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The Impact of Stock Options on Risk-Taking

Founder-CEOs and Innovation

Michael Hickfang/Ulrike Holder

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Abstract

This paper investigates whether and how founder-CEOs' risk incentives (VEGA) are related to firm innovation. We exploit a change in the accounting treatment of stock-based compensation under FAS 123R in 2005 to show a relationship between founders' risk-taking incentive and innovation. Using a sample of 226 firm-year observations between 2002 and 2008, we first show that stock options are incentives that encourage founder-CEOs to engage in risk-taking behaviour and that these were significantly reduced as a result of FAS 123R. Secondly, we find that innovation activities of the observed firms are significantly declining due to the reduction of the option compensation and the associated reduction in VEGA of founder-CEOs. Finally, our difference-in-differences approach provides strong evidence that there is a relationship between CEOs risk-taking and innovation output. Our results imply that even in founder-led firms it is important to incentivise founders' risk-taking behaviour in order that firms continue to innovate and remain competitive.

JEL-Codes: G30, G32, G38, D80, O31

Der Einfluss von Aktienoptionen auf die Risikobereitschaft

Gründervorstandsvorsitzende und Innovationen

Zusammenfassung

Diese Studie untersucht, ob und wie Risikoanreize (VEGA) von Gründervorstandsvorsitzenden mit Unternehmensinnovationen zusammenhängen. Wir nutzen eine Änderung in der Bilanzierung von aktienbasierten Vergütungen nach FAS 123R in den USA im Jahr 2005, um den Zusammenhang zwischen Risikoanreizen und Innovationen aufzuzeigen. Anhand von 226 Firmen-Jahr-Beobachtungen zwischen 2002 und 2008 zeigen wir, dass Aktienoptionen Anreize sind, die Gründervorstandsvorsitzende zu mehr Risikobereitschaft ermutigen. Wir finden, dass die Innovationsaktivitäten der beobachteten Firmen durch Reduzierung der Optionsvergütung und damit einhergehende Risikoverminderung der Gründervorstandsvorsitzenden signifikant rückläufig sind. Vor allem unser Differenz-von-Differenzen-Ansatz lässt den Rückschluss zu, dass eine Beziehung zwischen Risikoanreizen und Innovationsoutput besteht. Folglich implizieren unsere Resultate, dass es auch bei gründergeführten Unternehmen wichtig ist, das Risikoverhalten der Gründer zu fördern, damit Unternehmen weiterhin innovativ und wettbewerbsfähig bleiben.

Im Internet unter:

http://www.wiwi.uni-muenster.de/io/forschen/downloads/DP-IO_12_2018

Westfälische Wilhelms-Universität Münster
Institut für Organisationsökonomik
Scharnhorststraße 100
D-48151 Münster

Tel: +49-251/83-24303 (Sekretariat)
E-Mail: io@uni-muenster.de
Internet: www.wiwi.uni-muenster.de/io

The Impact of Stock Options on Risk-Taking

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1. Introduction

Well-known firms and innovators such as Amazon and Facebook are still being led by their founders. Both researchers and practitioners are interested in understanding the effects of founder-CEOs on firm-level outcomes. Previous research has shown that firms led by their founders versus firms led by non-founders differ in their investment choices, decision-making processes, governance structure, firm behaviour, and thus performance (Fahlenbrach, 2009; Jayaraman, Khorana, Nelling, & Covin, 2000). According to Fahlenbrach (2009) founder-led firms achieve better stock market performance and higher market valuation than non-founder-led firms. However, findings on founder-led firms with respect to differences in innovation are scarce. To the best of our knowledge, Lee, Kim and Bae (2016) are the only ones who focus on the relationship between founder-CEOs and innovation. They conclude that founders are more efficient innovators compared to non-founder-CEOs (whom we also refer to as agent-CEOs).

Innovation is a key driver of a firm's future competitiveness and performance and, thus, it is of outstanding importance for the firm. Yet, innovation requires a firm to commit resources. Smith and Stulz (1985) argue that in order to incentivise risk-averse managers to take on risk, firms' financial decisions and compensation contracts should ensure managerial wealth to be a convex function of firm value. The optimal innovation motivation in the context of managerial compensation was investigated by Manso (2011), who found that stock options are a common offering in compensation contracts. Stock options increase the convexity of mangers' payoffs and, therefore, provide an incentive for managers to take more risk by raising the sensitivity of managerial wealth to firm risk (VEGA) (Hall & Murphy, 2003). Consistent with this suggestion, prior studies have stated that high VEGA leads to higher-risk investments. Yet, these incentives to promote innovation, which primarily have been studied in the context of agent-CEOs, may not be effective for motivating founder-CEOs.

There are differences in the characteristics of founder-CEOs and non-founder-CEOs, and these differences may support innovation activities and processes known as being risky and idiosyncratic (Holmstrom, 1989). Hence, it is likely to assume that there is (almost) no need to motivate founder-CEOs to invest in innovation activities. By having already built a large firm, founders have proven their entrepreneurial view (Langlois, 2007; Le Breton-Miller, Miller, & Lester, 2011). They are the initial visionary of the company and consider their company as a personal life achievement. Founder-CEOs typically hold larger equity stakes of their firms compared to agent-CEOs (Fahlenbrach, 2009). Founder-CEOs also tend to be more risk tolerant than agent-CEOs (Eisenmann, 2002). Lee et al. (2016) conclude that founder-CEOs constantly tackle new projects and invest in exploration that will pay off in the long term. Further, Lee et al. (2016) state that in comparison to non-founders, founders are more likely to take a long-term perspective.

The purpose of this paper is to gain further understanding how founder-CEOs are incentivised to take risks and how this relates to innovation. Specifically, we investigate whether and how the risk incentive (VEGA) of founder-led firms drives innovation. Therefore, we investigate stock options as part of managerial compensation to motivate risk-taking, which is essential for uncertain investments in the innovation process. Following the literature on stock options (e.g. Agrawal & Mandelker, 1987; Coles, Daniel, & Naveen, 2006), we investigate the relationship between the sensitivity of the founder-CEO's wealth in options to a unit change in volatility (VEGA). This is in line with the findings by Lerner and Wulf (2007) that more long-term incentives, such as stock options, are associated with greater patent counts and higher numbers of citations per patent.

Previous empirical work has been successful in finding a correlation between compensation and innovation but not a direct effect. Hence, a major challenge in the existing literature on (founder) CEOs and innovation is to get exogenous variation in CEO compensation and, thus, an indication for managers' incentives for risk-taking. Findings are limited due to major challenges with endogeneity that are first attributable to the CEO compensation and founder status and second to unobservable firm heterogeneity, which is likely to be correlated with both compensation and innovation.

To provide further insights, we exploit a change in the accounting treatment of stock-based compensation under FAS 123R. The FAS 123R was implemented by the Financial Accounting Standard Boards (FASB) in 2005 and requires all firms to expense the value of employee stock options. Under FAS 123R, companies are required to subtract the expense of stock options from their earnings, whereas prior to its adoption, stock options provided a financial reporting benefit, whereby firms were allowed to expense stock options at their intrinsic value instead of their fair value. Carter, Lynch and Tuna (2007) conclude that this special accounting treatment of stock options prior to FAS 123R affected their use. Thus, the implementation of FAS 123R eliminated any accounting advantages that were previously associated with stock options.

Therefore, the implementation of FAS 123R can be viewed as an exogenous shock to the accounting requirements for using stock option compensation, but there is simultaneously no effect on the actual (economic) benefit of stock options (Hayes, Lemmon, & Qiu, 2012). We study whether changes in the accounting of options led to changes in risk-taking behaviour and, consequently, innovations. Following related studies, we estimate the difference between founder-led firms that responded relatively more strongly to the accounting regulation by heavily reducing stock option incentives (treatment group) and founder-led firms that were not affected as strongly by FAS 123R, in that they did not reduce stock option incentives as much (control group). This setting allows us to apply Difference-in-Differences (DiD) analysis.

In line with Hayes et al. (2012) and Mao and Zhang (2018), we first expect the use of stock options to decrease, and this would provide insight into the risk-taking incentives of founder-CEOs. Further, we hypothesise that this change in risk behaviour influences innovation output. Even though we do not directly compare founder-led and non-founder-led firms, we assume that this effect on innovation is different for the previously mentioned types of firms. On the one hand, this may be explained by the fact that founder-CEOs may have insider information about the prospects of their firms, and, thus, founders are able to plan options differently than agent-CEOs (Anderson & Reeb, 2003). On the other hand, founder-CEOs tend to become less influenced by managerial incentives as they continue to devote resources to their firm, whereas the opposite is true for non-founder-CEOs (Palia, Ravid, & Wang, 2008). To capture innovation activity, we follow the standards in the literature and use R&D expenditures as a proxy for innovation input and both patent counts and number of citations as innovation output.

We construct our sample with information on executive compensation from ExecuComp, firm characteristics from Compustat and patent data from the National Bureau of Economic Research (NBER), the Fung Institute, and the United States Patent and Trademark Office (USPTO) (Balsmeier, Fleming, & Manso, 2017). Our final sample consists of 266 founder-led firms in the manufacturing sector during 2002 to 2008. First, we directly compare the post-FAS 123R and pre-FAS 123R period and confirm that a substantial change in stock options occurred because of the FAS 123R. Then, we confirm the notion that a significant positive relationship exists between a founder's risk-taking incentives and innovation input. Lastly, we apply a DiD approach and identify the differential effect across two groups that are differently impacted by the reform. We find significant differences in innovation output between the treatment and control group, and we assume that the reduced innovation in the treatment group is a consequence of these founder-CEOs decreasing their risk-taking behaviour after FAS 123R.

Our paper contributes to the literature in several ways. First, we add to the various studies that have examined the usage of stock options in compensation contracts for CEOs, executives, and non-executive employees (Core & Guay, 2001; Core & Guay, 1999; Kole, 1997; Smith & Watts, 1992; Yermack, 1995) and we offer results for a specific subgroup of CEOs, namely founder-CEOs. Hence, we also contribute to the literature on founder-CEO. We validate that for founder-CEOs stock options do, in fact, represent incentives for risk-taking behaviour and we add empirical evidence to the debate on the relationship between VEGA and risk-taking. Additionally, our study contributes to the recent stream of research using the FAS 123R as an exogenous shock and the evidence we found supports arguments for an effect of option-based compensation on innovation. Our study is closely related to Mao and Zhang (2018), but we focus on a specific subgroup of CEOs, namely founder-CEOs.

The paper proceeds as follows: The next section provides detailed information on the institutional background and, thus, the FAS 123R. Section 3 describes the used data and summary statistics. Our empirical approach and main results are presented in Section 4. Finally, Section 5 concludes.

2. Institutional Background and Identification Strategy

In 2014, the Financial Accounting Standards Board (FASB) issued the Financial Accounting Standard (FAS) 123R, a revision and advancement of the previously applied accounting standards for based compensation FAS 123. Under the new guidelines, which took effect in December 2005, firms are required to expense their executive stock options at fair value, whereas prior to the revised version of FAS 123, stock options were only voluntarily expensed at their fair value. They were more often expensed at their intrinsic value. Hence, before the revision, compensation with stock options was viewed as a hidden source of income, which appeared in the financial income statements only in a footnote. Since this was associated with accounting advantages from companies' points of view, nearly all firms granted stock options. The main advantages came from the fact that the intrinsic value method allowed firms to issue options by granting them exercise prices equal to or higher than the grant-date market price of the underlying stock. Thus, firms were previously incentivized not to report expenses for the option-based compensation in their income statements and, not surprisingly, nearly all firms made use of the intrinsic value method.

However, due to several accounting scandals (by e.g. Enron or WorldCom) and other events, by 2003 there had been increasing demand for companies to expense stock options at their fair value. Investors claimed that the intrinsic value method did not reflect the real economic costs of stock options. Hence, in December 2004, FASB introduced FAS 123R to make accounting statements more transparent and overcome the above-mentioned concerns. While the FASB required most firms to expense options at their fair value beginning in the first fiscal quarter after June 15, 2005, the SEC allowed the implementation with a delay of six months. Thus, for most publicly listed firms, the new regulation became effective in fiscal years after December 15, 2005. Figure 1 summarises the main accounting differences imposed by FAS 123R.

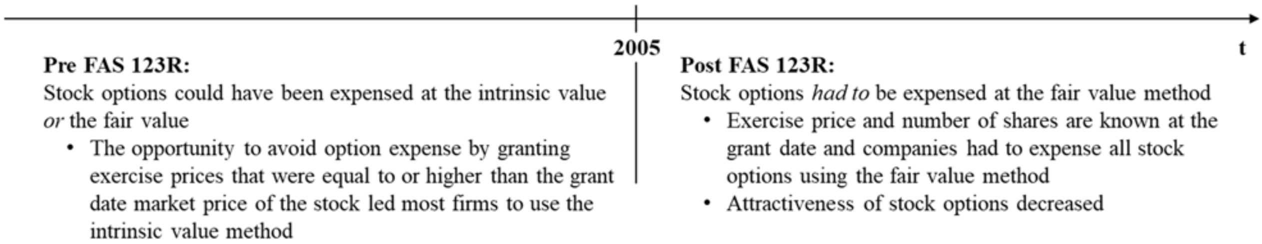

Figure 1: Main Accounting Difference Imposed by FAS 123R

The effects of FAS 123R have been analysed on different variables such as pay-out policy (Ferri & Li, 2018), risk incentives (Hayes et al., 2012) or innovation of agent-CEO-led firms (Mao & Zhang, 2018), as the FAS 123R provides a unique setting to overcome challenges in endogeneity.

The change in accounting treatment associated with the FAS 123R leads to an exogenous shock in stock option compensation, hence, in executive compensation. The new regulation made accounting treatment changes necessary. We suppose that option pay for founder-CEOs decreased in the post FAS period, as occurred for agent-CEOs, shown by e.g. Hayes et al. (2012) or Mao and Zhang (2018).

Theoretical studies about executive compensation show that stock options provide incentives for CEOs to take more risk. Using options helps structure executive compensation as a more convex function of firm performance, which is in the interest of shareholders. Further, option payment is positively associated with the CEO's expected wealth, as expected wealth is an increasing function of volatility (Smith & Stulz, 1985). Guay (1999) confirms the findings of Smith and Stulz (1985) and concludes that option pay is positively related to risk-taking activities such as investments in R&D. We reviewed this statement for our subgroup of interest and show that also for founder-CEOs there is a significant relationship between option payment and risk-taking incentive (VEGA).[1] Accordingly, we assume the impact chain to be as shown in Figure 2. Coles, Daniel, and Naveen (2006) find similar results and claim that there is a causal relationship between the convexity in CEO's compensation and R&D expenditures.

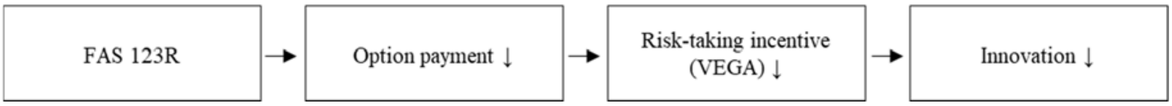

Figure 2: Expected Impact Chain of FAS 123R

Consistent with those studies, Figure 3 illustrates the trend in the development of option compensation for the target group of our study, founder-CEOs. We observe a clear reduction in the option pay of founder-CEOs in response to the regulatory changes associated with FAS 123R.

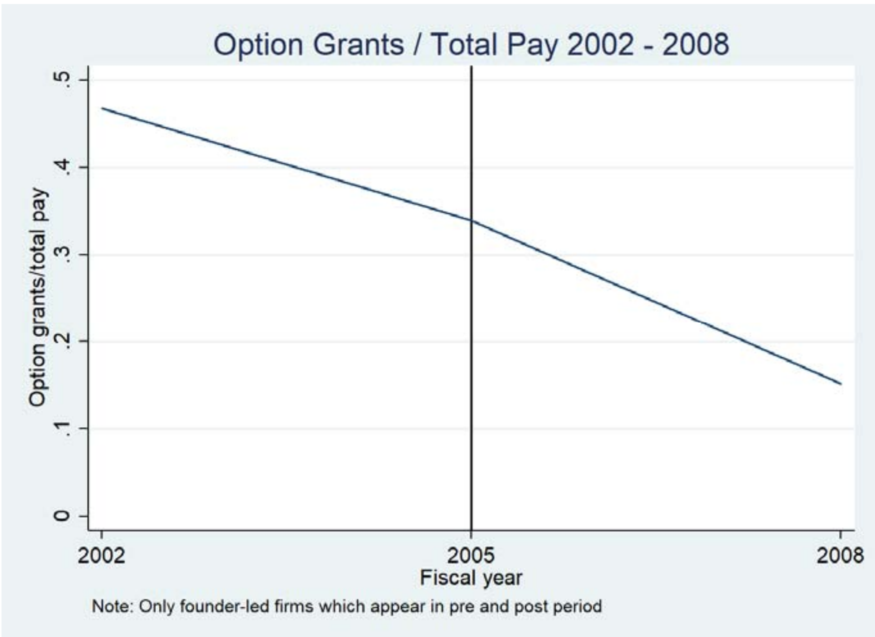

Figure 3: Trend in Option Pay Development

Our empirical setup identifies the relationship between founder-CEO compensation and innovation because we compare companies having implied option expenses above and below the sample median prior to FAS 123R. By classifying the two groups in this way, we follow Hayes et al. (2012) and Mao and Zhang (2018), who argue that firms with implied options (scaled by fully diluted shares) above the sample median between 2002 and 2004 (firms with high accounting impact) should respond more to changes associated with FAS 123R than firms below

[1] See Appendix 1 for the referring regression results.

the sample median (firms with low accounting impact). As described above, the changes stemming from the FAS 123R mainly affected the option compensation of executives, such that a change in the founder-CEOs' VEGA occurred, which, consequently, lessened CEOs' willingness to take on risky investments (e.g. in innovation activities). We follow the previously mentioned authors and define founder-led firms with a high accounting impact as the treatment group, whereas we define founder-led firms with a low accounting impact as the control group.

3. Sample Selection, Variable Construction and Summary Statistics

3.1 Sample Selection

We obtained the main data for founder-CEO compensation from ExecuComp and used several other databases to construct our final sample. Starting with ExecuComp, we defined founder-CEOs as CEOs who also founded their company and, thus, have both founder and CEO written in their job title. We further validated the founder indicator and checked the proxy statement of each firm in our sample to ensure that the firm is truly founder-led. As a consequence, we eliminated from our sample eight firms that were initially defined as founders by ExecuComp. By definition, founder-led firms are relatively young firms, which led to a relatively homogenous sample of firms. For the founder-CEO of each, firm we collected information on their salary, bonuses, grants of stock options, grants of restricted stock and long-term incentive awards. We followed similar studies by only considering the manufacturing sector (two-digit SIC codes 20 to 39). To measure managerial incentives, we considered DELTA and VEGA: DELTA is defined as the dollar change in an executive's annual compensation to changes in stock price, and VEGA is measured as the expected rate of change in an option's value for a one-unit change in implied volatility. Thereby, VEGA reflects executives' incentives for engaging in risk-taking behaviour (Coles et al., 2006; Core & Guay, 1999). Next, we included information on innovation activity through using data on patents and citations from the NBER Patent Citation database and UC Berkeley – Fung Institute for Engineering Leadership (Balsmeier et al., 2017) and the corresponding assignee match by Kogan et al. (2017). For further controls, we supplemented our sample with accounting and financial information from Compustat and stock returns data from CRSP. We also added information on a firm's age by hand-collecting data on the founding year.

Relying on Hayes et al. (2012), we defined the fiscal years after 2005 as the beginning of the post FAS-123R period and required all firms in our sample to have more than one year of data in the pre and post-FAS 123R period.

3.2 Variable Construction

Regarding the time period of interest, we faced a major challenge with the data, as the reporting requirements for executive compensation changed for fiscal years ending after December 15, 2005. Under the new disclosure rules, firms report the details of option and equity awards in two newly introduced tables, namely the plan-based awards and outstanding equity awards table. Furthermore, under the new requirements, the compensation components for bonuses are redefined as non-equity incentive compensation. As we are particularly interested in whether and how the components of executive compensation changed during 2002 to 2008, we followed the example of Hayes et al. (2012) and Mao and Zhang (2018) to define our variables of interest consistently across the two different reporting requirements (for details, see the Appendix of Hayes et al., 2012). To calculate the Black-Scholes value of options and, in general, to obtain company details, we merged the ExecuComp data with the Center for Research in Security Prices (CRSP) and Compustat. We closely followed the description on WRDS-Compustat and by Hayes et al. (2012) to calculate the Black-Scholes value of options using information about the exercise price and option term from ExecuComp, the annual stock price volatility computed as the yearly 60-month rolling, and the annual dividend yield computed from Compustat averaged over the current year and two prior years. We winsorised volatility at the 5th and 95th percentiles. Building on previously explained calculations, we also calculated DELTA and VEGA.[2] We winsorised managerial incentives at the 1th and 99th percentiles.

In this study, we distinguished the innovation activities of the firms in our sample with two specific key figures, investment in R&D and the number of patents. We also used forward citations to measure the quality of patents granted by the USPTO.

As coined by Hall, Jaffe and Tratjenberg (2005), the use of R&D expenditures as an investment activity is widely understood as the firm's "knowledge stock". In practice, at least 50 % of investments in R&D are in the form of salaries for highly qualified employees or scientists. These scientists generate profits for the firm through their knowledge, which, in the long term, represents intangible assets (Hall & Lerner, 2010). Hence, we used investments in R&D scaled by total assets on the innovation measure (RD_AT).

As a further proxy for innovation, we also measured the patenting activities of our firms using the patent database by Balsmeier et al. (2017). More precisely, we counted the number of patent

[2] We validated our data for managerial incentives by comparing our variables to the dataset Lalitha Naveen provides at her website (https://sites.temple.edu/lnaveen/data/).

applications by firm i filed in a given year. This proxy is commonly used as a measure for innovation quantity (e.g. Balsmeier et al., 2017; Hall et al., 2005; Mao & Zhang, 2018). We followed Hall et al. (2001) and considered the number of patents in their application year instead of using the actual year the patent was granted. Further, we controlled for patent quality using the number of citations each patent received in the following years.

Then, we merged the patent data with our firm data. For firms where we could not observe any patent activities (i.e. when firm-year observations had missing values for patent variables), we set the patent counts to zero because our patent data contains all patents that have ever been filed with the USPTO. Appendix 2 and 3 show that the distribution of patents and citations are extremely right-skewed. Therefore, we used the natural logarithm of one plus the number of patents ($ln(PAT + 1)$) and citations ($ln(CITE + 1)$). We winsorised these variables at the 99th percentile and considered them as our main measures of innovation output.

3.3 Summary Statistics

Table 1 provides the summary statistics of founder compensation and firm characteristics for the whole period, before and after the introduction of FAS 123R. Our final sample consists of 266 firm-year observations during the period 2002 to 2008. As presented in Panel A, the average annual compensation of a founder-CEO was about $3.2 million. Among the different components of compensation, the value of stock options was the largest component, with a mean of $1.5 million.

In Panel B of Table 1, we compare the relevant variables of the pre- and post-FAS 123R period. There was an apparent difference in founder compensation before and after the adoption of FAS 123R. The average proportion of stock options making up total compensation dropped from 61 percent before FAS 123R to 33 percent after FAS 123R. In contrast, the value of bonuses and restricted stocks increased after the introduction of the FAS 123R. Comparing these two periods, there were also changes in managerial incentives and innovation activities. The average VEGA of founder-CEOs increased from 39 prior to FAS 123R to 47 after it was adopted; however, the median value of VEGA increased only slightly. Also, the average DELTA increased from 174 to 191.

Panel A	All sample years (2002 to 2008)					
	N	Mean	SD	25th percentile	Median	75th percentile
Salary components (thousands of dollars)						
Salary	266	561	309	356	544	750
Bonus	246	536	630	0	358	833
Options	257	1454	2616	0	226	1851
Restricted Stock	258	25	67	0	0	10
Total Compensation	264	3182	3662	1077	1984	4099
Risk measures (thousands of dollars)						
Delta	265	197	202	57	146	268
Vega	261	47	54	6	29	70
Innovation measures						
Patents	266	37	118	0	3	17
Cites	266	9815	30963	50	1119	7123
Others						
Assets *(in $millions)*	264	1663	2684	238	719	1863
R&D/Assets	264	0.04	0.05	0.01	0	0.06
Tobin's q	264	2.38	1.63	1.41	1.91	2.69

Panel B	Pre-FAS 123R period (2002 to 2004)				Post-FAS123R period (2006 to 2008)			
	N	Mean	SD	Median	N	Mean	SD	Median
Salary components (thousands of dollars)								
Salary	112	481	279	440	116	634	316	600
Bonus	112	418	616	200	96	661	596	500
Options	110	1830	3288	788	109	1120	2414	2
Restricted Stock	112	20	142	0	108	43	87	0
Total Compensation	110	3008	3929	1894	116	3351	3592	2252
Risk measures (thousands of dollars)								
Delta	111	174	156	130	116	191	208	148
Vega	109	39	42	27	114	47	49	29
Innovation measures								
Patents	112	49	154	5	116	23	66	1
Cites	112	9074	30196	937	116	10460	31660	1225
Other								
Assets (in $millions)	111	1479	2682	519	115	1860	2733	876
R&D/Assets	111	0.04	0.04	0.03	115	0.05	0.05	0.03
Tobin's q	111	2.33	1.48	1.86	115	2.37	1.72	1.89

Notes: The sample consists of around 110 firm-year observations in the pre- and post-FAS 123R period. Pre-FAS 123R is defined as fiscal years from 2002 to 2004, and the post-FAS 123R period as fiscal years 2006 to 2008. Different numbers of observations for salary components occurred because of incomplete ExecuComp data. Due to the calculation criteria for VEGA, VEGA cannot be reported in the year of the IPO.

Table 1: Summary Statistics

With regard to innovation output between these two periods, there was a decline in the average number of patents (49 before FAS 123R to 23 afterwards), but the average number of citations per patent slightly increased, from 9,074 before FAS 123R to 10,460. The last rows of Panel B provide information about firm characteristics. The average value of assets increased more than 25 percent between the pre- and post-FAS 123R period, but the average ratio of R&D divided by assets did not differ remarkably between the two periods. Further, the changes in Tobin's q were relatively small around the introduction of FAS 123R.

4. Empirical Analysis

4.1 Methodology

We start with pooled OLS regressions using a sample of 255 firm-year observations during 2002 to 2008. We develop the following regression model:

(1) $$RD\_AT_{i,t+j} = \alpha + \beta \times ln(VEGA + 1)_{it} + \Gamma_{it} + \theta_t + \epsilon_{it}$$

$RD\_AT_{i,t+j}$ reflects the investment in R&D, scaled by total assets, of firm i in year $t + j$, with $j = t, t + 1, t + 2$. Our main explanatory variable, $ln(VEGA + 1)_{it}$, is the natural logarithm of the CEO's risk-taking incentive plus one. Thus, β captures the effect of risk-taking on our innovation input. Γ_{it} denotes a vector containing several control variables such as $\ln(DELTA + 1)$, $Tobin's\ q$, as well as property, plant and equipment assets, scaled by number of employees, $ln(PPE\_EMP)$ and $Firmage$. Year fixed effects are captured by θ_t and control for changes in the macroeconomic environment over time.

Further regressions include our innovation output variables $ln(PAT + 1)$ and $ln(CITE + 1)$ as dependent variables, as illustrated in the following equation:

(2) $$INNOVATION_{i,t+j} = \alpha + \beta \times ln(VEGA + 1)_{it} + \Gamma_{it} + \theta_t + \epsilon_{it}$$

$INNOVATION_{it+j}$ reflects $ln(PAT + 1)_{it}$ or $ln(CITE + 1)_{it}$ of firm i in year t, with $j = t, t + 1, t + 2$. Again, β is the coefficient of interest and captures the impact of our main explanatory variable, risk-taking incentives $(ln(VEGA + 1)_{it}$ on patenting activities of firm i in year t. Main explanatory variables and other elements on the right hand side of equation (2) are defined as in equation (1). We present the results of equations (1) and (2) in Tables 2 and 3.

Our preferred specifications include the estimations of the DiD model to overcome the likely biased results of our OLS estimators. We estimate the difference between firms that responded more strongly to the accounting regulation (treatment group) and the firms that had a low accounting impact (control group).[3] The formal DiD is given by the following equation:

$$(3) \quad RD\_AT_{i,t+j}\ or\ INNOVATION_{i,t+j} = \alpha + \beta_1 \times POST_t + \beta_2 \times TREATED_i + \beta_3 \times (POST_t \times TREATED_i) + Z_{it} + \theta_t + \epsilon_{it}$$

$POST_t$ is a binary variable that equals one for post-FAS 123R periods and zero otherwise. This variable controls for changes that affected all firms, regardless of any treatment. The dummy variable $TREATED_i$ equals one for the treatment group and zero for the control group. Hence, β_2 captures the differences between the treatment and control groups. The interaction term between the latter two variables measures the difference between both groups in the post-FAS 123R period. If we assume that option payment is only higher for the treatment group but follows a parallel trend prior to FAS 123R, then β_3 captures the impact of firms having high accounting to firms having low accounting impact and should have a negative sign. As in equations (1) and (2), all regressions are estimated with $j = t, t+1, t+2$.

4.2 Baseline OLS Results

We start with our baseline OLS regressions of equation (1) and present the results in Table 2. Of particular interest is the extent to which the managerial incentives affect decisions to invest in innovation input, RD_AT_t. Since investments in innovation are often expected to be delayed, we consider the current year as well as the two following years $t+1$, and $t+2$ in the regression analysis. In columns (1) to (3) of our baseline OLS regressions, we find that the risk-taking incentive VEGA is only statistically significant in year t. Following recent literature, we set investments in R&D to zero if a firm's R&D recording in Compustat was missing. Koh and Reeb (2015) document that firms with missing R&D expenditures are not necessarily firms without any innovation activities, as they can still generate innovation output like patents. Thus, our results in columns (1) to (3) are very likely to be biased. To overcome a possible selection bias, we followed Koh and Reeb (2015) and estimate a Heckman selection model. To estimate this model, we create a dummy variable equal to one for firms that reported investments in R&D and zero otherwise. For the Heckman selection model, this dummy is the dependent variable, and the right-hand-side variables are equal to those of equation (1). Further, all models contain year fixed effects.

[3] Definitions of the treatment and control groups were given in Section 2.

	(1)	(2)	(3)	(4)	(5)	(6)
		OLS			Heckman	
Dep. Variables	RD_AT_t	RD_AT_{t+1}	RD_AT_{t+2}	RD_AT_t	RD_AT_{t+1}	RD_AT_{t+2}
ln(VEGA+1)	0.010**	0.008	0.007	0.009***	0.005	0.006*
	(0.005)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)
ln(DELTA+1)	-0.004	0.002	0.002	0.001	0.009**	0.008
	(0.007)	(0.006)	(0.007)	(0.004)	(0.004)	(0.005)
Tobin's q	0.007	0.005	0.006	0.003	0.000	0.002
	(0.004)	(0.004)	(0.005)	(0.003)	(0.002)	(0.003)
ln(PPE_EMP)	-0.000	-0.000	0.000	-0.000	-0.001	-0.000
	(0.006)	(0.005)	(0.006)	(0.002)	(0.206)	(0.218)
Firm age	0.000	0.001	0.001	-0.000	-0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.020)
Inv. Mills ratio				-0.032*	-0.036**	-0.022
				(0.019)	(0.016)	(0.016)
Observations	255	217	180	255	221	187
Adj. R-squared	0.111	0.120	0.121			
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Pooled OLS regressions. All regressions include a full set of year dummies. Regressions only include the manufacturing sector (SIC2 codes: 20-39). Heckman selection model:

$$RD\_D_i = \beta \times ln(VEGA + 1)_{it} + \Gamma_{it} + \epsilon_{it},$$

with $RD\_D = 1$ if firm i reports R&D expenses and zero otherwise. Dependent variable for year t, $t + 1$ and $t + 2$ is defined in Section 4.1. Control variables are defined in Section 3.3. Robust standard errors clusterd at gvkey level in parentheses. Coefficients: *** significant at 1 % level, ** significant at 5 % level, * significant at 10 % level.

Table 2: CEO Risk-Taking and Innovation Input R&D/Assets

The results of our selection models provide some new insights. First, the inverse Mills ratio indicates that our baseline OLS results are negatively biased. Second, managerial risk-taking is positively associated with investments in R&D in year t and $t + 2$. The results of Table 2 give a first indication that managerial risk-taking incentives are positively associated with innovation input.

However, innovation output, measured as patents and patent citations, is of central interest for our study. Hence, the results of equation (2) are reported in Table 3. In columns (1) to (3), the results for the dependent variable $ln(PAT + 1)$ can be found. The results show positive values and in all three columns statistically significant coefficients at the $p<0.01$ level for VEGA. When we focus on citations in columns (4) to (6), we also find positive and significant coefficients for CEOs' risk-taking incentives across all models. In all columns of Table 3, we find that as VEGA grows larger, the innovation output increases. Expressed in figures, this means that a change from $ln(VEGA+1)$ 25 % to 50 % percentile leads to an 82 % increase in number of patents (1.42×0.581) and a 124 % (1.42×0.878) increase in number of citations. If we consult Harhoff et al. (1999), our results seem economically relevant. That study surveyed German patent holders to determine what price they would assign to their patent rights and found that the number of citations was positively correlated with the patent holders' estimated value of their patent. In summary, our results so far show a positive association between managerial risk-taking behaviours and both innovation input and output.

Dep. Variables	(1) ln(PAT+1) $_t$	(2) ln(PAT+1) $_{t+1}$	(3) ln(PAT+1) $_{t+2}$	(4) ln(CITE+1) $_t$	(5) ln(CITE+1) $_{t+1}$	(6) ln(CITE+1) $_{t+2}$
ln(VEGA+1)	0.645***	0.581***	0.551***	0.996***	0.878***	0.835***
	(0.139)	(0.139)	(0.148)	(0.221)	(0.224)	(0.232)
ln(DELTA+1)	0.026	0.149	0.146	-0.123	0.104	0.139
	(0.158)	(0.187)	(0.214)	(0.240)	(0.276)	(0.312)
Tobin's q	0.109	0.128	0.159	0.211	0.243	0.282
	(0.126)	(0.145)	(0.162)	(0.202)	(0.229)	(0.248)
ln(PPE_EMP)	-0.022	-0.018	0.057	0.108	0.075	0.184
	(0.254)	(0.239)	(0.250)	(0.347)	(0.310)	(0.326)
Firm age	0.013	0.015	0.015	0.010	0.012	0.012
	(0.023)	(0.025)	(0.024)	(0.037)	(0.038)	(0.037)
Observations	255	217	180	255	217	180
R-squared	0.315	0.321	0.305	0.303	0.307	0.300
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Pooled OLS regressions. All regressions include a full set of year dummies. Regressions only include the manufacturing sector (SIC2 codes: 20-39). Dependent variables for year t, $t + 1$ and $t + 2$ are defined in Section 4.1. Control variables are defined in Section 3.3. Robust standard errors clustered at gvkey level in parentheses. Coefficients: *** significant at 1 % level, ** significant at 5 % level, * significant at 10 % level.

Table 3: CEO Risk-Taking and Innovation Output Patents and Citations

4.3 Difference-in-Differences Results

Overall, we find strong evidence that a change in VEGA causes significant and positive changes in both innovation input and output. However, based on the models used to estimate results in Table 1 and 2, it is worth noting that the results are very much likely to be biased due to unobserved heterogeneity and the violation of the strict exogeneity assumption. To overcome these issues, we employ a DiD approach. This approach will provide empirical evidence for an effect of FAS 123R on both innovation input and output, if the parallel assumption holds. This assumption requires that in the absence of a treatment, the treatment and control groups must show similar trends in the dependent variables. So far, we have shown that FAS 123R reduced the option remuneration of all founder-CEOs. Furthermore, Figure 4 shows that the FAS 123R amendment was also an exogenous shock to managerial risk-taking behaviour because VEGA followed a positive trend until 2005 but showed a negative slope from 2005 onwards. Taken together, these observations indicate that the parallel assumption is valid.

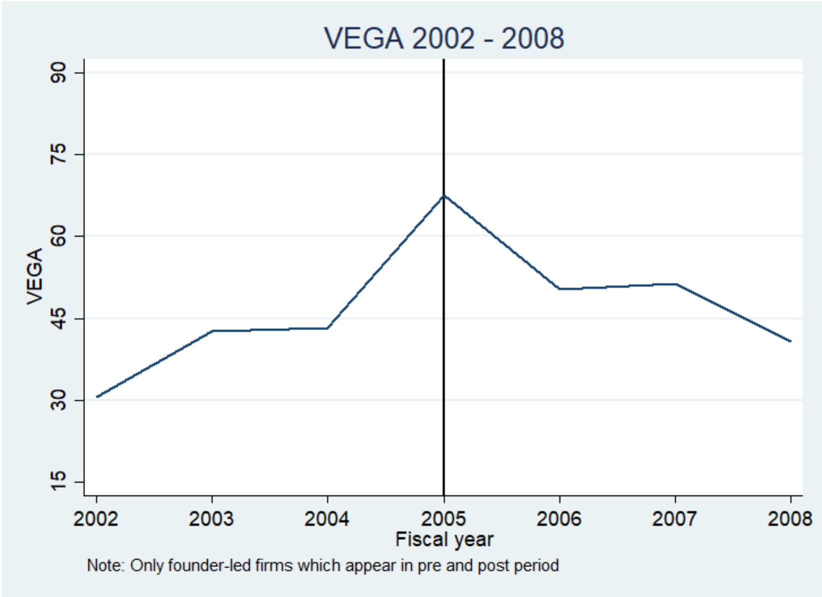

Figure 4: Different Slopes for VEGA Pre and Post FAS 123R

The results of our DiD regressions are reported in Table 4. The estimations for $j = t$ indicate that FAS 123R had no effect on both innovation input and output. Across all dependent variables, the results for year t are statistically insignificant. It should be mentioned, though, that while the FAS 123R had no effect on our innovation measures in the short term, this is not surprising. As mentioned above, innovations need time to develop.

Dep. Variables	(1) RD_AT_t	(2) $ln(PAT+1)_t$	(3) $ln(CITE+1)_t$	(4) RD_AT_{t+1}	(5) $ln(PAT+1)_{t+1}$	(6) $ln(CITE+1)_{t+1}$	(7) RD_AT_{t+2}	(8) $ln(PAT+1)_{t+2}$	(9) $ln(CITE+1)_{t+2}$
TR × POST	-0.242	0.002	-0.420	0.003	-0.457*	-0.636	0.009	-0.659***	-0.940**
	(0.228)	(0.006)	(0.395)	(0.007)	(0.247)	(0.441)	(0.006)	(0.236)	(0.409)
TR	1.936***	0.016	2.767***	0.034***	2.183***	3.180***	0.034***	2.117***	3.069***
	(0.501)	(0.020)	(0.790)	(0.010)	(0.472)	(0.717)	(0.010)	(0.457)	(0.668)
POST	-16.580	0.007*	-1.137***	-0.466	-0.729***	35.750	-0.383	-0.689***	30.074
	(34.643)	(0.004)	(0.324)	(0.655)	(0.201)	(42.169)	(0.603)	(0.155)	(42.686)
Tobin's q	0.016	0.002	0.064	0.001	0.032	0.137*	0.004	0.024	0.110*
	(0.037)	(0.002)	(0.057)	(0.002)	(0.049)	(0.077)	(0.003)	(0.041)	(0.066)
ln(PPE_EMP)	0.027	0.002	0.083	-0.002	-0.042	-0.116	-0.003	0.039	0.045
	(0.058)	(0.002)	(0.122)	(0.001)	(0.036)	(0.105)	(0.002)	(0.049)	(0.084)
Firm age	0.008	0.000	0.010	0.000	-0.005	-0.018	0.000	-0.004	-0.015
	(0.018)	(0.000)	(0.032)	(0.000)	(0.014)	(0.021)	(0.000)	(0.014)	(0.022)
Observations	260	260	260	221	221	221	183	183	183
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.345	0.156	0.333	0.236	0.381	0.373	0.261	0.377	0.375

Notes: All regressions include a full set of year dummies. Regressions only include the manufacturing sector (SIC2 codes: 20-39). Dependent variables for year t, $t + 1$ and $t + 2$ are defined in Section 4.1. Control variables are defined in Section 3.3. Robust standard errors clustered at gvkey level in parentheses. Coefficients: *** significant at 1 % level, ** significant at 5 % level, * significant at 10 % level.

Table 4: Effect of FAS 123R on Innovation Input and Output – DiD Approach

In year $t + 1$, we find negative signs for our innovation output variables $ln(PAT + 1)$ and $ln(CITE + 1)$, with only the first being statistically significant at the 10 % level. This indicates that the treatment groups' innovation output was more negatively affected by FAS 123R than the control groups'. In the second year after the implementation of FAS 123R, we find negative and statistically significant results for both patents and citations. The coefficients of the interaction terms in column (8) and (9) show that founder-led firms in the treatment group reduced their innovation output by 66 % and 94 % (depending on the innovation output variable being considered) compared to the control group in year 2 after FAS 123R. Our findings in Table 4 support the assumption that in founder-led firms, there is a relationship between the founders' risk-taking incentive and innovation output.

4.4 Validity of the Difference-in-Differences Approach

As mentioned above, the DiD approach is subject to the condition that in the absence of a treatment, the treatment and control groups will follow the same trend in their dependent variables. Because we did not find significant results for the innovation input, RD_AT, we do not further examine the common trend assumption for this dependent variable. With respect to $ln(PAT + 1)$ and $ln(CITE + 1)$, we plotted their means in year t over time in Figure 5. Regarding patents, we cannot clearly identify a common trend, especially because there is a little peak for the treatment group in 2004. Further, $ln(PAT + 1)$ only marginally increased for the treatment group (~2.8 to ~3.0) and decreased for the control group (~1 to ~ 0.9) over the whole period. However, what we can clearly identify are completely different slopes in this variable after FAS 123R became effective. For the treatment group, we observe a decrease from ~3.0 to ~1.75 (Δ = – 1.25), whereas the control group only drops by Δ = .45 (~ 0.9 – ~0.45). For citations, we observe a common trend in the pre-FAS 123R period, where both treatment and control groups were falling by about Δ = – 0.5. However, after 2005, the slope of this variable for the treatment group is steeper (Δ = – 2) than that for the control group (Δ = – .6). In summary, we can fully confirm the common trend assumption for the dependent variable $ln(CITE + 1)$, and there are also only marginal objections for this assumption regarding $ln(PAT + 1)$.

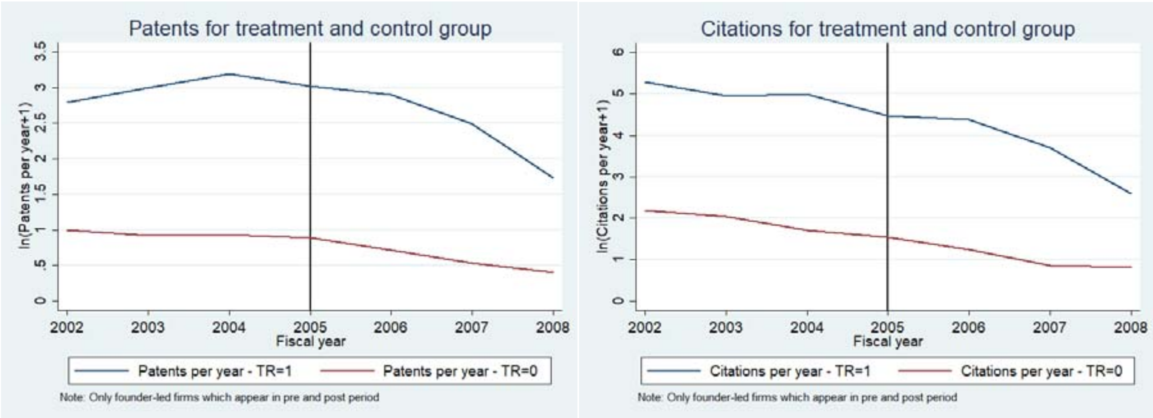

Figure 5: Common Trends for Dependent in the Pre-FAS 123R Period

To further confirm the validity of our approach, we perform a placebo test. For this test, we have to assume that the exogenous shock happens at a different time. We assume the shock to be in 2001 and set a new dummy, $POST_{Pseudo}$, that equals one for observations after the placebo shock and zero otherwise. The results are given in Table 5 and indicate that there is no significant effect of the interaction term in any of the regressions.

Dep. Variables	(1) RD_AT$_{t+1}$	(2) ln(PAT+1)$_{t+1}$	(3) ln(CITE+1)$_{t+1}$	(4) RD_AT$_{t+2}$	(5) ln(PAT+1)$_{t+2}$	(6) ln(CITE+1)$_{t+2}$
TR × POST$_{Pseudo}$	0.001	-0.042	-0.385	0.005	-0.012	-0.240
	(0.005)	(0.175)	(0.328)	(0.004)	(0.182)	(0.379)
TR	0.035***	2.266***	3.610***	0.031***	2.213***	3.439***
	(0.011)	(0.441)	(0.698)	(0.010)	(0.441)	(0.730)
POST$_{Pseudo}$	-0.362	21.930	44.489	-0.281	23.421	45.923
	(0.705)	(28.893)	(51.497)	(0.664)	(30.165)	(56.009)
Tobin‘s q	-0.001*	-0.016	0.030	-0.000	0.018	0.034
	(0.001)	(0.022)	(0.045)	(0.001)	(0.023)	(0.044)
ln(PPE_EMP)	0.001	-0.019	-0.122	0.001	0.066	0.091
	(0.001)	(0.054)	(0.115)	(0.002)	(0.063)	(0.096)
Firm age	0.000	-0.011	-0.022	0.000	-0.012	-0.022
	(0.000)	(0.015)	(0.026)	(0.000)	(0.015)	(0.028)
Observations	232	232	232	232	232	232
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.176	0.332	0.314	0.202	0.345	0.330

Notes: All regressions include a full set of year dummies. Regressions only include the manufacturing sector (SIC2 codes: 20-39). Dependent variables for year t, $t+1$ and $t+2$ are defined in Section 4.3. Control variables are defined in Section 3.3. Robust standard errors clustered at gvkey level in parentheses. Coefficients: *** significant at 1 % level, ** significant at 5 % level, * significant at 10 % level.

Table 5: DiD Approach with Pseudo-Treatment in 2001 – Years 1998 to 2004

In addition, we perform a robustness test in which we change the treatment and consider the treatment definition from Ferri and Li (2018). They define firms as treated if they have implied option expenses scaled by total assets that are above the sample median in year 2002. Accordingly, firms below the median are defined as the control group. Estimation results can be found in Appendix 4, which also show statistically significant coefficients for our main variable of interest $TR_{FL} \times POST$. The robustness check confirms our results and supports the view that innovations in founder-led firms are driven by risk-taking incentives.

5. Discussion and Concluding Remarks

This paper evaluates whether the incentives (stock options) for founder-CEOs to engage in risk-taking behaviour drive innovation activity. To provide further insights, we exploit a change in the accounting treatment of stock options. The implementation of the FAS 123R led companies to decreases their practice of offering stock options as part of the managers' compensation. Using a sample of founder-led firms in the manufacturing sector, our results of the DiD analysis provide strong evidence that there is a relationship between the implementation of FAS 123R and a reduction of innovation output in founder-led firms. We show that stock options are incentives that encourage founder-CEOs to engage in risk-taking behaviour. Therefore, this reduction caused them to reduce their risk-taking behaviours, which resulted in reduced innovation. Thus, as VEGA declines innovation output decreases. We also examined R&D investments in this context, but we find no significant relationship between risk-taking incentives and innovation input. We conducted several robustness checks to confirm our findings. Further, we used a different definition of the treatment condition to rule out the possibility that our results were driven by the differentiation between treatment and control groups.

In accordance with Mao and Zhang (2018), our results imply that the incentives promoting CEOs to take risks are crucial for firm innovation. However, in contrast to the results by Mao and Zhang (2018), who conducted a similar analysis for an unspecified sample, our coefficients are more than two times larger. Our results indicate that the firms more affected by the FAS 123R (treatment group) reduced their innovation output by about 66 %, this suggests that it is important to motivate founder-CEOs. This leads to the conclusion that even though there may be huge differences between agent- and founder-led firms, when considering risky, explorative innovations even founder-led firms must maintain risk-adjusted components as part of executives' compensation.

We need to remark that we dealt with truncated patent data. Usually, there exists a delay between the application of a patent and it grant date. In fact, it takes several years until the exact number of patents granted in a particular period can be reported. However, for the analysis we were interested in the patent application date, as this is expected to be closer to the actual innovation time than the grant date. As we have this data for all firms and we control for year fixed effects, this should not bias our results. Further, it should be noted that not all innovations can be accounted for via patent applications (Hall et al., 2005).

Summing up, this study provides a deeper understanding of the risk-taking behaviour of founder-CEOs. We found that our measure of risk-taking incentives (VEGA) is significantly associated with firms' innovation output. Further, VEGA was strongly negatively affected by FAS 123R, which we found to have an economically relevant influence on the decline in founder-led firms' patenting activities. All in all, we found that in even founder-led firms it is important to incentivize founders' risk-taking behaviour in order for firms to continue to innovate and remain competitive.

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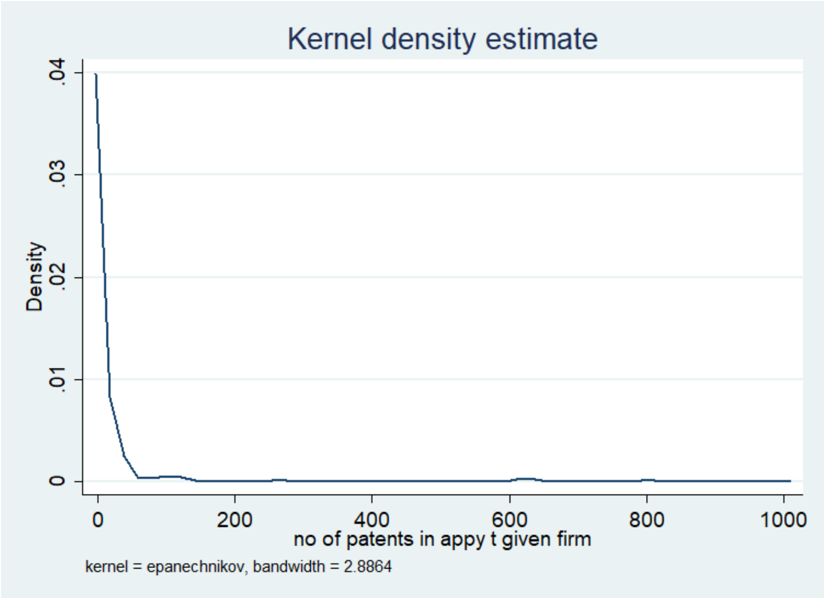
Appendix 1: Options and VEGA

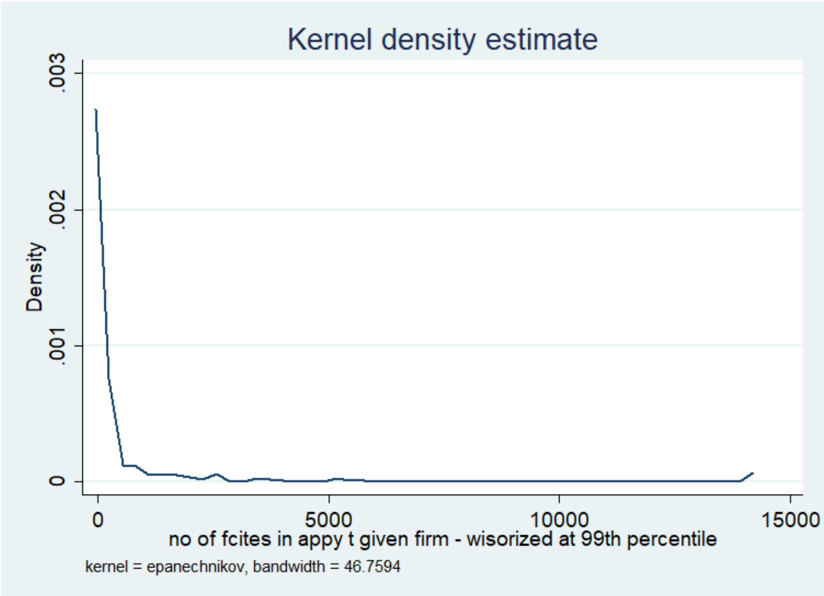
Dep. Variables	(1) VEGA	(2) VEGA
Options	0.00018*** (0.00004)	0.00019*** (0.00005)
Observations	254	254
R-squared	0.11730	0.15136
Year FE	No	Yes

Notes: Table reports regression estimates of options on the managerial risk incentive VEGA in thousands of dollars, defined as $ln(VEGA + 1)$. Both dependant and independent variable are measured in thousands of dollars. Regressions only include the manufacturing sector (SIC2 codes: 20-39). Robust standard errors clustered at gvkey level in parentheses. Coefficients: *** significant at 1 % level, ** significant at 5 % level, * significant at 10 % level.

Appendix 2: Density of Patents



Appendix 3: Density of Patent Citations



Appendix 4: Results with Different Treatment

Dep. Variables	(1) RD_AT_{t+1}	(2) $ln(PAT+1)_{t+1}$	(3) $ln(CITE+1)_{t+1}$	(4) RD_AT_{t+2}	(5) $ln(PAT+1)_{t+2}$	(6) $ln(CITE+1)_{t+2}$
TR_{FL} × POST	0.004	-0.519**	-0.854**	0.006	-0.750***	-1.306***
	(0.007)	(0.244)	(0.412)	(0.006)	(0.235)	(0.393)
TR_{FL}	0.025**	1.831***	3.177***	0.024**	1.726***	2.934***
	(0.012)	(0.532)	(0.751)	(0.011)	(0.509)	(0.692)
POST	0.007*	-31.371	-20.688	-1.151	-32.206	-25.192
	(0.004)	(44.116)	(58.711)	(0.949)	(44.263)	(59.309)
Tobin's q	0.001	0.042	0.153*	0.004	0.037	0.131*
	(0.002)	(0.052)	(0.085)	(0.003)	(0.039)	(0.073)
ln(PPE_EMP)	-0.002	-0.053	-0.154*	-0.003	0.032	0.012
	(0.001)	(0.034)	(0.093)	(0.003)	(0.044)	(0.084)
Firm age	0.001	0.016	0.011	0.001	0.016	0.013
	(0.001)	(0.022)	(0.030)	(0.000)	(0.022)	(0.030)
Observations	221	221	221	183	183	183
Firms	38	38	38	38	38	38
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.160	0.302	0.381	0.182	0.292	0.366

Notes: Cluster-robust standard errors clustered at gvkey level given in parentheses. All regressions include a full set of year dummies. Regressions only include the manufacturing sector (SIC2 codes: 20-39). Dependent variables for year t, $t+1$ and $t+2$ are defined in section 4.3. Control variables are defined in section 3.3. Coefficients: *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.

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Seit Institutsgründung im Oktober 2010 erscheint monatlich ein Diskussionspapier. Im Folgenden werden die letzten zwölf aufgeführt. Eine vollständige Liste mit Downloadmöglichkeit findet sich unter http://www.wiwi.uni-muenster.de/io/de/forschen/diskussionspapiere.

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Michael Hickfang/Ulrike Holder
Dezember 2018

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Herausgeber:
Prof. Dr. Alexander Dilger
Westfälische Wilhelms-Universität Münster
Institut für Organisationsökonomik
Scharnhorststr. 100
D-48151 Münster

Tel: +49-251/83-24303
Fax: +49-251/83-28429

www.wiwi.uni-muenster.de/io