

# Outside Directors on the Board and Innovation Activity

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## Abstract

We investigate empirically how outside directors on supervisory boards influence innovative performance of the firms they monitor. Based on panel data of the largest German companies the econometric analysis shows a robust and significantly positive correlation between external executives and innovative firm performance, measured by patent applications. Differentiating between outside directors from innovative and non-innovative companies reveals opposing effects. Solely outside directors from patenting firms seem to enhance innovative activities at the firms they monitor, while outside directors from non-innovative firms are associated with a reduction in patenting. The results indicate that outside board memberships serve as a channel for scarce specific knowledge if two innovating firms become linked.

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## **1. Introduction**

Innovation is recognized by scholars and policy makers as one of the most important determinants of long-term economic performance (see e.g. Stiglitz 1969, Griliches 1980, Schankerman 1981, Griliches and Lichtenberg 1984, Hall and Mairesse 1995). Starting already with Knight and Schumpeter at the beginning of the 20<sup>th</sup> century the literature on innovation has often highlighted the role of the entrepreneur. Although the existing findings are certainly still valid for owner-led firms, they are probably not applicable to the vast majority of large modern companies that are led by a team of managers instead. Manager-led firms entail a classic principal-agent problem, introduced by Berle and Means (1932), Baumol (1962), Marris (1963, 1964) and Williamson (1964). As managers do not bear the full costs of their decisions, they presumably deviate from the value maximizing behavior to enhance their private benefits of control. Bebchuk and Fried (2003, 2004) point out that the manager-owner conflict is still predominant in large modern companies.

As switching to an owner-led firm is usually not an option for large companies, and size and complexity often demands a team of managers, the composition of the board of directors has a central role in corporate governance. In general, the literature strongly supports the importance of certain board characteristics for corporate governance (see for an overview e.g. Adams et al. 2010 and Bebchuk et al. 2009). Among other aspects, great emphasis has been put on outside directors on the board. Several studies analyze how outside directors on boards influence variables such as corporate profitability, growth, CEO turnover, and remuneration. However, the relationship between outside directors and innovative firm activity as a key proxy for long run economic performance has been neglected so far.

Theoretical predictions and empirical findings on the influence of outside directors on corporate performance in general are still ambiguous. Concerning CEO directors Fahlenbrach et al. (2010a) point out, for instance, that external board mandates benefit the respective CEOs personally but not the firms they monitor, while Fich (2005) reports positive abnormal returns

on the announcement of new CEO director appointments. These findings are consistent with the different impressions of corporate networks via personal linkages of board members which can be assessed either as channels for scarce specific knowledge or signs for director entrenchment.

The present study sheds new light on this topic by analyzing the influence of outside directors on innovative firm activity. Thereby we enhance the existing knowledge on firm innovation as well as corporate governance.

Drawing on a sample of large German companies covering the period from 2000 to 2008 our analysis reveals that external managers on the board have an economically meaningful and statistically significant positive influence on the growth of patent applications, especially if the outside executive's home companies engage in innovative activity themselves. This result even holds after accounting for a variety of control variables, unobserved firm heterogeneity, and state dependence in innovative activity. Our results indicate that external managers transfer specific knowledge, skills and experience to the board. They may also improve monitoring and advising competences in terms of qualified and sustainable R&D investment strategies that lead in turn to a higher innovation output. However, executives from companies that do not engage in innovative activity - measured by patent applications - seem to have a negative effect on the innovation performance of the appointing firm. Apparently, different groups of directors vary in their expertise and influence on the firms they monitor.

The rest of the paper is organized as follows. In section 2 we briefly summarize the literature related to outside directors on the board and innovation and discuss the theoretical background in more detail. Section 3 deals with the compilation of the data set and presents a descriptive analysis of the variables used in the study. In section 4 we empirically analyze the relationship between outside directorships and the number of patent applications. Section 5 reviews the main findings and draws conclusions.

## **2. Related Literature**

### **2.1. Theoretical background**

The manager-owner conflict has received much attention in the corporate governance literature. It stems from the basic insight that managers have incentives and, due to asymmetric information, the possibility to carry out projects that are not necessarily in line with the shareholder's interests. In order to restrict the discretionary behavior of managers the shareholders of large modern companies assign a team of monitoring directors. Consequently, a vast and rapidly growing number of both theoretical and empirical studies analyze, how boards lessen or, in some instances, increase the manager-owner conflict. One of the most often analyzed board characteristic in this context is simultaneous external directorships of the monitoring board members.

Theoretically board members with outside board memberships could affect corporate outcomes either positively or negatively. The literature has derived several arguments towards both perceptions.

For a positive influence of external monitoring managers on corporate governance it is argued that external managers are more independent than their counterparts from inside the company, because their personal future career does not depend on the professional advancement of their board colleagues so much. Moreover, external managers may provide firsthand knowledge, expertise and scarce information to the appointing firm which cannot be acquired from sole insiders. Finally, according to Fama and Jensen (1983) multiple board mandates are a normal outcome of the market for top-managers where the best skilled managers are appointed to the most boards. Hence, external directorships should be assessed as a sign for outstanding managerial expertise.

In contrast to this view other researchers have outlined opposing arguments explaining why outside board members probably weaken corporate performance. First of all, outsiders

are less informed about internal process and operating performance. Facing this lack of information they are less able to evaluate the value of the executive's actions for the company. According to Hermalin and Weisbach (1998) CEOs try to influence appointments of new board members in their favor, resulting in appointments of buddies of the CEO who subsequently monitor the managers less intensively. Moreover, Conyon and Read (2006) argue that managers have incentives to accept more board mandates than would be value maximizing for the appointing companies because of prestige, extra salaries and power that come along with each additional mandate. This results in so called "busy" directors, who serve on too many boards from a shareholder's perspective.

Regardless which explanation actually holds, the relationship between outside board members and the allocation of firm resources toward innovative activities has been completely neglected so far. Zwiebel (1995) and Aghion et al. (1997) suggest that manager-led firms are less innovative than the owner-led firms but do not consider confounding effects of different kinds of monitoring directors on this relationship. While the expertise and specific knowledge argument point toward a positive relationship, the arguments toward a negative impact of outside board members on corporate performance can also be easily transferred to innovative activities. Thus, we do not formulate explicit hypothesis.

## **2.2. Previous Empirical Findings**

The existing empirical literature on outside board members may help to discriminate between both opposing theoretical predictions. Researchers in the field of corporate governance generally utilize stock-market performance, market reactions following outside director appointments, and accounting based performance measures to examine how outside directors on the board affect corporate performance. Further variables like executive remuneration, duration and turnover are used to assess the monitoring efficiency of the board.

Recently, Fahlenbrach et al. (2010a) focus on external CEOs serving as monitoring

directors on the board. They find positive stock-price reactions honoring initial CEO outside director appointments compared to non-CEO director appointments. However, they find no statistical significant relation between the presence of outside CEOs on the board and operating performance or other measures of corporate governance like CEO compensation and turnover or an influence on merger & acquisition success. The authors reason that CEO directors face high opportunity costs due to their day-to-day business in their home company. Indeed, CEO directors seem to choose outside board positions in companies that maximize their private benefits. Fahlenbrach et al. (2010b) support this view in an additional study by showing that outside directors are likely to leave the board prior to a decline in performance or shareholder lawsuits. In line with this perception Fich and Shivdasani (2006) shows that companies with a majority of so called “busy” directors on the board - defined as directors with at least three simultaneous external board mandates - face lower market-to-book ratios, lower operating performance and a reduced sensitivity between forced CEO turnover and performance.

In contrast, Ferris et al. (2003) argue that experienced outside directors on the board reflect more intensive monitoring and an increased reputation of controlling quality. They find positive stock-market reactions to appointments of outside directors (see also Fich 2005).

A number of empirical findings reveal both costs and benefits for the appointing companies taking into account different groups of outside board members. Some studies, for instance, suggest that representatives from financial institutions on the board are associated with higher firm debt and funding and are therefore considered to act rather in the interest of the sending financial institution than in the interest of the appointing company’s shareholders (Dittmann et al. 2010, Güner et al. 2008, Booth and Deli 1999). Masulis and Mobbs (2009) focus on the effects of non-CEO inside directors on the monitoring efficiency in the home company. Inside directors who simultaneously hold outside board positions exhibit higher operating and stock-market based performance values compared to inside directors that are

not associated with other companies. The authors argue that outside directorships help to reduce agency costs (similar Mobbs 2009). They also emphasize the importance of specific knowledge provided by outsiders, showing that the effect of independent inside directors is more positive in complex firms and firms with high growth opportunities.

Other empirical studies investigate the relevance of social networks between corporate board members. Hwang and Kim (2009), Fracassi and Tate (2008) and Larcker et al. (2005) find evidence that board-internal and -external social ties could have a negative influence on corporate governance structures. Cohen et al. (2008) emphasize the exchange of information between investors and board members who are members of shared social networks. Consistently Schonlau and Singh (2009) find that companies whose board members have a larger number of contacts to other boards in the firm network gain access to specific information. Consequently they make more successful acquisitions.

Summing up, the existing empirical studies find support for positive as well as negative effects on different corporate outcome variables.

One of the main advantages of focusing on innovative activities instead of financial measures of firm performance is that decisions for a higher degree of innovation is strongly correlated with growth strategies, probably at the cost of short-term maximization of return on capital (Czarnitzki and Kraft 2009). Innovation driven technological progress is an important factor for corporate growth opportunities and defends a sustained competitive position of a company. Long-term economic growth and competitive advantages are hard to measure with market-based or accounting variables that are otherwise often used in the corporate governance literature.

A limited number of empirical studies address the link between innovation and corporate governance in the first place. Studies concerned with the relation of corporate governance and innovation almost invariably focus on the role of firm or external ownership characteristics while neglecting the attributes of boards involved in allocating corporate

resources.

Czarnitzki and Kraft (2004a) argue that on the one hand, the risk of management dismissal could lead to reduced investment in innovation activities. On the other hand, higher R&D spending could also be the result of individual incentives for executives since director remuneration is rather related to size than to firm profitability. Based on a sample of German firms, the authors find evidence that in the absence of a large shareholder, manager-led companies exhibit higher R&D investment than owner-led companies. Similar, comparing companies in different countries, Czarnitzki and Kraft (2004b) report that manager-led companies have a higher share of product innovations. Further, Czarnitzki and Kraft (2009) provide evidence that patent applications increase with the proportion of widely held shares for German manufacturing firms.

Baysinger et al. (1991) were probably the first to analyze the relationship between certain board features and innovation. Based on a sample of 176 Fortune 500 firms they provide evidence on a positive effect of the fraction of inside directors on the board on R&D spending per employee. Kor (2006) analyzes the effects of top management team and board compositions on R&D investment strategy relying on a sample of technology-intensive firms that completed an initial public offering. According to her results, firms opt for lower levels of R&D investment intensity when an outsider-rich board interacts with a team of managers who have high levels of (1) firm tenure, (2) shared team-specific experience, or (3) functional heterogeneity. To the best of our knowledge, there is no study that deals with the effects of outside directors on innovation output. Our paper aims to fill this gap. We further contribute to the existing literature by differentiating between the effects of outside directors from innovative and non-innovative companies.

### **3. Data Compilation and Descriptive Statistics**

The empirical analysis is based on a sample of the largest German companies in the



period from 2000 to 2008, identified by the German Monopolies Commission, a government consultancy in competition economics. Corporate domestic value added serves as the selection criteria. This concept accounts for the fact that German companies are less capital market oriented than Anglo-Saxon countries, where empirical firm-level studies are often restricted to publicly quoted companies. The 100 largest companies of Germany are responsible for about 17% of the total value added of the economy per year, which illustrates the economic impact of the covered companies.

Table I specifies the variables and reports the data sources. We obtained accounting data from the database “AMADEUS” of Bureau van Dijk and shareholder information from the Hoppenstedt “Konzernstrukturdatenbank” and the Hoppenstedt “Companies & Sectors” database. We analyzed annual company reports and additional press releases to identify all management and supervisory board members of the identified companies.

We measure innovative activity by patent applications. Patent applications are a direct measure of the innovation activity compared to R&D expenditure, which is often used as a proxy for innovation at the firm-level, since patents represent the output and therefore the success of R&D activities. Data on patent applications is taken from the PATSTAT database, which has been developed by the European Patent Office and the OECD. We extract patent applications for the years 1978-2008 for all the companies in our sample. The data on patent applications are merged with the other firm-level data sets using a computer supported search algorithm based on the firms’ names, addresses and zip codes. Every match was checked manually to ensure a high data quality. We also extracted data on subsidiaries for each company from the AMADEUS database to obtain a consolidated count of patent applications.

*[Insert table I here]*

We adjusted the dataset by removing financial-companies and foreign-owned companies. The final panel consists of 411 firm-year observations from 73 companies during the period from 2000 to 2008. Pooled descriptive statistics of the variables at the firm-level are presented in table II.

*[Insert table II here]*

The number of annual patent applications among the companies in the sample ranges from 0 to 2,815 applications per year. On average, the companies file 151 patents per annum. Figure I illustrates the trend during the sample period. The average number of patent applications steadily increased from about 117 in 1996 to 199 in the year 2006. Until the year 2008 their number fell to 139. Over all the data reflects the broad trend of rising patent applications in developed economies in the last decade (see Harhoff and Wagner 2009).

*[Insert figure I here]*

The pre sample stock of patent applications measures the number of patents that the respective companies applied until the year 2000. On average, companies held a stock of 830 applications at the end of the year 2000, while the median stock is 4.

We use return on assets (ROA) to control for firm performance in our regression framework as better performing firms have probably more financial resources to conduct R&D. Actual data on R&D expenditures are not available as it is not mandatory in Germany to publish this information. The average return on assets amounts to 3.7 percent.

Larger companies are usually more innovative in terms of patent application. Therefore we include the logarithm of total assets in our regressions. Total assets range from 939 million EUR to 235,000 million EUR. We further control for possible confounding effects of different

ownership concentrations by the fraction of free floating shares. On average we observe 31.1 percent of dispersed shares which reflects the small stock market in Germany.

The institutional environment in Germany has some noteworthy features. One of the most important features is the two-tiered board structure, which is mandatory for all large German companies (for a detailed description of the German board system see for instance Gorton and Schmid 2004). This requirement implies a strict personal separation of the management board comprising all top-level executives, who are responsible for the operative leadership of the company and the members of the supervisory board who appoint, monitor and advise the members of the management board. To account for the specific governance structure in Germany, we separately include the number of the members of the management and the supervisory board in our empirical analysis.

Our main explanatory variable is the cumulative number of supervisory board members that simultaneously hold a position in the management board of another company within the sample. Since we excluded banks and insurance companies from our sample, the director linkages exclusively reflect outside managers from non-financial companies. Each supervisory board comprises on average 0.9 outside executive directors. Figure II illustrates that their number slightly decreased at a fairly high level from 1.1 to 0.8 during the years from 2000 to 2008.

Table III reports mean comparison t-tests and Wilcoxon rank-sum tests to assess possible structural differences between companies with at least one outside manager on the board (n=201) and those companies who have no outside executive on their board (n=210). Companies having outside executives on their board tend to be larger, have more free floating shares, have significantly more supervisory board members but less management board members compared to their counterparts. Median comparisons further suggest that the former group of companies is less innovative than the latter but this result is not statistically significant.

[Insert table III here]

In order to uncover possible positive effects of specific information, expertise or knowledge of external executives on supervisory boards in a second step, we separated those outside managers on supervisory boards who are active in companies with at least one patent application. On average, 77.6 percent of all outside executives come from innovative companies. Interestingly, figure II shows that the proportion of outside executives from innovative companies in all outside executives declined from 86.5 to 77.5 percent during the sample period.

[Insert figure II here]

#### 4. Empirical Framework

Our empirical model of innovative activity has to account for several problems. First, the outcome variable - the number of patent application - is a non-negative integer variable. Further, it is likely that unobserved firm heterogeneity - like managerial ability or technological and product characteristics - are correlated with both the composition of the board and innovative activity. Finally, we want to account for lagged values of patent application to account for state dependence in innovative performance. Hence, strict exogeneity of the regressors is violated by definition. It is also well possible that there is feedback from innovative activity to future values of outside board membership and other variables like profitability and firm size.

The empirical relationship has the form:

$$P_{it} = F(P_{i,t-1}, EM_{i,t-1}, X_{i,t-1}, \alpha_i)$$

$P_{it}$  denotes the number of patent applications in firm  $i$  at year  $t$ .  $EM$  denotes the number of external managers on the supervisory board,  $X$  denotes a vector of control variables and  $\alpha_i$  accounts for unobserved time invariant firm heterogeneity. All explanatory variables are lagged by one period to allow for a time lag between changes in the composition of the supervisory board and other variables on innovative activity. The use of lagged values also reduces simultaneity problems. We use the logarithm of the stock of previous patent applications and of total assets in the reported models. Further, time and industry dummies enter all estimations to control for macroeconomic shocks and industry characteristics.<sup>1</sup> To address the above mentioned econometric problems we estimate count data models for panel data. Several alternative estimation procedures are applied. The first procedure is an exponential feedback model takes the form:

$$E(P_{it}) = \exp(\rho P_{i,t-1} + \delta EM_{i,t-1} X'_{i,t-1} \beta + \alpha_i).$$

A disadvantage of this model is that it can lead to rapidly exploding series for high values of  $\rho$  (see e.g. Windmeijer 2006). An alternative specification is the linear feedback model proposed by Blundell et al. (2002). This model can be specified as

$$E(P_{it}) = \theta P_{i,t-1} + \exp(\delta EM_{i,t-1} + X'_{i,t-1} \beta + \alpha_i).$$

As argued by Cameron and Trivedi (2005) the exponential feedback model is preferred on predictive performance when the proportion of zeros is high, while the linear feedback model usually outperforms the exponential feedback model when the proportion of zeros is small, but the mean of the dependent variable is high. Following Blundell et al. (1995), Blundell et al. (2002) we relax the assumption of strict exogeneity and account for unobserved time invariant firm heterogeneity by using the pre sample patent stock as a proxy for  $\alpha_i$ .<sup>2</sup> Our

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<sup>1</sup> As we observe only about 55 companies per year, we distinguish between three broad sectors, namely manufacturing, service and trade.

<sup>2</sup> This requires, for instance, that the first moments of the variables are stationary (see e.g. Blundell et al. for a

baseline for the exponential feedback model is a Poisson regression estimated by maximum likelihood techniques. The linear feedback model is estimated by generalized method of moments (GMM). We use robust standard errors to account for possible heteroscedasticity, over-dispersion, and auto correlated errors at the firm-level. Note that consistency only requires a correct specification of the conditional mean and is not affected by violation of distributional assumptions of the Poisson model. Nonetheless, we check the robustness of our results to using alternative models like a negative binomial regression.

#### **4.1. Regression Results**

Table IV reports the results from Poisson estimations for different model specifications. Specifications (a) and (c) show the results from regressing the number of patent applications on the number of external managers. Specification (b) and (d) split the variable external managers into external managers from innovative and non-innovative companies. Specifications (c) and (d) include the logarithm of the patent stock to control for unobserved time invariant firm heterogeneity. All interpretations below refer to these models.

*[Insert table IV here]*

We find a highly significant positive relationship (p-value <0.01) between outside managers on the supervisory board and patent applications in all models. On average each additional outside executive on the supervisory board is associated with an increase in the number of patent applications by about 11% (model c). As R&D expenditure are a measure for innovation input while patents measure innovation output it is likely that a time lag exists between patent applications and R&D investment (for the delay between product development

and introduction see Ravenscraft and Scherer 1982). To address this objection, we alternatively allowed for a time lag of two and three year between the explanatory variables and the number of patent applications which leads to comparable results (not reported).

In specifications (b) and (d) we split the number of outside managers on the supervisory board in two groups, first managers from innovative companies and second managers from companies without patent activity. Indeed, we find significant but opposing influences of both groups of outside directors. Apparently, managers from companies that apply patents significantly increase the number of patent applications of the receiving company. In contrast, outside managers from those companies that are not experienced in patenting have a significant negative effect on the innovation activity. Hence, the positive correlation between external managers and innovative firm activity in model (c) is basically driven by outside directors who are active managers of innovative firms themselves.<sup>3</sup> This result supports the perception that specific managerial skills and experience of directors on the board matter for corporate governance. Moreover it seems that multiple board memberships alleviate the allocation of scarce human resources to different firms. Consequently, personal corporate networks of the top-management may help to reach the socially desirable level of innovations in an economy.

A caveat of our study is that our results might be driven by the fact that unobservables affecting innovation might also affect the decision to employ outside directors in the supervisory board. In this case our estimation results would not reflect causal effects. However, our results hold conditional on a variety of control variables including past patenting activity. Accounting for time invariant unobserved firm heterogeneity we also find that *within-firm variation* in outside board membership is correlated with *within-firm variation* in patenting activity. Further, our empirical framework allows for feedback from

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<sup>3</sup> Estimating a linear instead of an exponential feedback model confirms the positive association between outside directors from innovative firms and patent applications, while the correlation between outside directors from non innovative firms and patent applications remains negative but becomes insignificant.

past innovation to future values of outside board membership.<sup>4</sup>

Regarding the control variables ROA is significantly correlated with innovative activity. Higher previous performance increases the output of patent applications. The finding is consistent with the suggestion that higher earnings enable companies to invest in R&D projects more successfully. A similar relationship is observed for the logarithm of total assets. In line with the results of Czarnitzki and Kraft (2009) who control for the influence of the number of employees, we find that larger companies apply more patents. Neither the size of the management board nor the size of the supervisory board influence patenting significantly.

## **5. Concluding Remarks**

In contrast to the classic entrepreneurial firm, large modern companies are usually led by managers who are controlled and advised by a team of monitoring directors. So far, it is largely unknown how certain board characteristics affect innovative firm activities, although a vast and rapidly growing literature in the field of corporate governance proves features like outside directors on boards to influence various corporate outcome variables. The present analysis provides new insights on this topic by investigating the relationship between outside board mandates and patent applications for the first time.

Our econometric analysis reveals that external managers on supervisory boards are associated with enhanced innovative firm performance measured by the number of patent applications of the appointing company. We interpret these finding as evidence that external managers provide expertise and scarce managerial skills for innovation management to the board. This additional monitoring and advising competence helps companies to generate a higher number of innovations, observable by a higher number of filed patents.

The empirical analysis shows that not all outside directors benefit the companies they monitor, at least in terms of innovation output. In order to control for specific experiences and

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<sup>4</sup> Nonetheless, it is still possible that time varying unobservables are correlated with both changes in innovative activity and changes in external managers on the supervisory board. To check whether this drives our results instrumental variable techniques will be applied in future work on this project.



knowledge of outside executives on the board, we separately examine executives from innovative companies and executives from companies without innovative activity. Apparently, the advising and monitoring quality of outside directors is higher when they simultaneously deal with patent applications at their home company as well. Those outside directors who come from non-innovative companies even seem to negatively influence innovations at the companies they monitor.

In terms of policy recommendations our results suggest that corporate networks via multiple board memberships may be an efficient mechanism of scarce specific knowledge allocation. Concerning innovations top-management networks may help to reach the socially desirable level of innovative activity in an economy.

## Appendix

Table I *Definitions and Sources of Variables Used in the Study*

Variable	Description	Source
Patent Applications	Number of patent applications in the current year	Patstat
Stock Patent Applications	Cumulated number of patent applications up to year t (discount factor 15%)	Patstat
Return on Assets	$(\text{net income after taxes} / \text{total assets}) \cdot 100$	Bureau van Dijk: "AMADEUS" database
Total Assets	Total assets (Mio. EUR)	Bureau van Dijk: "AMADEUS" database
Free Float	Fraction of widely held shares	Hoppenstedt: "Companies & Sectors", "Konzernstrukturdatenbank"
SB Members	Number of supervisors on the supervisory board	Annual Reports
MB Members	Number of executives on the executive committee	Annual Reports
External Managers on the SB	Cumulative outside management board positions of the supervisory board members	Annual Reports, Monopolies Commission
... from Companies with Patent Applications	Cumulative outside management board positions of the supervisory board members in companies with at least one own patent application	Annual Reports, Monopolies Commission, Patstat
... from Companies without Patent Applications	Cumulative outside management board positions of the supervisory board members in companies without own patent applications	Annual Reports, Monopolies Commission, Patstat

*Table II Summary Statistics on Company Level*

Variable	Obs.	Min	Mean	Median	Max	Std. Dev.
Patent Applications	411	0	151.07	6	2,815	392.66
Stock Patent Applications	411	0	829.73	4	18,138	3,046.61
Return on Investment	411	-19.32	3.73	3.20	21.64	4.12
Total Assets	411	939	28,900	8,915	235,000	44,900
Free Float	411	0	31.08	22.14	97	33.37
SB Members	411	3	16.85	19	24	4.09
MB Members	411	1	6.30	6	26	3.66
External Managers on the SB	411	0	0.88	0	8	1.37
... from Companies with Patent Applications	411	0	0.68	0	7	1.16
... from Companies without Patent Applications	411	0	0.20	0	6	0.57

*Table III Mean and Median Comparisons*

Variable	SB without External Managers	SB with External Managers	Mean comparison t- test (t-value)	Wilcoxon rank-sum test (z-value)
Patent Applications	179.38	121.48	1.52	-3.32***
Stock Patent Applications	947.97	706.20	0.81	-3.39***
Return on Assets	3.55	3.91	-0.88	-1.29
Total Assets	24,000	34,100	-2.29**	-5.56***
Free Float	19.84	42.83	-7.41***	-7.29***
SB Members	15.95	17.80	-4.72***	-5.22***
MB Members	6.84	5.74	3.15***	0.07
No. Observations	210	201		

*Table IV Estimations of the Effect of Outside Executives on the Number of Patent Applications*

*Notes:* The table reports the results from poisson regressions with robust standard errors. The dependent variable is the number of patent applications. The explanatory variables are lagged by one period. All models include industry and year dummies. Coefficients: \*\*\* Significant at 1%, \*\* Significant at 5%, \* Significant at 10% level. t-statistics reported in parentheses.

	(a)	(b)	(c)	(d)
Constant	-3.276*** (-3.08)	-3.251*** (-3.12)	-2.533** (-2.21)	-2.514** (-2.26)
Lagged Patent Applications	0.001*** (8.94)	0.001*** (8.98)	0.001*** (8.76)	0.001*** (8.82)
Pre Sample Patent Stock			0.094** (2.18)	0.097** (2.27)
Return on Assets	12.092*** (5.78)	11.427*** (5.29)	11.880*** (5.80)	11.210*** (5.29)
Log Total Assets	0.369*** (6.23)	0.373*** (6.30)	0.324*** (5.00)	0.329*** (5.19)
Free Float	-0.002 (-1.14)	-0.003 (-1.27)	-0.004* (-1.86)	-0.005** (-1.99)
SB Members	0.009 (0.40)	0.009 (0.40)	0.007 (0.31)	0.007 (0.30)
MB Members	0.042 (0.97)	0.044 (1.05)	0.032 (0.73)	0.033 (0.77)
External Managers on the SB	0.114*** (2.81)		0.110*** (2.58)	
... from Companies with Patent Applications		0.163*** (3.81)		0.159*** (3.57)
... from Companies without Patent Applications		-0.258* (-1.76)		-0.272* (-1.91)
Observations	411	411	411	411
Pseudo R <sup>2</sup>	0.746	0.753	0.750	0.757

Figure I Average Number of Patent Applications in the Period 2001 to 2008

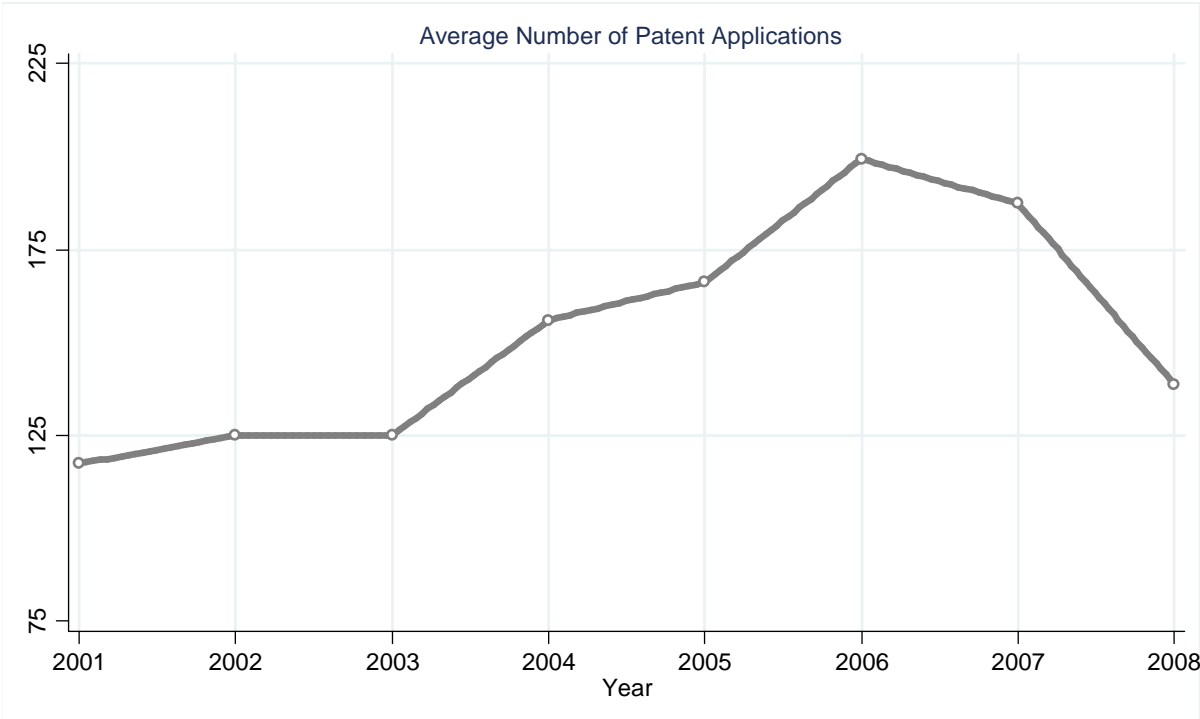
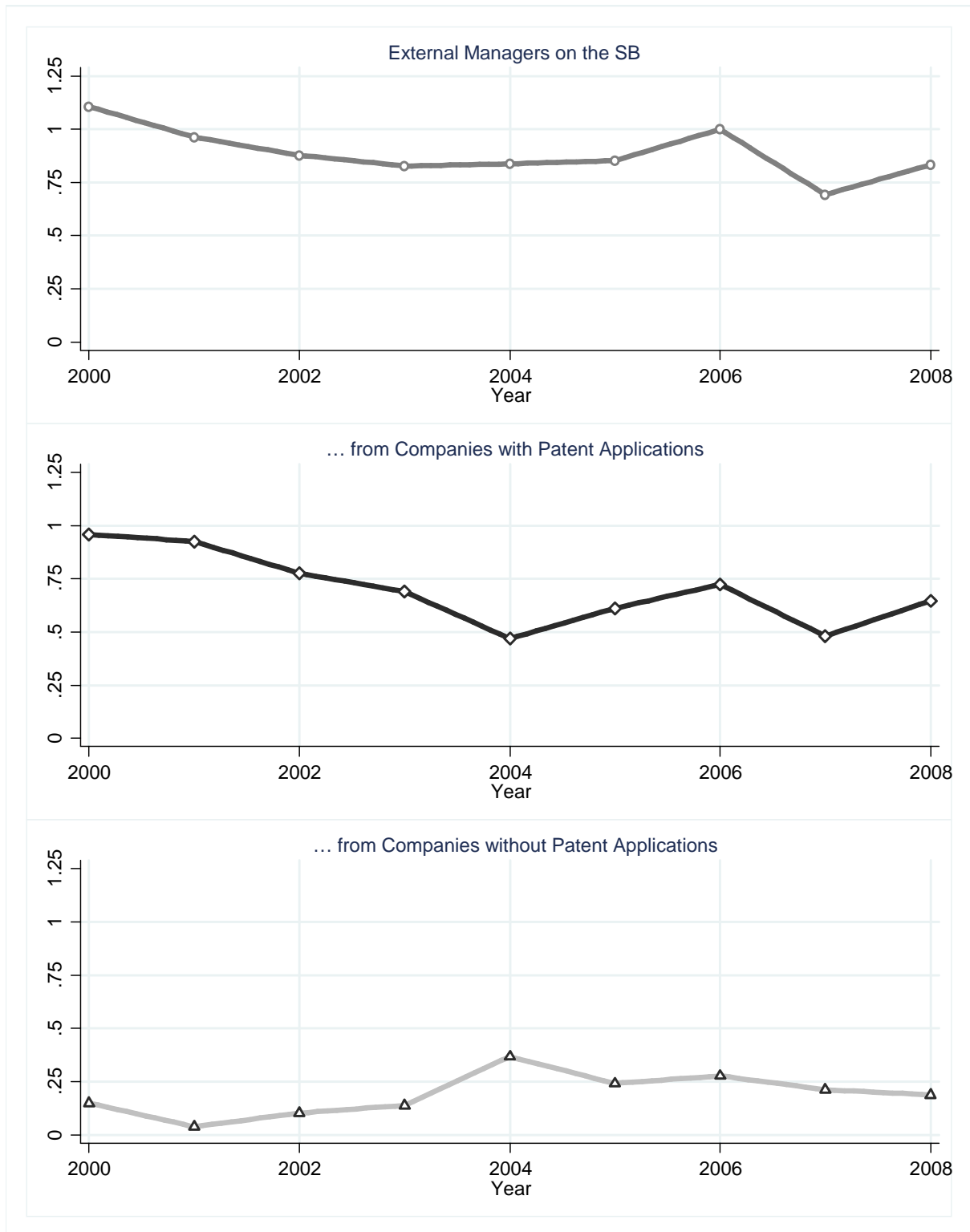


Figure II External Managers on the Supervisory Board between 2000 and 2008



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