus uses the Probit model of estimation. As the negative and statistically significant coefficient of the interactive variable between distance and research output in the natural sciences suggests, the likelihood that a director holds an academic degree depends on university spillovers. However, these results hold only with close geographic proximity to a university and for the natural sciences. There is no statistically significant evidence that university spillovers in the social sciences influence board selection, regardless of firm geographic proximity to the university.

The results from Probit estimation also indicate that the likelihood of a given director holding an academic degree is clearly influenced by the industry. A director is more likely to hold an academic degree in biotechnology and medical technology, which are the fields where external knowledge has the highest scientific component.

Table 2
Geographic Proximity, University Spillovers and the Selection of Directors

	Probability that a director holds an academic degree (Probit)	Share of directors with an academic degree (Tobit)	Number of directors with an academic degree (Negative Binomial)
Distance* Natural Science Publications	-0.03978 ^a (1.69) ^{*b}	-0.0088 (1.64) [*]	-0.1789 (1.51)
Distance*Social Science Publications	0.0451 (1.40)	0.0111 (1.31)	0.01998 (0.97)
LNAge	0.0643 (1.05)	0.0020 (0.13)	-0.0002 (0.01)
LNSize	-0.0061 (0.09)	-0.0245 (1.32)	0.0443 (1.01)
Software	0.0565 (0.63)	0.0063 (0.28)	-0.0250 (0.43)
Service	-0.2489 (1.08)	-0.0263 (0.45)	-0.0427 (0.31)
E-Commerce	0.04063 (0.11)	-0.0978 (0.99)	-0.3063 (1.18)
Hardware	0.0476 (0.09)	0.0065 (0.07)	-0.0019 (0.01)
Telecommunication	-0.0422 (0.13)	-0.1671 (1.93) [*]	-0.3912 (1.70) [*]
Biotechnology	0.9473 (2.28) ^{**}	0.13078 (1.41)	0.4600 (2.17) ^{**}
MedTec	1.001 (2.17) ^{**}	0.2509 (2.15) ^{**}	0.3263 (1.38)
Media & Entertainment	0.0913 (0.32)	-0.0775 (1.02)	-0.1297 (0.71)
Constant	-0.4555 (1.19)	0.4915 (4.99) ^{***}	0.3094 (1.32)
Pseudo R2	0.062	0.061	0.025
N	278	278	278

Notes:

^a Estimated regression coefficients, ^b Absolute t(p)-values in parentheses

* $p < 0.1$

** $p < 0.05$

*** $p < 0.01$.

The second column uses the share of directors holding an academic degree as the endogenous variable. Thus, Tobit estimation is used in the second column. As the negative and statistically significant coefficient of the multiplicative variable between distance and publications in the natural sciences suggests, the share of directors with an

academic degree is significantly influenced by the university spillovers in the natural sciences, but this influence tends to decline as the geographic distance from the closest university increases. By contrast, in the social sciences, as the statistically insignificant coefficient implies, geographic proximity to a university has no impact on the composition of the board, at least in terms of human capital.

The share of board members holding an academic degree is found to be influenced by the particular industry. In Telecommunications and Medical Technology a greater share of board members tend to hold an academic degree than in other industries.

The third column uses the number of directors as the dependent variable, which is estimated using negative binomial estimation. The only statistically significant coefficients are for the industry dummies, suggesting that the number of directors tend to be systematically higher for firms in Biotechnology and Medical Technology.

While firm age and size have no significant impact in the three different estimates based on different measures for the dependent variables, the results also show that the selection of directors is not independent of the specific industry. Especially in high-technology and science-based industries such as Biotechnology and Medical Technology, there is a statistically significant higher likelihood that the directors hold an academic degree. These findings strongly support the results from Audretsch and Stephan (1999) that particularly in science-based industries members of a board may serve a role that is distinct from the traditional function of controlling and monitoring the directors. In such high-technology and science-based industries, there is a different role for board members – to serve as conduits for accessing and absorbing external knowledge spillovers.

Separate regressions were estimated to identify whether geographic distance or university, and not interactively as is specified in the estimates shown in Table 2, may have a significant impact on the selection of scientists as directors. All the results are not significant. This leads us to conclude that both factors geographic proximity and a strong university output in the natural sciences are necessary to change the composition of the board of directors towards including directors with a greater degree of human capital.

4. Manager Selection and Entrepreneurial Access

Directors serving on the board are not the only possible conduit for accessing and absorbing external knowledge spillovers. Representatives serving on the board of managers provide a second conduit for accessing and absorbing external knowledge spillovers. In the strategy literature, a key task of the managers is to accumulate and protect valuable knowledge or capability (Wernerfelt, 1984; Teece et al, 1997, Sadler-Smith et al. 2003). Such knowledge defines a venture's capacity to efficiently convert its input into valuable outputs (Nelson and Winter, 1982, esp. p. 59-60). Thus, managers enhance the venture's capacity to produce efficiently by advancing their knowledge. In particular, managers must decide how to access relevant knowledge and transform it into valuable output (Nickerson and Zenger, 2004).

There is only one prescribed legal restriction constraining the selection of the board of managers. One of the board members must be the CEO of the venture. Thus, the minimum size of the board is one, while the prescribed maximum is seven. The median size of the board is three managers. The distribution of firms with managers holding

academic degrees is summarized in Table 3. This distribution of managers holding academic degrees varies considerably from the distribution for the board of directors. Less than 40% of the firms in the IPO sample employ a manager with an academic degree. In 70 or about 25% of the firms, only one manager of the board of managers holds an academic degree. This gives a first hint that for managing a venture, holding an academic degree is certainly not a prerequisite.

Table 3

Number of Directors on the Board of Managers Holding an Academic Degree

Managers with an academic degree	Frequency	Percent	Cumulative Percent
0	168	60.43	60.43
1	70	25.18	85.61
2	32	11.51	97.12
3	5	1.78	98.90
4	2	0.72	99.64
5	1	0.36	100.00

To test the *Entrepreneurial Access Hypothesis* for this second conduit potentially facilitating the access and absorption of external knowledge spillovers, managers, the same three model specifications are used as in the previous section, except that managers are substituted for directors.

Table 4
Geographic Proximity, University Spillovers and the Selection of Managers

	Probability that a manager holds an academic degree (Probit)	Share of managers with an academic degree (Tobit)	Number of managers with an academic degree (Negative Binomial)
Distance*Natural Science Publications	-0.0315 ^a (1.36) ^b	-0.1712 (1.65)*	-0.0435 (1.66)*
Distance*Socia Science Publications	0.0343 (1.07)	0.01846 (1.23)	0.0465 (1.27)
LNAge	0.0555 (0.90)	0.0224 (0.78)	0.0838 (1.21)
LNSize	0.1633 (2.29)**	0.0678 (2.05)**	0.1911 (2.45)**
Software	-0.4173 (1.56)	-0.2054 (1.64)*	-0.3536 (1.44)
Service	-0.4921 (1.93)*	-0.2373 (2.00)**	-0.4418 (1.70)*
E-Commerce	-0.4278 (1.06)	-0.1632 (0.85)	-0.1165 (0.26)
Hardware	-0.2954 (0.86)	-0.0494 (0.31)	-0.1282 (0.39)
Telecommunication	-0.771 (2.12)**	-0.3756 (2.16)**	-0.7283 (1.70)*
Biotechnology	0.7683 (1.72)*	0.3516 (1.93)**	0.7838 (2.35)**
Medical Technology	0.7678 (1.57)	0.3186 (1.65)*	0.5994 (1.69)*
Media & Entertainment	-0.6075 (1.90)*	-0.3276 (2.16)**	-0.7699 (2.00)**
Constant	-0.695 (1.73)*	-0.2482 (1.31)	-1.2551 (2.83)**
Pseudo R2	0.0941	0.0952	0.0699
N	278	278	278

Notes:

^a Estimated regression coefficients, ^b Absolute $t(p)$ -values in parentheses

* $p < 0.1$

** $p < 0.05$

*** $p < 0.01$.

The results are shown in Table 4. The coefficient of the interactive variable of distance times research output in the natural science is statistically significant for the share of managers holding an academic degree as well as the number of managers holding an academic degree, but not for the likelihood that a given manager holds an

academic degree. There is no evidence that university spillovers in the social sciences influence the selection of managers in terms of human capital, regardless of geographic proximity.

As the positive and statistically significant coefficient of firm size suggests for all three dependent variables, having managers with a higher level of human capital increases along with the size of the firm. This is consistent with the Jovanovic (1982) model of learning and evolution, which suggests that the primary function of new ventures is to learn whether the underlying idea upon which the firm is founded is viable and compatible with the market, and only subsequently will it become a larger firm and need to absorb external knowledge spillovers.

The statistical significance of only the science-based and high-technology industries again support the findings of Audretsch and Stephan (1999) that possessing the qualifications to access and absorb external knowledge is more important in contexts with a greater prevalence of tacit knowledge. In contrast to other industries such as E-Commerce, Software, Services, or Media & Entertainment, science-based industries such as Biotechnology and Medical Technology require a greater level of academic training to access and absorb external knowledge.

5 Conclusions

A growing literature has established that the potential access to external knowledge spillovers influences entrepreneurial location, which in turn influences the entrepreneurial competitive advantage. External knowledge spillovers can be accessed by

close geographic proximity to a knowledge source through the locational choice of a new venture.

The results of this paper suggest, however, that it does not suffice to provide only entrepreneurial access to knowledge spillovers through geographic proximity to knowledge sources, but that external knowledge spillovers also need to be accessed and absorbed. In particular, this paper has identified two factors facilitating the access and absorption of external knowledge spillovers – a spillover conduit, such as a board director or manager, and close geographic proximity.

These findings not only suggest that the composition of boards is endogenous to the relative importance of absorbing external knowledge spillovers for the entrepreneurial firm, but also that the composition of boards may be influenced by factors other than controlling managers to reduce agency problems. The evidence in this paper suggests that board directors and managers can also play an important role by facilitating the access to and absorption of external knowledge spillover, thus enhancing the competitive advantage of entrepreneurial firms. However, to facilitate the entrepreneurial access and absorption of such external knowledge spillovers, not only must the new venture be in the right place, it must also have the right board composition.

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