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# Outside Board Directors and Start-Up Firms' Innovation

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# Outside Board Directors and Start-Up Firms' Innovation

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**Abstract**

We exploit increased access to detailed employer-employee data to assess whether outside board members affect innovation performance among start-up firms. Using data for all new limited companies in Sweden born during 1999–2013 which have no more then 10 employees when formed, we provide structural equation estimates that deal with the endogenous selection of board directors. Our empirical findings show that an increase in the board's expertise, measured by the relative productivity of the firms where outsiders are employed, has a significant and positive impact on the new firm's propensity to apply for both patents and trademarks.

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**Keywords:** Start-ups, outside directors, innovation, patents, trademarks, productivity, endogeneity.

**JEL classification:** D24, O33

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# 1 Introduction

Two issues that have become prominent in the political debate in recent years in almost all OECD countries are innovation and entrepreneurship, motivated by unemployment, slow growth and technical opportunities. In particular, innovative start-ups have been seen as an important economic generator.

Economic theory provides some guidelines regarding how new ventures affect the economy, with the literature focusing on both renewal and viability. The endogenous Schumpeterian growth theory predicts that the long-run rate of growth should be positively correlated with the flow of new firms that replace obsolete incumbents (Howitt & Aghion 1998), commonly described as creative destruction. Jovanovic (1982) represents an early attempt to formally model the post-entry evolution of new entrants. His selection model shows that only efficient firms are likely to survive and grow.

As most start-ups fail (Colombelli et al. 2016), there is a growing awareness of the importance of conditions for viable entrants rather than new firms in general. Recent research has documented a number of regularities regarding prerequisites for successful new entrepreneurship. Acs et al. (2007) find that the conditions for survival, productivity and growth of newborn firms vary with location attributes. They might be correlated with particular industry factors such as knowledge and technology intensity (Brixy & Grotz 2007), industry clusters (Saxenian 1994), and a variety of firm-specific factors such as close attachment to a previous employer, financial sources, managerial capacity and human capital. The primary motivation to start a new venture has also been found to be a predictor of post-entry performance (Vivarelli & Audretsch 1998, Arrighetti & Vivarelli 1999). A main distinction is made between pull and push factors such as new innovative ideas and escaping from unemployment (Pfeiffer & Reize 2000, Andersson Joona et al. 2006, Andersson & Klepper 2013).

Prior research suggests that it is difficult for new entrants to create, maintain and

improve capabilities and strategies for innovation processes without sufficient external support (Dalziel et al. 2011, Jones et al. 2011), the board performs three major roles in a firm. First, it sets the strategic direction of the firm, second, it monitors management, and third, it provides support and advice to the firm. A large literature reports that effectiveness of the board depends on a variety of factors, including its composition, constitution, diversity and the competencies of the members. There is also growing evidence that boards in start-ups have a somewhat different role than boards in established companies, as the agency problem is less relevant to most startups. In recent years, board composition has changed in most industrialized countries and extensive research has studied the impact of an increased proportion of outside directors. The challenges in these studies are to quantify board members' expertise and test whether a change in expertise of the board through increased outsiders has a causal impact on various measures on firm value.

This paper is a first attempt to investigate the relationship between outside board members and innovation activities with a focus on start-up firms. It exploits the opportunities provided by the information in linked employer-employee data to assess whether a firm with board members from firms with high productivity is more likely to apply for patents or trademarks. We study the influence of outside board members on innovation performance among all the 50,786 newly formed limited companies in Sweden over the period 2001–2015 with no more than 10 employees when formed.

A main empirical problem in our analysis is endogeneity, as outside directors with a particular expertise are not randomly assigned to start-up firms but may be endogenously selected by factors directly related to the firm's initial innovative capabilities. Ignoring this non-random assignment would result in biased estimates and incorrect conclusions about the importance of outside directors. A second challenge is how to observe the expertise of the external board members. While prior studies have con-

sidered their individual demographic characteristics, we focus on the characteristics of the firm in which the outside director is employed. We then calculate an outside board productivity (OBP) measure using information from both the firm where the director is employed and from all other firms in the same sector.

Our first specification, a nonlinear probit model, finds no impact of the OBP measure on start-ups' innovation as quantified by patent and trademark applications. We then estimate a structural model where the outsider productivity is instrumented by using information on exogenous changes of the outside directors' employment in order to account for omitted factors and measurement errors. With this model, we find a causal effect, showing that an increase in board productivity has a significant and positive impact on the new firm's propensity to apply for both patents and trademarks.

The rest of this paper is organized as follows. Section 2 reviews the literature. Section 3 introduces the data and explains how the OBP and the instrumental variables are constructed. Section 4 discusses the empirical strategy. Section 5 reports evidence on the link between outside director productivity and firm performance. Section 6 concludes and discusses implications.

# 2 Review of the literature

While most of the previous literature on the role of board of directors has been focused on large publicly listed firms and the agency problem, more recent research studies increasingly consider both small entrepreneurial firms and innovation. The literature on the importance of the board of directors in innovative start-ups is, however, still scarce. Some of the explanations for this shortcoming are the limited availability of data and the difficulty of observing innovative processes in start-up companies.

In accordance with the corporate governance literature on the resource dependency

theory, Zahra & Filatotchev (2004) and Zhang et al. (2011) show that in practice boards of young firms act as extensions to the top management teams rather then monitoring the firm. One way for young firms unable to employ full-time professional managers is to engage part time non-executive directors to the board who may possess more experience and specific knowledge than the founders of the firm (Zhang et al. 2011). Appointing well-educated and experienced directors with broad business networks is one strategy of small and young firms to gather human and social capital resources to supplement the founders' and employees' expertise. Knowledge about the firm is the main expertise of inside directors.

A growing body of corporate governance research argues that the expertise of outside directors in terms of finance (DeFond et al. 2005), business knowledge (Fich 2005) and management (Yermack 2006) are more important than their share of board memberships. This might be even more relevant for new entrants, as they often operate in a different environment than large established firms. New entrepreneurship is often characterized by great uncertainty and have severe resource constraints.

Challenging and overlapping issues in all these studies are how to quantify board members' expertise and how to test whether a change in expertise of the board has a causal impact on various measures on firm value. The first problem is related to how the expertise or competence of the board members can be observed. Some papers consider the share of outside directors not only as a measure of independence of the board but also as a reflection of social network ties between internal and and external factors (Carpenter & Westphal 2001). Other studies proxy director expertise terms of formal financial, corporate and academic knowledge (Duchin et al. 2010). The literature reports mixed results on the importance of board members applying both these categories of indicators (Garg 2013).

The other problem when assessing the impact of board of directs is endogeneity. Hermalin & Weisbach (2001) and Adams et al. (2010) argue that all the variables of interest when analyzing the importance of board members typically are endogenous.

For instance, the particular strategy of a firm tends to influence the choice of outside board members. It is therefore uncertain whether the results should be interpreted in terms of correlation or causality. Empirically it has been found difficult to to find evidence that outside directors matter for firm performance (Duchin et al. 2010, Bhagat & Black 2002, Fields & Keys 2003). To address the endogeneity problem associated with board performance, the identification strategy in several papers is to apply a reduced form model where exogenous changes in the board are identified in a first-stage regression, and the fitted changes are used in the second stage to explain firm performance: see, for instance, Duchin et al. (2010). The critical issue in this approach is the validity of the instruments.

Analyses of board members' link to innovation are dominated by studies on large firms. For example, Balsmeier et al. (2017) investigate the relationship between the share of outside directors and the firms' innovativeness by distinguishing between outside directors employed in innovative and non-innovative firms. The authors use a panel of 100 large German firms and find that outside directors who manage firms that innovate within the same technological field as the focal firm increase the number of patent applications of the focal firm.

A large fraction of the literature on external resources for spurring innovation in small firms has been examining the importance of financial sources and venture capital (Gompers & Lerner 1998). This literature has identified a close relationship between the strength of intellectual property rights (IPR) and factor such as absolute return on innovation, reduced threat of expropriation from established firms and increased return to cooperation relative to competition (Kortum & Lerner 2001).

Previous literature on new firms and intellectual property rights (IPR) mainly focuses on patents (Blind et al. 2006, De Rassenfosse 2012). Surveying the literature on IPR in small firms, Block et al. (2015) report that several studies use trademarks as proxy for firm's innovation activities. Trademarking seems to have a similar effect as patents on firm value, productivity, and survival. Evidence from the literature

suggests that trademarks are complementary to patents, and that both can be used to support each other to offer more complete protection of intellectual property. Trademark registration has also the advantage that it is relatively inexpensive and non-complex, and may therefore especially suit resource-scarce innovative start-ups. Statistics on IPR applications published by the World Intellectual Property Organization (WIPO) shows that trademarks are the fastest growing IPR. During 2016, trademark applications increased by 9.8 million, compared to 3.1 million for patents, 1.6 million for utility models and 1.2 million for industrial designs.

Overall, the existing literature on the importance of outside board members is not conclusive regarding their effect on firm performance. The importance of outsiders on innovation activities in large firms is conditionally positive, and the relationship between outside directors and innovation performance in start-ups has rarely been discussed.

Beginning with Klepper (2002), a number of microeconomic spin-off studies have shown that start-up viability can be linked to their founders' background and spillovers from incumbent firms. What follows builds further on this research tradition by providing new empirical evidence on outside board members as a link for informational spillovers from successful incumbents to innovative start-ups.

# 3 Data

The firm-level data used in this study were originally constructed from audited register information on firm characteristics based on annual reports on firms in Sweden provided by Statistics Sweden (SCB). All new firms with over ten employees during the first year of operation are dropped to restrict the sample to independent new firms and to avoid capturing the probable effect of outsourcing and mergers and acquisitions. Moreover, new firms with only one employee throughout the sample period are also omitted from the sample. To this data we match patent data from

PATSTAT (EPO) and trademark data from the European Union Intellectual Property Office (EUIPO) as well as data on the boards of directors retrieved from the Swedish Companies Registration Office. The trademark data contains registers of all applications for trademarks that were granted. The trademarks are then valid for 10 years before they must be renewed. As all firms in the sample are observed over a ten year period, each trademark application can be considered unique. We have matched 99% of the patent applications and 100% of the trademark data with Swedish firms.

The sample consists of 15 cohorts of firms that were formed during the period 1999–2013. Each focal firm is then observed for a maximum of ten years and a minimum of three years. While firms formed 1999–2006 are observed ten years or as long as they survive, firms formed in 2013 are only observed during their first three years.

In total, we observe 50,786 start-up firms that remain active for at least three years and exploit employer-employee (EE) data for the years 1988–2014 to trace the background of outside directors and employees of the focal firms. The EE data contain extensive information on all firms in Sweden and their employees.

Table 3.1 presents the variables. The key variable in the analysis is outside board productivity, OBP, which measures the normalized productivity of the firm where the board member is employed. To calculate this measure, we first divide turnover per employee with the median turnover per employee for the focal two-digit industry. We then construct the OBP variable for each new firm by the log of the sum of outside director productivity. The sum of outside director productivity is winsorized at the 1% level in both tails of the distribution.

To mitigate potential endogeneity, we create two instrumental variables. The first, "New employer," is similar to OBP but only considers the log sum of productivity measures of outside directors for those who changed employment between years (t-1) and (t-2), winsorized in the same manner as OBP. The second instrument, "New",

indicates whether any of the outside directors of the focal firm's board were newly hired in a more productive firm in year (t-1) compared to where they were employed in year (t-2).

Table 3.1: Variables

| **Variable** | **Description** |
|---|---|
| $\text{Patent}_t$ | Indicator (0/1): firm applied for any patents in year $t$. |
| $\text{Trademark}_t$ | Indicator (0/1): firm applied for any trademarks in year $t$. |
| $\text{OBP}_{t-1}$ | log(Sum of $\text{Productivity}_{t-1}$) of the firms where the focal firm's outside directors were employed in year (t-1), winsorized. |
| $\text{New employer}_{t-1}$ | log(Sum of $\text{Productivity}_{t-1}$) of the firms where the focal firm's outside directors were newly hired in year (t-1) and were employed elsewhere in year (t-2), winsorized. |
| $\text{New}_{t-1}$ | Indicator (0/1): True if any outside director newly hired in year (t-1) in a more productive firm compared to firm where employed in year (t-2). |
| $\text{Board size}_{t-1}$ | Number of direectors on the focal firm's board. |
| $\text{log(Total assets)}_{t-1}$ | Log of total assets, winsorized. |
| $\text{Human capital}_{t-1}$ | Share of employees with 3 or more years of university education. |
| Metro | Indicator (0/1): focal firm is located in metro area (Stockholm, Gothenburg or Malmö). |
| Firm age | Firm age, 1-10 years. |

Table 3.2 reports the summary statistics for the whole panel of young ventures over the years 2001 to 2015. All dependent variables are observed in year t and the explanatory variables in year t-1. As could be expected, the proportion of new firms considered as innovative according to our definition is small. Only 0.8% of the new entrants apply for at least patent during the years 3–10 after the firm was born. The corresponding figure for trademarks is 0.9%.

We measure the potential knowledge transfer between incumbent firms and the start-up firm through outside members of the board of directors. The measure is constructed from information on the labor productivity of the incumbent firm where the director is employed, normalized by the median for that firm's two-digit industry. We then calculate outside board productivity (OBP) of the focal firm as the log sum of the relative productivity of outside directors. In average, there are two outside

board members in a start-up firm.

The size of the new firms is captured by the log of total assets, and their human capital by the fraction of employees with three years of university education or more. This fraction is 21% at entry, with half of the firms are located in three Swedish metro regions: Stockholm, Gothenburg and Malmö. In the regression analysis, we observe firms between 3–10 years old. Table 3.2 reveals that the distribution is relatively uniform, with the strongest concentration in the 4–5 year range.

# 4 Empirical approach

A substantial complication in the existing empirical studies on boards of directors and firm performance is that they tend to be plagued by the presence of endogeneity. In analyzing the performance of start-ups, it is likely that the owners of the firm knowingly seek "high quality" directors to be appointed to the board by screening characteristics of the potential directors' employers and networks. Without appropriate instruments for mitigating endogeneity, the prior literature fails to find a clear link between external knowledge and firm performance via outside directors.

The identification strategy in this paper is to construct an instrumental variable *New employer* as the log sum of the productivity measures of the employing firms of the directors who have changed their workplace since the previous year. We assume that owners of the focal firms cannot foresee that elected directors will change place of work in the future, so that this variable may be taken as predetermined. Furthermore, we assume that there is some stickiness in the composition of the board, such that current directors are more likely to be candidates and reelected in the following year. Changes in the outside directors' employment could thus be argued to be exogenous to the focal firm. We also construct a second instrument *New*, an indicator variable indicating whether any of the firm's outside directors have not only changed employment, but moved to a more productive firm between years

Table 3.2: Summary statistics

| **Variable** | **Mean** | **Std. Dev.** | **Min.** | **Max.** | **N** |
|---|---|---|---|---|---|
| $\text{Patent}_t$ | 0.004 | 0.064 | 0 | 1 | 343371 |
| $\text{Trademark}_{t-1}$ | 0.003 | 0.055 | 0 | 1 | 343371 |
| $\text{OBP}_{t-1}$ | 1.348 | 0.464 | 0 | 3.618 | 343371 |
| $\text{New employer}_{t-1}$ | 0.169 | 0.43 | 0 | 3.367 | 343371 |
| $\text{New}_{t-1}$ | 0.017 | 0.128 | 0 | 1 | 343371 |
| $\text{Board size}_{t-1}$ | 1.813 | 1.402 | 1 | 26 | 343371 |
| $\text{Log(total assets)}_{t-1}$ | 14.55 | 1.289 | 6.908 | 25.063 | 343371 |
| $\text{Human capital}_{t-1}$ | 0.227 | 0.333 | 0 | 1 | 343371 |
| $\text{Metro}_{t-1}$ | 0.243 | 0.429 | 0 | 1 | 343371 |
| | | | | | |
| *Firm age* | | | | | |
| 3 | 0.145 | 0.352 | 0 | 1 | 343371 |
| 4 | 0.15 | 0.357 | 0 | 1 | 343371 |
| 5 | 0.141 | 0.348 | 0 | 1 | 343371 |
| 6 | 0.133 | 0.339 | 0 | 1 | 343371 |
| 7 | 0.126 | 0.331 | 0 | 1 | 343371 |
| 8 | 0.116 | 0.321 | 0 | 1 | 343371 |
| 9 | 0.102 | 0.303 | 0 | 1 | 343371 |
| 10 | 0.087 | 0.281 | 0 | 1 | 343371 |
| | | | | | |
| *Year* | | | | | |
| 2001 | 0.021 | 0.145 | 0 | 1 | 343371 |
| 2002 | 0.034 | 0.181 | 0 | 1 | 343371 |
| 2003 | 0.047 | 0.211 | 0 | 1 | 343371 |
| 2004 | 0.059 | 0.235 | 0 | 1 | 343371 |
| 2005 | 0.071 | 0.256 | 0 | 1 | 343371 |
| 2006 | 0.082 | 0.274 | 0 | 1 | 343371 |
| 2007 | 0.095 | 0.293 | 0 | 1 | 343371 |
| 2008 | 0.098 | 0.297 | 0 | 1 | 343371 |
| 2009 | 0.098 | 0.298 | 0 | 1 | 343371 |
| 2010 | 0.095 | 0.293 | 0 | 1 | 343371 |
| 2011 | 0.082 | 0.275 | 0 | 1 | 343371 |
| 2012 | 0.071 | 0.257 | 0 | 1 | 343371 |
| 2013 | 0.061 | 0.24 | 0 | 1 | 343371 |
| 2014 | 0.052 | 0.222 | 0 | 1 | 343371 |
| 2015 | 0.033 | 0.18 | 0 | 1 | 343371 |

(t-1) and (t-2). The addition of this instrument allows us to specify an overidentified and testable model.

**Empirical modeling strategy**

Our empirical models analyze the influence of outside directors on firms' propensity to apply for patent and trademark registration, accounting for endogeneity. We estimate the reduced form of a structural equation system to mitigate endogeneity, applying an instrumental variables approach. In the regressions, the variables *New Employer* and *New* is used as instruments for the potentially endogenous measure of outside board productivity, OBP.

The empirical analysis employs a probit model. For firm $i$ in industry $j$ and time $t$, the model is

$$Pr[Y_{it} = 1] = \alpha OBP_{it-1} + X'_{it-1}\beta + \epsilon'_{it}\gamma + t'_t\theta + e_i \tag{1}$$

where $Y_{it}$ is an indicator of whether the focal firm applied for any patent or trademark respectively during year $t$, $OBP_{it-1}$ is the sum of the productivity measures of the firms where the outside directors are employed, $X_{it-1}$ is a vector of firm specific control variables including firm age, total assets, human capital, location and board size, and $\epsilon_{it}$ and $t_t$ denotes industry and year fixed effects respectively.

We employ equation (1) to estimate the new firms' propensity to be innovative, proxied by patent and trademarks respectively.

To handle potential endogeneity we specify a first stage equation that is used in the structural equation (1) as:

$$OBP_{it-1} = X'_{it-1}\pi_0 + \epsilon'_{it}\pi_1 + t'_t\pi_2 + Z'_{it-1}\pi_3 + \mu_i \tag{2}$$

where $Z_{it-1}$ is a vector of the two instrumental variables. The predictions from this first stage equation are used in the instrumental variables probit model of equation

(1), applying the Newey (1987) two-step estimator.

# 5 Results

We estimate an instrumental variable model for the likelihood of application intellectual property protection, adopting a structural equation approach. Year, industry and firm age fixed effects are included in the model. Tables 5.1 and 5.2 provide estimates of the instrumental variables probit model specified by equation (1), using equation (2) as a first stage equation for $OBP_{it-1}$. For comparison, we estimate a probit model assuming OBP to be exogenous. In these tables, column (1) reports the comparison results of the model not accounting for endogeneity, column (2) presents first stage estimates and column (3) presents the second stage estimates of the structural model.

Looking first at the estimates for the patent model in column (1) of Table 5.1, there is no impact of outside directors from productive firms when not accounting for endogeneity. This is in line with our expectation based on previous literature. The controls board size, total assets, human capital and start-ups located in metro regions are all positively associated with patent applications in column (1).

The important result of the first-stage regression in column (2) is that the instrumental variables *New Employment* and *New* are correlated with $OBP_{i,t-1}$, which is a requirement of valid instrumental variables. The coefficient estimates for both instruments are positive and highly significant. The magnitude of estimates for the main instrument *New Employment* is 0.072 while that for *New* is somewhat lower, 0.027.

The third column reports the results from the second stage equation of the IV probit. The estimate on the lagged variable OBP is sizable in magnitude (0.932) and highly significant, suggesting that there is a spillover effect of information from productive incumbents to new firms through their board of directors. Regarding

the controls, the sign of board size switches from positive to negative compared to column (1). Our explanation for this result is that the impact of size is captured by the competence of the board of directors. The estimated effects for other controls in columns (3) are similar to those of column (1). The Wald test, akin to a Hausman test, clearly rejects estimating the model of column (1). The Amemiya–Lee–Newey test statistic reported in the bottom part of Table 5.1 is a test of overidentifying restrictions. On the basis of this test, the instruments' validity cannot be rejected. A comparison of the estimates for patent applications with the less studied trademark measure regarding innovative activities are provided in Table 5.2. The results of both measurements of innovative activities among start-ups show striking similarities, which support previous findings in the literature suggesting that trademarks are complementary to patents for small businesses.

The OBP estimate is positive but non-significant in column (1), both instruments are positive and highly significant in column (2), and the estimated impact of outsiders is significant at the 5% level in column (3) with a point estimate close to 0.7.

Once again, estimation of the model ignoring endogeneity is clearly rejected by the Wald test. Looking at the p-values for the Amemiya-Lee-Newey test, an interesting difference between the two models emerges. Our instruments are valid for the patent application model, but not for the trademark model. Both of the first stage equations are essentially the same but the sample used and the number of included industry dummies differs between the two models. The reason for this is that in certain industries, no patent (trademark) applications are recorded. As there is no variation within these industries in the outcome variable, those industry dummies perfectly predict the outcome, and are omitted from the estimation.

Our estimates indicate that start-ups with outside board directors from successful firm in terms of relative productivity are more likely to apply for patents and trademarks than other start-ups. This suggests that there are other effective ways of spreading knowledge from competitive established companies to new innovative

companies than the spin-out and spin-off processes documented in previous literature.

# 6 Summary discussion

A vigorous policy debate is ongoing in all industrial countries on new firm formation and their impact on jobs and growth. Extensive research shows that only a small proportion of new firms are capable of being a driving force for dynamic development of the economy. To a large extent, these companies are started by entrepreneurs with a focus on innovation. Existing studies document that it often is difficult for start-ups to develop effective innovation capabilities and conceive of innovative strategies without effective guidance and sufficient resources.

This paper is a first attempt to investigate the relationship between outside board directors (OBD) and innovation performance with a focus on start-up firms. Our motivation is that outsiders may have a profound effect on firms' strategy by introducing external expertise which otherwise would difficult to achieve for a new firm. We exploit the opportunities provided by the information in linked employer-employee data to assess whether a firm with OBD from firms with high productivity is more likely to apply for patents or trademarks.

The sample is constituted of firm-level repeated cross-sectional data collected from several sources: employer-employee data based on annual register data is provided by statistics Sweden, we have retrieved board data from the the commercial database SERRANO, patent data is from European Patent Office (PATSTAT) and trademark data from European Intellectual Protection Office. Our paper observes a total of 15 cohorts corresponding to about 50,000 start-ups which have no more then 10 employees when formed, studied during the period 2001-2015.

The major difficulties in the analysis are measurement error and omitted variable bias. Prior research has shows that these problem may mismeasure the impact of

Table 5.1: Patent applications

| | Probit | IV probit | |
|---|---|---|---|
| | | 1st stage | 2nd stage |
| | $\text{Patent}_t$ | $\text{OBP}_{t-1}$ | $\text{Patent}_t$ |
| $\text{OBP}_{t-1}$ | -0.052 | | 0.932*** |
| | (0.037) | | (0.254) |
| $\text{Board size}_{t-1}$ | 0.115*** | 0.247*** | -0.135** |
| | (0.009) | (0.000) | (0.065) |
| $\text{Log(total assets)}_{t-1}$ | 0.138*** | 0.005*** | 0.133*** |
| | (0.009) | (0.000) | (0.007) |
| $\text{Human capital}_{t-1}$ | 0.698*** | -0.005*** | 0.700*** |
| | (0.045) | (0.002) | (0.033) |
| $\text{Metro}_{t-1}$ | 0.092*** | -0.012*** | 0.099*** |
| | (0.030) | (0.001) | (0.024) |
| $\text{New employer}_{t-1}$ | | 0.072*** | |
| | | (0.001) | |
| $\text{New}_{t-1}$ | | 0.027*** | |
| | | (0.004) | |
| Year, industry, firm age fixed effects | Yes | Yes | Yes |
| Constant | -5.941*** | 0.854*** | -6.770*** |
| | (0.225) | (0.008) | (0.280) |
| Observations | 343371 | 343371 | 343371 |
| Wald test of exogeneity $\chi^2$ statistic | | | 15.092 |
| p-value | | | 0.000 |
| Amemiya-Lee-Newey minimum $\chi^2$ statistic | | | 0.747 |
| p-value | | | 0.387 |

Standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5.2: Trademark applications

| | Probit | IV probit | |
|---|---|---|---|
| | Probit | 1st stage | 2nd stage |
| | $\text{Trademark}_t$ | $\text{OBP}_{t-1}$ | $\text{Trademark}_t$ |
| $\text{OBP}_{t-1}$ | 0.044 | | 0.682** |
| | (0.037) | | (0.286) |
| Board size $_{t-1}$ | 0.051*** | 0.247*** | -0.111 |
| | (0.010) | (0.000) | (0.073) |
| $\text{Log(total assets)}_{t-1}$ | 0.148*** | 0.005*** | 0.145*** |
| | (0.009) | (0.000) | (0.008) |
| $\text{Human capital}_{t-1}$ | 0.261*** | -0.005*** | 0.262*** |
| | (0.047) | (0.002) | (0.035) |
| $\text{Metro}_{t-1}$ | 0.111*** | -0.012*** | 0.116*** |
| | (0.029) | (0.001) | (0.025) |
| $\text{New employer}_{t-1}$ | | 0.073*** | |
| | | (0.001) | |
| $\text{New}_{t-1}$ | | 0.027*** | |
| | | (0.004) | |
| Year, industry, firm age fixed effects | Yes | Yes | Yes |
| Constant | -5.913*** | 0.840*** | -6.444*** |
| | (0.367) | (0.013) | (0.435) |
| Observations | 344975 | 344975 | 344975 |
| Wald test of exogeneity $\chi^2$ statistic | | | 4.182 |
| p-value | | | 0.041 |
| Amemiya-Lee-Newey minimum $\chi^2$ statistic | | | 10.224 |
| p-value | | | 0.0014 |

Standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

outside impact in firm performance. To address the issue of endogeneity, we create instruments using observations on outside directors elected in year t who changed their employment between years (t-1) and (t-2). For those directors, we also take account of the relative productivity levels of their employers.

Estimating a structural equation model, we provide instrumental variables probit estimates accounting for year, industry and firm age age fixed effects, and show that an increase in OBP has a causal positive impact on start-ups' propensity to be innovative. This result applies for both patents and trademarks, although the validity of the instruments is rejected for the latter.

There are several directions this work could be taken. One is to examine the importance of board members representing venture capital. Another topic for further study is the relationship between outsiders and firm outcomes in terms of both productivity and bankruptcy.

# References


Acs, Z. J., Catherine, A. & Ting, Z. (2007), 'The determinants of new-firm survival across regional economies: The role of human capital stock and knowledge spillover', *Papers in Regional Science* **86**(3), 367–391.
**URL:** *https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1435-5957.2007.00129.x*

Adams, R. B., Hermalin, B. E. & Weisbach, M. S. (2010), 'The role of boards of directors in corporate governance: A conceptual framework and survey', *Journal of economic literature* **48**(1), 58–107.

Andersson Joona, P., Wadensjö, E. et al. (2006), Do the unemployed become successful entrepreneurs? a comparison between the unemployed, inactive and wage-earners, Technical report, Institute for the Study of Labor (IZA).

Andersson, M. & Klepper, S. (2013), 'Characteristics and performance of new firms and spinoffs in sweden', *Industrial and corporate change* **22**(1), 245–280.

Arrighetti, A. & Vivarelli, M. (1999), 'The role of innovation in the postentry performance of new small firms: Evidence from italy', *Southern Economic Journal* pp. 927–939.

Balsmeier, B., Fleming, L. & Manso, G. (2017), 'Independent boards and innovation', *Journal of Financial Economics* **123**(3), 536–557.

Bhagat, S. & Black, B. (2002), 'The non-correlation between board independence and'.

Blind, K., Edler, J., Frietsch, R. & Schmoch, U. (2006), 'Motives to patent: Empirical evidence from germany', *Research Policy* **35**(5), 655–672.

Block, J. H., Fisch, C. O., Hahn, A. & Sandner, P. G. (2015), 'Why do smes

file trademarks? insights from firms in innovative industries', *Research Policy* **44**(10), 1915–1930.

Brixy, U. & Grotz, R. (2007), 'Regional patterns and determinants of birth and survival of new firms in western germany', *Entrepreneurship & Regional Development* **19**(4), 293–312.
**URL:** *https://doi.org/10.1080/08985620701275510*

Carpenter, M. A. & Westphal, J. D. (2001), 'The strategic context of external network ties: Examining the impact of director appointments on board involvement in strategic decision making', *Academy of Management journal* **44**(4), 639–660.

Colombelli, A., Krafft, J. & Vivarelli, M. (2016), 'To be born is not enough: the key role of innovative start-ups', *Small Business Economics* **47**(2), 277–291.

Dalziel, T., Gentry, R. J. & Bowerman, M. (2011), 'An integrated agency–resource dependence view of the influence of directors' human and relational capital on firms' r&d spending', *Journal of Management Studies* **48**(6), 1217–1242.

De Rassenfosse, G. (2012), 'How smes exploit their intellectual property assets: evidence from survey data', *Small Business Economics* **39**(2), 437–452.

DeFond, M. L., Hann, R. N. & Hu, X. (2005), 'Does the market value financial expertise on audit committees of boards of directors?', *Journal of accounting research* **43**(2), 153–193.

Duchin, R., Matsusaka, J. G. & Ozbas, O. (2010), 'When are outside directors effective?', *Journal of financial economics* **96**(2), 195–214.

Fich, E. M. (2005), 'Are some outside directors better than others? evidence from director appointments by fortune 1000 firms', *The Journal of Business* **78**(5), 1943–1972.

Fields, M. A. & Keys, P. Y. (2003), 'The emergence of corporate governance from wall st. to main st.: Outside directors, board diversity, earnings management, and managerial incentives to bear risk', *Financial Review* **38**(1), 1–24.

Garg, S. (2013), 'Venture boards: Distinctive monitoring and implications for firm performance', *Academy of Management Review* **38**(1), 90–108.

Gompers, P. & Lerner, J. (1998), 'Venture capital distributions: Short-run and long-run reactions', *The Journal of Finance* **53**(6), 2161–2183.

Hermalin, B. E. & Weisbach, M. S. (2001), Boards of directors as an endogenously determined institution: A survey of the economic literature, Technical report, National Bureau of Economic Research.

Howitt, P. & Aghion, P. (1998), 'Capital accumulation and innovation as complementary factors in long-run growth', *Journal of Economic Growth* **3**(2), 111–130.
**URL:** *https://doi.org/10.1023/A:1009769717601*

Jones, M. V., Coviello, N. & Tang, Y. K. (2011), 'International entrepreneurship research (1989–2009): a domain ontology and thematic analysis', *Journal of business venturing* **26**(6), 632–659.

Jovanovic, B. (1982), 'Selection and the evolution of industry', *Econometrica* **50**(3), 649–670.
**URL:** *http://www.jstor.org/stable/1912606*

Klepper, S. (2002), The evolution of the us automobile industry and detroit as its capital, *in* '9th Congress of the International Joseph A. Schumpeter Society, Gainesville, Florida, March', Citeseer, pp. 22–23.

Kortum, S. & Lerner, J. (2001), Does venture capital spur innovation?, *in* 'Entrepreneurial inputs and outcomes: New studies of entrepreneurship in the United States', Emerald Group Publishing Limited, pp. 1–44.

Newey, W. (1987), 'Efficient estimation of limited dependent variable models with endogeneous explanatory variables', *Journal of Econometrics* **36**, 231–250.

Pfeiffer, F. & Reize, F. (2000), 'From unemployment to self-employment–public promotion and selectivity', *International Journal of Sociology* **30**(3), 71–99.

Saxenian, A. (1994), 'The limits of autarky: Regional networks and industrial adaptation in silicon valley and route 128', *Prepared for HUD Roundtable on Regionalism sponsored by the Social Science Research Council, Dec* pp. 8–9.

Vivarelli, M. & Audretsch, D. (1998), 'The link between the entry decision and post-entry performance: Evidence from italy', *Industrial and Corporate Change* **7**(3), 485–500.
**URL:** *http://dx.doi.org/10.1093/icc/7.3.485*

Yermack, D. (2006), 'Board members and company value', *Financial Markets and Portfolio Management* **20**(1), 33–47.

Zahra, S. A. & Filatotchev, I. (2004), 'Governance of the entrepreneurial threshold firm: a knowledge-based perspective', *Journal of Management Studies* **41**(5), 885–897.

Zhang, J. J., Baden-Fuller, C. & Pool, J. K. (2011), 'Resolving the tensions between monitoring, resourcing and strategizing: Structures and processes in high technology venture boards', *Long Range Planning* **44**(2), 95–117.