ESSAYS ON INNOVATION AND FINANCE

by

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ABSTRACT OF THE DISSERTATION

Essays on Innovation and Finance

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The focus of this dissertation is on the interactions of real and financial decisions. First, I investigate the role of minority equity purchases on the innovation activities of the US firms. I provide evidence of an increased innovation activity following minority equity purchases targeting firms with a small size patent portfolio prior to acquisition. Using a hand collected data I show that the positive effect of minority equity purchases is nonexistent when there is no simultaneous cash transfer to the target firm. Target firms in minority acquisitions increase their innovation while a matched sample of firms in the same industry with similar technological stock and having similar size show no increases in the innovation performance. I also show that

firms which are financially constrained prior to the minority acquisition increase their innovation afterwards.

Second, I try to address the question that whether insiders who know about success/failure probabilities of innovation projects ahead of outside investors trade on this private information? This study finds that insiders' purchases in large firms precede the patent application for important innovation. US publicly held large firms increase their innovation quality, as measured by non-self citations received per patent applied, by 25% subsequent to the share purchase of top insiders. An event study analysis is conducted to understand the stock price reaction to the important innovations. I provide the evidence that the average cumulative abnormal returns of insiders on their purchases prior to the important patent applications are economically large and significant especially in the long run. The study also show that the positive price reaction to important innovations only occurs when insiders purchases their firm's stock and stock prices react negatively to the application or grant of the important breakthroughs. The use of private information by insiders seems to be less prevalent in firms with better corporate governance. Firm innovation quality also deteriorates after insiders sell their share in the company. The results are robust to changing the econometric methods employed, controlling for time and firm fixed effects as well as stock return and other firm characteristics.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

Chapter 1: Financing Innovation through Minority Acquisitions

(jointly with Mariana Spatareanu)

1.1. Introduction

This paper investigates the innovation performance of target firms following minority acquisitions.[1] This is an important topic for at least two reasons: first, innovation plays a crucial role in the survival, competitiveness, and growth of firms, and second, minority acquisitions are widespread,[2] yet their impacts on the subsequent performance of firms are little understood. Additionally, financing innovation might be difficult even in freely competitive market. The difficulty is closely related to the need of making financial decisions by relying on the opaque informational structure associated with high tech investments. Still, financial synergies are often motivations among the participants of the market for corporate control. An unexplored side of acquisitions is the degree to which these acquisitions affect the innovation activities of target firms when minority stake is purchased.[3]

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[1] Partial acquisitions, block acquisitions, minority acquisitions will be used interchangeably and will refer to the acquisitions of equity stakes where acquirers acquire less than 50 percent of targets' shares.

[2] Between 1990 and 2009, one in seven public firms around the world was a target of a minority block acquisition (Liao, 2014).

[3] Bayer's purchase of minority interest in Millennium Pharmaceuticals provides an illustrative case. The acquisition announcement "Bayer A.G., the German drug and chemical company, said yesterday that it would pay $96.6 million to buy a 14 percent equity stake in Millennium Pharmaceuticals Inc,… Bayer will also pay $33.4 million in licensing fees, and up to $335 million in research and development financing in the next five years" and analysts' comments on the deal " A validation of Millennium's science and strategy" , "For Millennium, it is a critical deal, both in terms of alleviating their short-term cash flow

While majority acquisitions are studied in the finance literature, the studies on minority acquisitions are only recent and scarce.[4] However, minority acquisitions comprise a substantial share of the overall M&As activity in the US. For instance, during 1983-2002 period, SDC reports 29,217 M&As deals for US public firms[5] out of which 10,585 (~36%) deals are coded as partial or minority acquisitions.

Several considerations might lead firms to acquire minority positions in other firms: mitigating incomplete contracts and facilitating cooperation between two independent firms, aligning the incentives of the acquirer with those of the target, preserving or enhancing target's managerial incentives, providing an opportunity for the acquirer to learn more about the target before acquiring a majority stake, providing financing directly to the target, etc. (Allen and Phillips (2000), Fee, Hadlock, and Thomas (2006), Ouimet (2012)). Some of these considerations apply to majority acquisitions too, however Ouimet (2012) highlights the importance of costs associated with the weakening of target's managerial incentives following a majority acquisition in selecting the mode of acquisition. She finds evidence that firms are willing to forgo benefits of control in order to preserve targets' incentives. Acquirers may in this case favor minority acquisitions. A strong determinant of minority acquisitions is also relieving target firm's

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problems, and allowing them to increase productivity across the board for their in-house research and development[3]," highlights the financing role of minority acquisitions along with the other implications.

[4] Ouimet(2012), and Liao(2014) are exceptions. Ouimet(2012) investigates various motives for minority versus majority acquisitions, while Liao(2014) studies minority block acquisitions and examine possible theories for the presence of equity stake purchases. None of these papers analyses the performance of firms following acquisitions.

[5] Excluding Repurchases, Buybacks, Acquisition of Assets, Exchange Offers, Acquisition of Remaining Interest.

financial constraints. Liao (2014) finds strong support for this hypothesis. She finds that firms that are financially constrained are more likely to be targets in minority equity acquisitions. Cash flow from the sale of minority stakes can relieve financial constraints of the target and thus provide cash to fund innovation or investment activities of the target. Overcoming the financial constrains while staying as an independent entity may provide the advantage of keeping target's incentives to innovate alive (Ouimet, 2012). This would precisely be the case of young, small, innovative firms, which are often the case of minority acquisitions. Even in case there is no capital flow, as in the exchange of equities between target and acquirer, the acquirer may certify the innovation potential of the target through investing in it. If holding large blocks of target[6], the acquirer may mitigate free-rider problems, monitor and obtain more accurate information about the investment opportunities and may have the power on the investment decisions of the target (Shleifer and Vishny, 1986)). A prior alliance of two tech-firms in the same industry may become more strengthened through acquisitions of minority stakes or an alliance can be formed at the same time with the purchase of minority stake. Minority acquisitions may therefore impact the performance of the target firms.[7]

Despite the increasing body of research unveiling the acquirers and their innovative performances (Sevilir and Tian, 2012, Bena and Li, 2014), target firms and their post-acquisition performances are relatively left unexplored. One explanation is that

[6] In some cases, the acquirer firm assigns a board member to the target firm following the minority share purchase.

[7] It is common in high tech industries that firms form joint product development alliances and fund them through equity purchases.

the information about the activities of target firms is not available independently following mergers and majority acquisitions. However, focusing on minority acquisitions enables us to examine the innovation performance of targets as independent units even after the acquisition.

This study sheds lights on these issues. Combining several databases and hand-collecting data on cash flows transfers for every minority acquisition deal in the study allow us to address several questions: Is there a role for minority acquisitions in improving the post-acquisition innovation performance of the target firms? How is the post-acquisition innovation performance affected by the pre-acquisition innovation capability of the target? Do pre-acquisition financially constrained target firms innovate more following the minority stakes acquisition? Does a minority stake purchase result in an increase in innovation when there is no cash flow transfer to the target?

One of the main econometric issues when investigating issues like these is the possible endogeneity in estimation. It may be the case that the acquirer firms selectively purchase minority stakes from targets with better innovation potential. We overcome this problem in several ways: first, we use information on previously announced but failed minority acquisitions. We compare the innovation output of those targets where the acquisition failed to go through with the innovation output of target firms that were successfully acquired, following the approach suggested by Savor and Lu (2009). We find that targets that were successfully acquired innovate more, particularly those with small patent portfolio prior to the acquisitions, and which receive cash transfers from the

transaction. If there is no systematic relation between the innovativeness of a firm and the probability that the firm's announced acquisition fell through, this approach allow us to establish a causal relation between minority acquisition and the subsequent innovation performance of the target. Second, we control for the unobserved heterogeneity of firms before entering the sample by dividing firms into two subsample based on their innovation performance prior-to-acquisition. Blundell et al (1999) argues that pre-sample technology shocks to the firms are exogenous to shocks to innovation in the post-acquisition period. Therefore, the division of firms before entering the sample enables us to control some permanent innovative capabilities of target firms. Third, we identify acquisitions where targets issue shares directly to the acquirer and disclose the amount investment by acquirer. We classify these as minority acquisitions with cash transfers to target. This information provides us a convenient experimental design to test whether it is the inflow of cash from minority acquisitions causes the subsequent increase in the innovation performance of the target firms. Fourth, we collect data on minority acquisitions where there is no simultaneous cash transfer to target, such as equity exchanges or open market purchases long after the new share issues. We present results indicating that when there is no financing from minority share purchase there is no discernible impact on post-acquisition innovation performance of the target firms. Finally, the year when a firm is targeted in minority acquisition we find a similar-sized firm in the same industry also having a similar technological stock and examined whether innovation performance of these matched firms also increase. The results from this analysis show that target firms in minority acquisitions increase their innovation while a

matched sample of firms in the same industry with similar technological stock and having similar size show no increases in the innovation performance.

We provide evidence that US publicly held non-financial firms having small patent portfolios prior to the sale significantly increase their patenting quality and quantity after the sale of the minority stakes to non-financial firms. As a measure of quality and quantity of the patenting we use the total number of non-self citations received per patent applied by the firm, and the total number of patents applied by the firm each year, respectively. Specifically, controlling for target firm and year fixed effects and pre-acquisition technology stock, and other firm characteristics we find that the acquisition of the minority interest in the publicly held target firms having less than the median cumulative patent count prior to the acquisition increases targets' total number of non-self citations per patent received by 23% following the acquisition. Additionally, the total number of simple patent count increases by 10%. The positive impact on innovation is present only if there are cash transfers from the acquirer to the target, indicating that cash transferred through minority stake purchase is an important source of financing for target firms to fund their innovation activities. The results from the regressions using no-cash flow minority acquisitions support our argument. The positive impact of the minority acquisitions on innovation performance is nonexistent when there is no cash flow transfer to the target firm.

This paper contributes to the M&A literature by investigating a highly important outcome of the previously overlooked minority acquisitions, namely increased innovation

performance afterwards. In addition, it contributes to the literature on the financing of young firms with intangible assets in high tech industries. Further, the paper presents results consistent with the recent studies in the M&A literature arguing that targets are financially constrained prior to the acquisitions and increase investments afterwards (Ouimet (2013), Liao (2014), and Erel, Jang and Weisbach (2014)). To the best of our knowledge this study is the first to investigate the post-acquisition innovation performance of target firms, using detailed patent data. We focus on minority acquisitions and highlight the crucial importance of cash transfers for target firms' post acquisition innovation performance.

The reminder of the paper is organized as follows. The next section briefly reviews the related literature. Section 1. 3 explains the data sources and the empirical methodology used. Section 1.4 presents the empirical findings. Section 1.5 discusses endogeneity in estimation. Section 1.6 conducts additional robustness checks and presents the results from an alternative econometric model. Section 1.7 concludes.

1.2. Related Literature

There are three lines of research on which our paper builds and to which it contributes: the first investigates the financing of innovative firms. The second line of related literature sheds light on how M&As effect firms' innovation performance. Lastly, studies on the relation between financial constraints and M&As are reviewed.

1.2.1. Financing of Innovation

First, out paper contributes to a large literature documenting the effects of financial frictions on innovation and R&D expenditure. Brown, Fazzari, and Petersen (2009) is one of the most influential papers to investigate the financing of innovative firms. They show that only seven high tech industries are responsible for almost all the variation in R&D spending and show that most of the R&D in those industries is conducted by young firms, which finance innovation mostly with cash flows and new share issues. "The financial cycles for young high-tech firms alone can explain about 75% of *the aggregate R*&D boom and subsequent decline". Similarly Atanassov, Nanda, and Seru (2007) compare high-tech and non-high-tech firms in terms of their financing decisions and highlight public equity as an important source of funding and as an efficient mechanism for the evaluation of intangible assets. They stress not only the type of financing itself, but its continuity as well for the success of innovation. Ayyagari et al. (2007) study the determinants of broadly defined innovation and find a positive relationship between the use of external finance and the extent of innovation. A more recent paper by Gorodnichenko and Schnitzer (2013) provide theoretical rationale why access to external finance matters for firms' innovation, even though most firms report to rely on internal finance for their innovation activities. They also find empirical evidence that difficult and costly access to external finance hampers firms' innovation and exporting activities, and preclude firms from benefiting from potential complementarities between exporting and innovation. They also find that financial frictions affect primarily small and young firms, especially in services sectors.

The above studies generally stress how crucial equity financing is for innovative firms. They also show that equity financing is preferable to debt financing due to lack of assets which can be used as collateral, particularly in the case of lending to innovative, high tech firms. The study here contributes to this literature by unfolding another way of funding innovation, namely, minority stake purchases which come with cash inflows.

1.2.2. M&As and Innovation

While the M&As literature is relatively large, studies focusing on the impact of M&As on innovation have been scarce until very recently. Two recent studies in the finance literature examined the innovation outcome of the M&As from the perspective of the acquirer. Bena and Li (2014) investigate what characteristics of corporate innovation activities are related to whether a firm becomes an acquirer or a target firm. They show that firms with large patent portfolios and low R&D expense are acquirers, while companies with high R&D expenses and slow growth in patent output are more likely to be targets. They also find that acquirers with prior technological linkage to their target firms innovate more after acquisitions. The paper concludes that synergies obtained from combining innovation capabilities are important drivers of acquisitions. Similarly, Sevilir and Tian (2012) provide evidence that acquiring firms innovate more following acquisitions. They find that the effect is more pronounced when the acquirer's innovation output is lower than that of the target firm, which suggests that firms with a lower ability to innovate acquire more innovative firms to enhance their innovation output. The paper uses detailed patent data to provide evidence that firms in a wide

variety of industries rely on M&A to increase their innovation output. Our study differentiates from these studies in that we are able to investigate the target firms' performance following acquisitions and highlight the financing role of the M&As activity.

In a similar vein and consistent with the above studies, Phillips and Zhdanov (2013) find that an active market for corporate control leads to more R&D activities undertaken by smaller firms, with larger firms engaging more in acquisitions of smaller innovative firms. They argue that it is more advantageous for larger firms to purchase smaller innovative firms instead of competing against them.

Our study contributes to this literature by examining the innovation output when targets and acquirers invest in each other while staying as independent organizations. Furthermore, none of the studies relating M&As transactions to innovation examines what happens to target's innovation performance afterwards.

1.2.3. M&As and Financial Constraints

Financial synergies between target and acquirer as a motivation is one of the numerous topics studied in the M&As literature. Ouimet(2013), Liao (2014) and Erel, Jang and Weisbach (2014) are some of the studies employing various measures of being financially constrained and providing evidence that targets are financially constrained firms. Ouimet (2013) examines the choice between minority and majority acquisitions and indicates that minority equity acquisition is more likely when target experiences

negative cash flows and when it is important to keep the incentives of the target management alive. Similarly, Liao (2014) provides an international comparison of targets of minority acquisitions versus other existent firms, and show that non-dividend payer firms are more likely to be targets of minority acquisition deals. Non-dividend payments are used as a measure of liquidity constraints.

The recent study by Erel, Jang and Weisbach (2014) is unique due to its ability to examine both financial constraints and post-acquisition investment activities of European target firms in case of majority acquisitions. Using the level of cash, the sensitivity of cash to cash flow, the sensitivity of investment to cash flow as a measure of being financially constrained for target firms in European countries they document declines in all these measures of financial constraints and report increases in the investments in the post-merger period.

Following these highlighted findings in the literature, a natural question to ask is whether innovative, patenting firms, which are more likely to be in need of financing due to their intangible information structure, benefit from funding through the partial equity stake sales. Further, if there are improvements in the financial situation of target firms it is important to know whether or not these improvements are reflected in the innovation performance in the post-acquisition period.

1.3. Data, Sample Construction and Empirical Methodology

1. 3.1. Data

Several databases are combined for this study. Our starting point is the data on minority acquisition deals. First, from Thomson Reuters Securities Data Commission (SDC), a database covering M&As, we extract data on partial equity acquisitions of United States publicly held companies between 1983 and 2002, for all industries except the financial sector. We restrict the sample to deals in which the acquirer firm acquires less than 50 percent of the target. These deals are coded as "Acquisition of Partial Interest" in the database. There are 10,584 such partial acquisition deals identified in the database. In these 10,584 deals, the targets are 5,968 unique US publicly traded firms. This database contains identifier codes for targets and acquirers, deal characteristics such as payment methods, deal status, the value of the partial acquisition, the percentage of the shares acquired, the announcement date for the acquisition, etc.

Second, the balance sheet information of these target firms is obtained from WRDS Compustat Database for the same period. We are able to obtain target firms' financial information for 5,160 deals from Compustat. Even though we exclude targets in financial industries while downloading SDC data, after a second check with merged Compustat file we still observe some financial firms among targets. Using Compustat SIC codes we dropped the deals in which the target operates in the financial industries with the codes between 60 and 69. It further drops the sample size to 4149 deals. Moreover, the deals where financial companies such as banks, investment and insurance

companies are the acquirers are excluded from the sample due to their more complicated motivations, which further decreases the number of acquisitions significantly to 1194. Dropping the deals for which we do not have at least 3 years post-acquisition and 1 year prior financial information and deals which are not completed gives us a sample of 508 partial acquisitions during the 1983-1999 period.

Patenting is not a common activity among firms in most of the industries and even in patent intense industries there are many firms which do not patent. Therefore, to examine the relevant targets of minority acquisitions in terms of patenting we follow Chava et al (2013) and Lerner et al (2011) and keep only those firms which patented at least once over the sample period. After this final adjustment, the deal number drops to 297.

Patent Data is obtained from the National Bureau of Economic Research (NBER) Patent Database. We make use of 2006 version of NBER data which includes all patents (over 3.2 million) granted by the Unites States Patent and Trademark Office (USPTO) between 1976 and 2006 and documents over 20 million citations received by these granted patents. Detailed explanation about the database is given by Hall, Jaffe, and Trajtenberg (2001). Instead of grant year of a patent we make use of patent application year; Comanor and Scherer (1969) find that the timing of a new product introduction is better reflected in the patent applications since grant year of a patent may depend on external factors rather than firm related ones. Patent data suffers from truncation problem since it only includes a patent if it is granted by the USPTO. Therefore, toward the end of

the sample period the number of the patents granted per applied patent number increases dramatically since the data only includes granted patents. Similarly, since patents keep receiving citations after the sample period, citation numbers of patents applied in the later periods are downward biased. Following Hall, Jaffe, and Trajtenberg (2005) we address these problems by using truncation correction weights calculated from application-grant lag distribution for both citation numbers and patent counts. As an additional precaution we do not use the patent data later than 2002 since the variation of the ratio of number of patents applied divided by the number of patents granted is very high for those years.

Finally, for all 297 minority stake acquisition deals, data on the existence of a cash flow transfer from acquirer to target through the transaction is collected. Cash flows are identified through online resources, such as factiva and online newspapers. In most cases, the amount of shares issued to the acquirer is announced, together with the cost of the shares. However, not all minority acquisitions are conducted between target and acquirer directly. In many cases, acquirer firm purchases minority stakes in the stock market long after shares issued by target. We code those acquisitions as open market purchases with no simultaneous cash flows to target and examine them separately. Further, when we code these deals as open market minority acquisitions we also use the SDC Global New Issues database to verify that there are no new shares issued by the target firms during the year of minority stake purchases. We subsequently make use of the open market deals in placebo regressions as control groups.

1.3.2. Summary Statistics

The definitions of all variables used in this study are explained in Table 1.1 below. We focus on firm innovation measured using patent data. Firm age, size, R&D expenses, Cash/total assets, EBITA/total assets are used as control variables.

[Insert Table 1.1.1 here]

Table 2 below presents the summary statistics for variables used in regressions, together with the results from mean difference tests for various classes of target firms before and after acquisition. We classify firms into two categories, based on their cumulative patent portfolios before acquisitions. We use this classification in order to account for some ex ante firm characteristics which may impact post-acquisition innovation. As Blundell et al (1999) argues, pre-sample technology stocks to firms are exogenous to shocks to innovation in the post-acquisition period.

[Insert Table 1.1.2 about here]

To conduct the mean difference tests the sample is restricted to firms for which we have observations at least two years before and after the deal. The significance tests are conducted using deal level clustered standard errors. The table is divided into four panels. In Panel A presents statistics for whole sample of target firms which obtained cash through deals. Panel B consist firms which had a small patent portfolio prior to the minority acquisitions, while Panel C include firms which had larger patent portfolios

relative the firms in Panel B[8]. The summary statistics presented in Panel D are for targets of minority acquisitions where no cash was transferred to the target.

Firms in Panel B have some distinct properties. Targets in this subsample have lower than the median cumulative patent count before acquisition, and got cash inflow through minority acquisition. These firms are younger and smaller in size, but average R&D expenses are high and comparable with targets in samples C and D. Unlike all other subsamples they experienced a statistically significant increase in the mean patent quantity and quality following the minority acquisitions. Noticeably, targets in this subsample significantly increase their cash holdings after acquisitions, unlike targets in all other subsamples.

Panel C shows firms that were the target of minority acquisitions with cash transfer, and which had an above median cumulative patent count before the acquisition. They too had large R&D expenditure levels, but contrary to the small patent portfolio firms, they had much higher levels of cash flow before being acquired, and there is no statistically significant change after acquisition neither in the levels of cash nor in their levels of innovation.

Subsample D also provides interesting observations. Deals in this subsample, where no cash is transferred to the target firm, are used to conduct regressions for placebo

[8] The year prior to a minority acquisition, firms divided based on their cumulative patent stock. If a firm possesses more than the median cumulative patent count among all firms, the firm is coded as Pre-Acquisition Large Patent Portfolio Firm, and a firm with less than the median cumulative patent count prior to the minority acquisitions is coded as Pre-Acquisition Small Patent Portfolio Firm.

minority acquisitions. These targets are also the oldest in the data, and have high R&D expenses, and high levels of innovation. Interestingly, target firms' size is the largest, and the ratio of Cash over Total Assets is the smallest relative to the other samples. Very small Cash holding relative to their size implies that they are not financially constrained as much as the other targets. There is no statistically significant difference between the levels of innovation, cash to total assets or R&D, before and after minority acquisition.

Comparisons of the mean age among the various subsamples show that there seems to be a nonlinear relation between the mean ages of the target firms and the ratio of cash holdings to total assets. The oldest and largest firms in the sample are the targets of no cash transfer minority acquisitions and have the lowest cash holdings rates among the subsamples. Interestingly, among the cash transfer acquisitions, pre-acquisition small patent portfolio firms are the youngest and have lower cash holdings relative to their total assets, especially relative to large-patent portfolio firms.

1.3.3. Empirical Methodology

We start to investigate the impact of minority acquisitions on the post-acquisition innovation performance of target firms by using ordinary least squares method. We set up the following baseline panel regression model:

$$lnY_{it} =$$

$$\alpha_i + \beta After\_Acquisition_{it} +$$

$$\lambda(After\_Acquisition_{it} * Small\ Patent\ Portfolio\ Firm_i) + \gamma X_{it-1} + \delta_t + \tau_i + \varepsilon_{ict} \quad (1.1)$$

Where the dependent variable lnY_{it} is the measure of innovation, calculated in two ways: first, as the log of one plus the total number of patents applied in year *t*; and second, as the log of one plus firm *i*'s total number of non-self citations received per patent applied in the year *t*. The independent variable *After-Acquisition* is a dummy variable equals one for five years following the acquisition of minority interest in the target firm.[9] X_{it-1} is a vector of time variant target firm control variables lagged one year. It includes log of total assets as a measure for firm's size, earnings before interest taxes depreciation and amortization (EBITA) divided by total assets, log of R&D expenses, Cash amount held divided by total assets. The firm's age and age squared are also introduced in the regression. $\boldsymbol{\tau_i, \delta_t,}$ control for firm and year fixed effects, respectively. Standard errors are clustered at deal level in all regressions.

The empirical methodology presented above is used to analyze the impact of minority acquisition on the post-acquisition innovation performance of the whole sample of acquisitions as well as of two subsamples. The variable of interest in dividing the sample of firms is the cumulative number of patents applied by the target firm until the year of acquisition announcement.[10] Firms with less than median cumulative patent count

[9] Redefining the *After-Acquisition* dummy equal to one for three years after the minority acquisition does not change the results.

[10] The cumulative patent count considers patent applications since 1976, the beginning of 1976-2006 version of the NBER patent data.

before the acquisition form the subsample of *small pre-acquisition patent portfolio firms* (the dummy takes the value 1 for target firms which had lower than median cumulative patent count before announcement, and zero otherwise). The independent variable of interest is therefore the interaction term *After-Acquisition*Small Patent Portfolio Firm*. Through this division we aim to account for the size of the patent portfolio of firm *i* before the acquisition and thus to some extent capture some permanent differences among firms.

1.4. Empirical Results

1.4.1. Baseline Regressions

The results, presented in Table 3 show how target firms' innovation performance is affected by minority equity purchase. We take into account the before acquisition innovation performances across target firms and divide the sample into two subsamples: *Pre-Acquisition Small Patent Portfolio Firms,* and *Pre-Acquisition Large Patent Portfolio Firms*. If indeed cash inflow from minority stakes purchases is most beneficial to target firms which are financially constrained, the coefficient of the interaction variable *After-Acquisition*Small Patent Portfolio Firm* will be positive and statistically significant.

[Insert Table 1.3 about Here]

The first two columns of Table 1.3 provide estimates for the quantity of the innovation measured as the patent count, while the last two columns capture the quality

of innovation, measured as the number of non-self citations received per patent applied. The regression sample includes all minority acquisitions accompanied by cash transfers to the target firms. Interestingly, *After-Acquisition* dummy, which equals one for five years after the minority stake purchase is statistically insignificant and indicates no impact of minority acquisitions on the post-acquisition innovation performance of the target. However, this is not the case for all targets. Small patent portfolio firms, which are also most likely to be financially constrained, innovate more following minority acquisitions accompanied by cash transfers. The interaction term *After-Acquisition*Small Patent Portfolio Firm* is positive, statistically, and economically highly significant, suggesting that it is precisely the cash constrained innovative firms which benefited from cash inflows following minority acquisitions by increasing their innovation activity. The other variables have the expected signs. R&D expenditure is an important determinant of innovation, and has positive and significant impact on the innovation. The results also show that the size of the firm is positively and significantly related to the innovation quantity.

The last two columns of Table 3 confirm our previous findings. In the last two columns we capture the quality of innovation, measured as the log of one plus simple count of the nonself citations received per patent applied in the year. As before the coefficient of the interaction term *After-Acquisition*Small Patent Portfolio* is positive and statistically significant. Minority acquisitions accompanied by cash transfer positively affect target's innovation but only in the case of financially constrained, pre-

acquisition small patent portfolio firms. The impact is economically significant, controlling for age in the last column we find that the number of nonself citations received per patent applied by a small patent portfolio firm increases by 23% (55-32) following the sale of minority equity stake. The age of the firm is important, estimated coefficients confirming a non-linear relation between firm's age and its innovation performance, younger firms innovate more, while the innovation of older firms tappers down.

1.4.2. Dynamic Effects

It is possible that the impact of cash infusion through minority acquisition on the patenting activity may take some time to manifest itself. Patenting in some industries, such as pharmaceutical industry, is a long and costly process. In this section we analyze the dynamic impact of minority stake acquisitions on the target firms' patenting quality and quantity. In particular we consider the first five consecutive years following the year of the minority acquisition. The results are presented in Table 1.4.

[Insert Table 1.4 about Here]

Again, the first two columns present the results using patent counts as a measure of innovation, while the last two columns provide estimates using the non-self citations per patent applied. The regression sample includes all minority acquisitions accompanied by cash transfers to the target firms. The results using both measures of innovation are similar – as expected, they show that the effect takes some time to manifest itself. Indeed

the positive impact of minority acquisitions occurs in the second, third and fourth years following the minority shares sale. When we look at patent quality, the impact is most significant in the third, fourth, and fifth years. Our results thus show that minority acquisitions accompanied by cash transfers have a significant impact on innovation, and that this effect takes at least one year to manifest itself.

1.4.3 Financial Constraints

As previously mentioned, financial synergies between targets and acquirers are often stressed in the literature as one of the main determinants of acquisitions. Particularly, alleviating target firms' liquidity constraints, which allows firms to increase investment following the acquisition has been stressed as an important outcome of majority acquisitions (Erel, Yang, Weisbach (2014)). Our previous results corroborate these findings in the context of minority acquisitions, but only when accompanied by cash flow to the target firms. To strengthen our results from the financial constraints perspective, we provide further analysis in this section. We divide the sample of target firms into more or less financially constrained and test whether minority acquisitions accompanied by cash transfers to targets improve their post-acquisition innovation performance.

First, we follow the classification suggested by Fazzari, Hubbard, and Petersen (1988). The authors highlight the difference in the costs of internal versus external financing, and argue that firms facing financial constraints will retain more of their funds to finance their investments. Therefore, they differentiate firms based on the retention

rates, and label those who pay low percentage of their incomes in dividend as financially constrained. We conduct a similar analysis. Based on target firms' pre-acquisition dividend policies we divide them into two samples; firms which pay dividends and firms which do not. We then reestimate the regression model for these two subsamples of firms. The results for both subsamples are presented in Table 1.5. The first two columns of Table 1.5 provide estimates for financially constrained firms, i.e. non-dividend payer firms prior to the minority acquisition. The results show that these firms increase the number of non-self citations received following the sale of minority stakes accompanied by cash transfers. The coefficient of the interaction term *After-Acquisition*Small Patent Portfolio* is positive and statistically significant. The economic impact of acquisitions is similar to the baseline regressions. Similar results are also obtained when the number of patents applied is used, financially constrained firms increase the number of the patent applications after the sale of minority stakes. Consistent with the observations of Fazzari, Hubbard, and Petersen (1988), excluding non-dividend payer firms, thus financially constrained firms, our positive significant interaction term becomes statistically insignificant in the last two columns of table 1.5.

Further, we use another definition for financially constrained firms. We divide firms based on their *Earnings before interest, taxes, depreciation, and amortization* prior to the sale of minority shares. Excluding firms which had negative earnings (i.e. financially constrained firms) produces estimates which are no longer statistically

significant.[11] That is, the post minority acquisition innovation performance of target firms increases, but only in the case of a priori liquidity constrained targets which received cash inflows.

As another measure of liquidity constraints we use the Kaplan-Zingales index(KZ-Index)[12]. The higher KZ-Index for a firm indicates that firm faces higher financial constraints to finance ongoing operations. Using the pre-acquisition observations for target firms, we create KZ-Index for each firm. Then, we repeat our baseline regressions for firms which had a KZ-Index which is lower than the median among other firms. These firms have lower KZ-Index so that they are not financially constrained as other firms. The first column in Table 1.6 present the results for firms with low KZ-Index, thus less financially constrained. The results are in line with the previous findings; when target firm is not financially constrained, minority acquisitions do not result in increases in the innovation. The last three columns provide the results for financially constrained firms, which had KZ-Index larger than the median(Column II), the third quartile(Column III), the highest decile(Column IV). All of the results in these regressions indicate that there are economically and statistically significant increases in the innovation performance of financially constrained firms. Together with the results from the baseline model, these findings suggest that it is particularly the relief of financial constraints through the sale of minority equities which drives our results.

[11] Results not reported to save space, but available upon request.
[12] For more detail about the index, see Livdan, Sapriza and Zhang(2009).

1.5. Robustness Checks

1. 5.1. No-Cash Transfer Placebo Minority Acquisitions

One of the possible concerns related to the results in the previous section is that the increased innovation performance of small patent portfolio firms following minority stake acquisitions might be biased due to endonegenity. If acquirer firms purchase minority stakes because they anticipate that some targets with specific characteristics will increase their innovation in the near future then our causality is flawed. We hypothesize that the channel through which the increase in the innovation performance is experienced is cash flow transfer to liquidity constrained target firms. Therefore, if there is no cash flow transferred from acquirer to target we should not see any positive impact of minority acquisition on the post-acquisition innovation performance of the target.

The hand-collected data identifying open market purchases with no cash transfer to the target enable us to set up a natural experimental design to address the concerns. We focus on minority acquisitions where the acquirer purchase already issued and traded shares in the open market. In these acquisitions shares change hands but no cash funds are transferred to the target firm. However, if indeed it is the case that acquirer firms cherry pick targets with potential of increased innovation performance regardless of their cash constraints, we should obtain the same positive impact after acquisition.

We therefore focus next on a sample of open market minority acquisitions, where there was *no* simultaneous cash transfer to target firms. The econometric model and the

criteria for sample classifications are the same are in the baseline specification. The results are presented in Table 1.7.

[Insert Table 1.7 about here]

We again present two estimates for the quantity and two for the quality of innovation. The estimates across all models show that minority acquisitions do not impact the post-acquisition innovation capability of the target when there is no cash transfer to the target firm. Interestingly, the formerly positive and statistically significant effect of minority stake purchase on the innovation of target firms with small patent portfolios prior to acquisition turns insignificant. The results confirm our hypothesis that when minority acquisitions that are not followed by cash transfers there is no impact on the post-acquisition performance of any target firms. We thus find no support for the argument that firms anticipate the increase in the innovation performance and invest in a priori potentially highly innovation targets. The results support our hypothesis that it is precisely the cash transfer to target firms which helps liquidity constrained innovative (captured here by small patent portfolio firms) targets to innovate more after the acquisitions.

1. 5.2. Matched Sample

While the previous results strongly indicate that firms increase their innovation performance after being financed through minority acquisitions, in this section we try to address the following question; whether a similar size firm, which is not targeted in the

acquisition, having similar previous technological stock in the same industry as in targeted firms would increase the innovation performance.

For the sample of target firms examined in the baseline regressions, we found patenting firms which are not targeted in minority acquisition but with similar characteristics the year prior to the minority acquisition. In the same year and in the same two digit industry we found firms with the closest size and having similar the technological stock (cumulative patent stock). One year before the minority acquisition firms in the base sample have a mean total assets of $1.12B while firms in the matched sample has the mean total assets of $1.08B . In addition, the average cumulative number of patent applied until the year of minority acquisition is 110 for base sample while it is 119 for the matched sample.

[Insert Table 1.8 about here]

The main analysis investigating the impact of minority acquisition on innovation in table 3 is repeated for the matched sample. The results for the matched sample are presented in the table 1.8. The results indicate that there is no significant increase in the innovation for the matched firms unlike the targeted firms. If there is anything, similar size matched firms having smaller patent stocks show a deteriorating innovation performance. Together with the main results, it suggests that while firms financed through minority acquisitions increase their innovation performance in the following years, firms, which are not targeted in that year, are very similar in terms of size and

patent stock, also existing in the same two digit industry do not increase their innovation output.

1. 5.3 Announced but Failed Acquisitions

The next thing we do to address the endogeneity concern is to investigate incomplete deals. Thomson Reuters SDC database also report deals where a minority acquisition is announced but the acquirer and the target do not complete the transaction. In those deals there is an attempt by the acquirer firms to purchase shares in target firms, but the transaction is not finalized and no money is transferred from acquirer to target. Again, if acquirers indeed select target firms with potential for increased innovation performance we would expect that firms targeted in acquisitions improve their performance even after the failed acquisition attempt. If, on the other side, minority acquisitions improve target's performance by alleviating target firms' liquidity constrained, announced but failed acquisitions should show no impact the performance of targets.

[Insert Table 1.9 about here]

Table 1.9 presents the results using the baseline regressions on a sample of announced but failed minority acquisitions. The estimates are insignificant when we use the number of patents applied as our dependent variable, supporting our hypothesis. However, the number of non-self citations received increases significantly following the

incomplete deals. This increase might be because target firms may get more publicity when the acquisitions are announced, more exposure and thus get more citations.

1. 6. Additional Robustness Checks

1. 6.1 Alternative Econometric Model

We next consider an alternative econometric model to check if our results are still valid. Following Hausman, Hall, and Grilliches (1984) we employ a fixed effects panel Poisson regression model for two dependent variables in count data form: the number of patents applied by target firm and the number of non-self citations received per patent applied after the minority acquisition. The dependent variables are thus used without any transformation in their count data form. We set up the following model;

$$E[Y_{it}|Minority\ Acquisition_{it}] = exp[\alpha + \beta After + \gamma X_{it-1} + \tau_i + \delta_t] \quad (1.2)$$

To address the concerns related to the use of interaction terms in non-linear models (see Ai and Norton (2003)) we estimate the Poisson regressions without interaction terms, separately for the two subsamples: the pre-acquisition smaller patent portfolio firms and the pre-acquisition large patent portfolio firms.

[Insert Table 1.10 about here]

The results of the panel Poisson model are presented in a dynamic setting in Table 1.10 for two count dependent variables. The first two columns present the results for firms with large pre-acquisition patent portfolio; in the last two columns firms with small pre acquisition patent portfolios are considered. The dependent variables are the simple non-self citation count per patent (columns 1 and 3) and patent count (2^{nd} and 4^{th}columns). The results are consistent with our previous findings - there is a strong positive correlation between the minority equity sale and our measures of innovation, but only in the case of small pre acquisition patent portfolio firms. The results hold when both measures of innovation are used. The impact is economically significant: the size of the coefficient fluctuates between 34% and 60% over the first four years.

1. 6. 2 Other robustness checks

Since our analysis at the deal level, there are some deals where the acquirers are the same firms. Therefore, a concern related to this is that our results might be driven by a few acquirers. While the percentage of the deals where one acquirer buys minority shares in different targets is very low, we take into consideration this possibility and re-estimate the regressions including acquirer fixed effects. While not reported to save space, all results are similar to the ones reported above. Also, sometimes firms are targeted in minority share acquisitions more than once over the sample. While these deals do not comprise a large percentage of our sample, we repeat the analysis by only including first time minority acquisition deals, and our results are similar in that case.

Including further control variables commonly used in the finance literature such

as HHI(Herfindahl-Hirschman Index), Leverage, Capital Expenditures do not change the results significantly.

1. 7. Conclusion

The results of the study indicate that cash transferred through minority stake purchase is an important source of financing for target firms to fund their innovation activities. The change in the innovation performance of the publicly held firms is investigated after the minority equity purchases. The study indicates that the acquisition of the minority interest in the publicly held target firms having a small patent portfolio prior to the acquisition increases targets' total number of non-self citations per patent received by 23% following the acquisition. Additionally, the total number of simple patent count increases by 10%. We find that if minority shares are acquired from a priori large patent portfolio firm or a firm which is not financially constrained, the acquisitions do not result in any change in targets' post-acquisition innovation.

To address the endogeneity concerns, we differentiate the acquisitions where no cash is transferred to the target firms by hand collecting data from news papers and other online sources. The results from the regressions using no-cash flow minority acquisitions support our argument. The positive impact of the minority acquisitions on innovation performance is not existent when there is no capital flow to the target firm. Further, in the year of minority acquisition, the examination of similar-sized firms in the same industry and having similar technological stock show that these matched firms do not show

increased innovation performance. We also investigate announced but failed acquisitions and find that there is no impact on ex post innovation quantity of targets following incomplete deals. Alternative economic model using count data without any transformation and without using interaction terms provide similar results with the baseline regressions.

In sum, our study provides a previously unexplored benefit of the minority stake purchases. Funds obtained by firms through minority stakes sale with previously weak innovation performance result in increased patenting and higher citations received per patent applied afterwards.

Table 1.1: Variable Definitions and Data Sources

Table 1.1 provides the definitions of the variables used in the study and sources of the variables.

Dependent Variables	
Ln(Non-Self Citations per Patent Applied)	Logarithm of one plus The total number of non-self citations received per patent applied by firm i in year t. (NBER Patent Data Project)
Ln(Total Patent number Applied)	Logarithm of one plus The total number of patents applied by firm i in year t. (NBER Patent Data Project)
Patent Count	The total number of patents applied by firm i in year t (NBER Patent Data Project)
Non-Self Citation Count	The total number of non-self citations received for the patents applied by firm i in year t (NBER Patent Data Project)
Total Citation Count	The total number of citations received for the patents applied by firm i in year t (NBER Patent Data Project)
Independent Variables	
Ln(Sales)	Logarithm of Sales (Compustat)
Ln(Total Assets)	Logarithm of Total Assets(Compustat)
Ebitda/Total Assets	Earnings Before Interests, Taxes, Depreciation and Amortization divided by Total Assets (Compustat)
Cash/Total Assets	Cash Amount held by firm i in year t normalized by total assets. (Compustat)
Ln(R&D Exp)	Research and Development Expenses by firm i in year t. (Compustat)
Age	The total number of years since the time firm first appears on compustat (Compustat)
After-Acquisition	A dummy which equals one for the observations five years after the announcement of the minority acquisition.
Smaller Patent Portfolio Firm	A dummy variable which equals one if the target firm has lower than the median cumulative patent count one year prior to the announcement of the minority stake purchase

Table 1.2: Summary Statistics and Non-Parametric Before-After Acquisition Mean Tests

Table 1.2 shows the descriptive statistics for targets of minority acquisitions. In all panels except panel D cash is transferred to target firms. Panels B and C are subsamples of Panel A based on the median cumulative patent portfolios of the target firms before acquisitions. To be able to conduct mean difference tests we restrict the observations to one, respectively two years before and after acquisitions. In the last three columns summary statistics for the unbalanced sample used in regressions are presented. The definitions of all variables are provided in Table I. Deal level clustered standard errors are used to conduct mean difference tests. ∗, ∗∗, and ∗∗∗ denote significance at 10%, 5%, and 1% level, respectively.

	Before-After Acquisition Mean Comparison Test		**Overall Sample Statistics**		
Variable Name	**Before Mean**	**After Mean**	**Sample Mean**	**St. Dev.**	**Observation Number**
Panel A: Whole Sample - Cash Transferred to Targets					
Ln(Total Assets)	4.77	4.93	5.04	2.19	2075
Ebitda/Total Assets	-0.09	-0.07	-0.06	0.30	2075
Ln(R&D Exp)	2.98	3.09	3.24	2.04	2075
Cash/Total Assets	0.17	0. 20	0.17	0.21	2075
Ln(Total Patent number Applied)	1.18	1.50	1.38	1.45	2075
Ln(No of non-self citations received)	1.63	2.06***	1.91	1.32	2075
Age			23.29	26.29	2075
Percentage of Shares Acquired			10.75	7.98	2075
Panel B: Subsample; Pre-Acquisition Small Patent Portfolio Firms					
Ln(Total Assets)	4.66	4.59	4.79	2.15	1019
Ebitda/Total Assets	-0.08	-0.07	-0.06	0.30	1019
Ln(R&D Exp)	3.04	3.01	3.30	2.31	1019
Cash/Total Assets	0.13	0.18	0.16	0.19	1019
Ln(Total Patent number Applied)	0.30	0.90***	0.77	1.03	1019
Ln(No of non-self citations received)	0.96	1.68***	1.55	1.37	1019
Age			16.30	19.64	1019

Percentage of Shares Acquired			11.21	8.94	1019
Panel C: Subsample; Pre-Acquisition Large Patent Portfolio Firms					
Ln(Total Assets)	4.88	5.23	5.29	2.19	1056
Ebitda/Total Assets	-0.11	-0.08	-0.06	0.30	1056
Ln(R&D Exp)	2.93	3.17	3.18	1.74	1056
Cash/Total Assets	0.20	0.21	0.19	0.22	1056
Ln(Total Patent number Applied)	2.21	2.40	1.97	1.55	1056
Ln(No of non-self citations received)	1.97	2.02	2.26	1.17	1056
Age			30.04	29.89	1056
Percentage of Shares Acquired			10.24	6.79	1056
Panel D: No-Cash Transfers Sample (Targets of Open Market Minority Acquisitions)					
Ln(Total Assets)	5.31	5.54	5.56	2.12	1399
Ebitda/Total Assets	0.09	0.08	0.09	0.15	1399
Ln(R&D Exp)	3.50	3.81	3.65	2.56	1399
Cash/Total Assets	0.08	0.08	0.08	0.14	1399
Ln(Total Patent number Applied)	0.99	0.98	1.03	1.32	1399
Ln(No of non-self citations received)	1.18	1.41	1.45	1.18	1399
Age			47.11	38.25	1399
Percentage of Shares Acquired			7.55	6.59	1399

Table 1.3-Baseline Regressions, Patent Number Applied and Non-Self Citations Received per Patent Applied after Minority Acquisitions

The table presents estimates from panel OLS regressions. Only minority stake purchases with cash transfer to target are included. Any deal in which acquirer or target is a financial firm excluded from the sample. The dependent variables are: log total number of patent applied by target firm in the year (first two columns), and log total number of non-self citations received per patent applied by firm (last two columns). *After-Acquisition* dummy equals one for five years after the minority acquisition announcement year. *After-Acquisition*Smaller Patent Portfolio Firm* is a dummy which equals one for five years after the acquisition announcement of the target firms which had lower than median cumulative patent count before announcement. Standard errors are robust and clustered at deal level. The definitions of all variables are provided in Table 1.1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable			
	Ln(Patent Count)		Ln(Non-Self Citations per Patent)	
	(I)	(II)	(III)	(IV)
After-Acquisition	-0.088	-0.088	-0.330***	-0.324***
	(0.060)	(0.056)	(0.088)	(0.090)
After-Acquisition*Smaller Patent Portfolio Firm	0.186**	0.186**	0.558***	0.554***
	(0.090)	(0.088)	(0.147)	(0.148)
Ln(Total Assets)	0.198***	0.197***	0.242**	0.246**
	(0.062)	(0.061)	(0.112)	(0.113)
Ebitda/Total Assets	-0.063	-0.064	0.081	0.089
	(0.144)	(0.146)	(0.335)	(0.336)
Cash/Total Assets	0.063	0.063	0.160	0.159
	(0.138)	(0.138)	(0.287)	(0.287)
Ln(R&D Exp.)	0.474***	0.473***	0.009	0.017
	(0.099)	(0.099)	(0.123)	(0.124)
Age		-0.025		-0.116***
		(0.017)		(0.025)
Age(Squared)		-0.000		0.000
		(0.000)		(0.000)

Constant	-0.760**	0.023	-1.014**	2.428***
	(0.339)	(0.404)	(0.451)	(0.543)
Firm Fixed Effects	yes	yes	yes	yes
Year Fixed Effects	yes	yes	yes	yes
Deal Number	165	165	165	165
N	1587	1587	1587	1587
R-Squared	0.3232	0.3232	0.1892	0.1894

Table 1.4- Dynamic Effects

Table 1.4 shows the results from Ordinary Least Squares regressions. Deals where acquirers or targets are financial firms and deals without cash flow to target firms are excluded from the sample. The dependent variable is the log of the total number of patent applied for first two columns, (I)-(II), the log of the number of non-self citations received per patent applied by firm in the year is for the last two models, (III),(IV). After-Acquisition(t+n) equals one for n^{th} year after the announcement of the minority acquisition. After-Acquisition(t+n)* Smaller Patent Portfolio Firm equals one for n^{th} year after the announcement of the minority acquisition for firms with cumulative patent counts lower than the median cumulative patent count for whole sample prior to the acquisition. Standard errors are robust and clustered at deal level. The definitions of the variables are provided in Table 1.1. $*$, $**$, and $***$ measure significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable			
	Ln(Patent Count)		Ln(Non-Self Citations per Patent)	
	(I)	(II)	(III)	(IV)
After-Acquisition(t+1)* Smaller Patent Portfolio Firm	0.107	0.164	0.556***	0.236
	(0.112)	(0.115)	(0.199)	(0.228)
After-Acquisition(t+2)* Smaller Patent Portfolio Firm	0.193*	0.226*	0.601***	0.385*
	(0.117)	(0.128)	(0.193)	(0.219)
After-Acquisition(t+3)*Smaller Patent Portfolio Firm	0.379***	0.272**	1.120***	0.777***
	(0.122)	(0.117)	(0.184)	(0.209)
After-Acquisition(t+4)* Smaller Patent Portfolio Firm	0.443***	0.302**	1.184***	0.789***
	(0.132)	(0.129)	(0.182)	(0.194)
After-Acquisition(t+5)* Smaller Patent	0.139	-0.084	1.006***	0.615***
	(0.134)	(0.127)	(0.181)	(0.201)

Portfolio Firm

After-Acquisition(t+1)	0.073	-0.092	-0.231*	-0.284**
	(0.088)	(0.075)	(0.125)	(0.127)
After-Acquisition(t+2)	0.089	-0.075	-0.162	-0.166
	(0.084)	(0.078)	(0.112)	(0.122)
After-Acquisition(t+3)	-0.049	-0.128*	-0.460***	-0.394***
	(0.095)	(0.074)	(0.118)	(0.120)
After-Acquisition(t+4)	-0.113	-0.121	-0.566***	-0.412***
	(0.102)	(0.086)	(0.124)	(0.119)
After-Acquisition(t+5)	-0.011	-0.014	-0.522***	-0.360**
	(0.101)	(0.086)	(0.144)	(0.142)
Ln(Total Assets)		0.201***		0.243**
		(0.061)		(0.112)
Ebitda/Total Assets		-0.064		0.101
		(0.147)		(0.334)
Cash/Total Assets		0.063		0.184
		(0.139)		(0.286)
Ln(R&D Exp.)		0.472***		0.007
		(0.100)		(0.125)
Age		-0.024		-0.116***
		(0.017)		(0.025)
Age(Squared)		-0.000		0.000
		(0.000)		(0.000)
Constant	0.821***	0.010	1.241***	2.444***
	(0.198)	(0.409)	(0.236)	(0.543)
Firm Fixed Effects	yes	yes	yes	Yes

Year Fixed Effects	yes	yes	yes	Yes
Deal Number	183	165	183	165
N	2075	1587	2075	1587
R-Squared	0.1547	0.3270	0.1651	0.1952

*Standard errors in parentheses, $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.

Table 1.5- Financially Constrained vs Not-Constrained Firm: The case of Dividend/No-Dividend Payer Firms

The table presents results separately for pre-acquisition dividend paying and not paying firms. The dependent variable is the log of the total number of non-self citations received per patent applied by firm in the year in the columns I and III, the log of the total number of patent applied by firm in the year in the columns II and IV. After-Acquisition dummy equals one for five years after the announcement year of the minority acquisition. *After-Acquisition*Smaller Patent Portfolio Firm* is a dummy which equals one for five years after the announcement year for the target firms which had lower than median cumulative patent count one year before the announcement. Standard errors are robust and clustered at deal level. The definitions of the variables are provided in Table 1.1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	No-Dividend Payer		Dividend Payer	
	Ln(Non-self Citation Count)	Ln(Patent Count)	Ln(Non-self Citation Count)	Ln(Patent Count)
	(I)	(II)	(III)	(IV)
After-Acquisition*Smaller Patent Portfolio Firm	0.501***	0.334***	0.114	0.153
	(0.120)	(0.096)	(0.180)	(0.157)
After-Acquisition	-0.238**	-0.122*	0.041	0.050
	(0.094)	(0.069)	(0.101)	(0.130)
Ln(Total Assets)	-0.020	-0.020	0.062	0.054
	(0.039)	(0.038)	(0.102)	(0.087)
Ebitda/Total Assets	0.119	-0.073	-0.534**	-0.582**
	(0.157)	(0.118)	(0.262)	(0.252)
Cash/Total Assets	0.547**	0.218	-0.180	-0.838***
	(0.249)	(0.160)	(0.406)	(0.302)
Ln(R&D Exp.)	-0.022	0.077	-0.015	0.169*
	(0.040)	(0.048)	(0.080)	(0.097)
Age	0.159***	0.119***	0.092***	0.015
	(0.020)	(0.024)	(0.031)	(0.028)
Age(Squared)	-0.000*	-0.001***	0.000	0.000

	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.086	-0.123	-2.579***	-0.086
	(0.326)	(0.479)	(0.891)	(0.795)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Deal Number	131	131	52	52
N	1318	1318	574	574
R-Squared	0.2748	0.2420	0.2050	0.1275

*Standard errors in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$

Table 1.6 -Financially Constrained vs Not-Constrained Firms: Kaplan-Zingales Index

The table presents results separately for pre-acquisition financially constrained/not-constrained firms. KZ is Kaplan-Zingales Index of Financial Constraints. The higher index for a firm indicates higher financial constraints. Only the minority stake purchases with cash flow to target are included. Any deal in which acquirer or target is a financial firm excluded from the sample. The dependent variables are the log of the total number of non-self citations received per patent applied by firm in the year for all models. The *After-Acquisition* dummy equals one for five years after the announcement year of the minority acquisition. *After-Acquisition*Smaller Patent Portfolio Firm* is a dummy which equals one for five years after the announcement year for the target firms which had lower than median cumulative patent count one year before the announcement. Standard errors are robust and clustered at deal level. The definitions of the variables are provided in Table 1.1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable Ln(Non-Self Citations Per Patent Applied)			
	KZ<Q50 (I) OLS	KZ>Q50 (II) OLS	KZ>Q75 (III) OLS	KZ>Q90 (IV) OLS
After-Acquisition	0.215	0.661***	0.878***	1.493***
*Smaller Patent	(0.278)	(0.172)	(0.235)	(0.412)
Portfolio Firm				
After-Acquisition	0.058	-0.469***	-0.737***	-0.945***
	(0.156)	(0.102)	(0.137)	(0.250)
Age	-0.160***	-0.112***	-0.087	0.040
	(0.045)	(0.030)	(0.053)	(0.099)
Ln(Total Assets)	0.010	0.326**	0.374**	0.219
	(0.191)	(0.128)	(0.179)	(0.302)
Ebitda/Total Assets	0.373	0.012	-0.164	-0.453
	(0.594)	(0.397)	(0.543)	(1.157)
Cash/Total Assets	0.112	0.136	0.446	0.734
	(0.468)	(0.338)	(0.616)	(0.944)
Ln(R&D Exp.)	0.035	0.044	0.003	-0.188

	(0.155)	(0.161)	(0.211)	(0.349)
Constant	5.534***	1.307**	1.114	-1.647
	(0.712)	(0.621)	(1.262)	(1.351)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Deal Number	54	111	64	27
N	446	1141	648	285
R-Squared	0.2554	0.2022	0.1822	0.2257

Table 1.7- Regressions for No-Cash Flow Placebo Minority Acquisitions

The table presents estimates from panel ordinary least square regressions below. Only the minority stake purchases without cash flow to target are included. Any deal in which acquirer or target is a financial firm excluded from the sample. The dependent variable is the log of the total number of patent applied for first two columns, (I)-(II), the log of the number of non-self citations received per patent applied by firm in the year is for the last two models, (III),(IV).After-Acquisition dummy equals one for five years after the announcement year of the minority acquisition. *After-Acquisition*Smaller Patent Portfolio Firm* is a dummy which equals one for five years after the announcement year for the target firms which had lower than median cumulative patent count one year before the announcement. In all regressions year fixed effects are included and standard errors are robust and clustered at deal level. The definitions of the variables are provided in Table 1.1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable			
	Ln(Patent Count)		Ln(Non-Self Citations per Patent)	
	(I)	(II)	(III)	(IV)
After-Acquisition	-0.067	-0.106	0.101	0.100
*Smaller Patent	(0.148)	(0.148)	(0.203)	(0.201)
Portfolio Firm				
After-Acquisition	-0.052	-0.018	-0.189*	-0.187*
	(0.087)	(0.085)	(0.108)	(0.109)
Ln(Total Assets)	-0.177	-0.188	0.419**	0.420**
	(0.192)	(0.189)	(0.188)	(0.188)
Ebitda/Total Assets	1.281***	1.403***	0.176	0.179
	(0.426)	(0.438)	(0.515)	(0.514)
Cash/Total Assets	0.208	0.256	0.750*	0.752*
	(0.289)	(0.279)	(0.449)	(0.451)
Ln(R&D Exp.)	0.867***	0.939***	-0.185	-0.183
	(0.218)	(0.221)	(0.185)	(0.187)
Age		-0.031		-0.084***
		(0.029)		(0.030)
Age(Squared)		0.000**		0.000
		(0.000)		(0.000)
Constant	0.838	1.033	-1.530*	2.834***
	(0.974)	(1.060)	(0.870)	(0.806)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Deal Number	85	85	87	87
N	590	590	891	891
R-Squared	0.3514	0.3637	0.0963	0.0963

Table 1.8- Matched Sample Results

The table presents results from panel ordinary least square regressions. Firms in this sample have the same two digit SIC code, have the similar size and similar patent stock with the firms in the base sample one year before the minority stake purchases occur. The dependent variable is the log of the total number of patent applied for first two columns, (I)-(II), the log of the number of non-self citations received per patent applied by firm in the year is for the last two models, (III),(IV).After-Acquisition dummy equals one for the matched firm for five years after the announcement year of the minority acquisition for the base sample firms. Standard errors are robust and clustered at deal level. The definitions of the variables are provided in Table 1.1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable			
	Ln(Patent Count)		Ln(Non-Self Citations per Patent)	
	(I)	(II)	(III)	(IV)
After-Acquisition *Smaller Patent Portfolio Firm	-0.225**	-0.178*	-0.127	-0.086
	(0.102)	(0.095)	(0.194)	(0.193)
After-Acquisition	0.054	0.019	0.070	0.042
	(0.072)	(0.065)	(0.127)	(0.126)
Ln(Total Assets)	0.055	0.026	0.159*	0.143
	(0.081)	(0.084)	(0.086)	(0.089)
Ebitda/Total Assets	-0.335**	-0.301*	-0.567**	-0.609**
	(0.158)	(0.156)	(0.269)	(0.270)
Cash/Total Assets	0.193	0.112	0.240	0.224
	(0.200)	(0.202)	(0.306)	(0.317)
Ln(R&D Exp.)	0.300***	0.277***	0.020	0.011
	(0.105)	(0.095)	(0.095)	(0.096)
Age		-0.069***		-0.080***
		(0.023)		(0.019)
Age(Squared)		-0.000		-0.000
		(0.000)		(0.000)
Constant	-1.667***	1.234***	-1.217**	1.570***
	(0.605)	(0.405)	(0.528)	(0.368)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Number	107	106	112	111
N	1043	1032	1845	1830
R-Squared	0.2261	0.2474	0.2069	0.2025

Table 1.9- Failed Minority Acquisitions

In this table only incomplete deals are included in the analysis. Any deal in which acquirer or target is a financial firm excluded from the sample. The dependent variables are the log of the total number of non-self citations received per patent applied by firm in the year for the first two models and the log of the total number of patent applied by firm in the year for the last two models. After-Acquisition dummy equals one for five years after the announcement year of the minority acquisition. *After-Acquisition*Smaller Patent Portfolio Firm* is a dummy which equals one for five years after the announcement year for the target firms which had lower than median cumulative patent count one year before the announcement. The standard errors are robust and clustered at deal level. The definitions of the variables are provided in Table 1.1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable Ln(Non-Self Citations Per Patent Applied)	Dependent Variable Ln(Patent Count)
	(I)	(II)
After-Acquisition	0.614***	0.008
*Smaller Patent Portfolio Firm	(0.208)	(0.132)
After-Acquisition	-0.149	0.162*
	(0.139)	(0.088)
Ln(Sales)	-0.047	0.012
	(0.121)	(0.084)
Ebitda/Total Assets	0.520	0.203
	(0.381)	(0.207)
Cash/Total Assets	0.127	0.093
	(0.470)	(0.204)
R&D/Total Assets	0.063	0.409***
	(0.160)	(0.096)
Constant	0.503	1.588**
	(0.561)	(0.748)
Firm Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Deal Number	78	76
N	790	571
R-Squared	0.1449	0.2907

Table 1.10-Alternative Models: Poisson Regressions

Patent Count, Non-Self Citation Received Count After Minority Acquisitions
Table shows the results from fixed effects panel data poisson regressions. Any deal in which acquirer or target is a financial firm excluded from the sample. In the first two columns, only target firms having more than the median cumulative count before the announcement year are included and firms with less than the median cumulative count before the announcement year are included in the last two columns. In first and third columns, the dependent variable is the number of non-self citations received by firm in the year. For the second and fourth columns, the total number of patents applied by firm is the dependent variable. After-Acquisition(t+n) quals one for n^{th} year after the announcement of the minority acquisition. In all regressions firm and year fixed effects are included and standard errors are robust and clustered at deal level. The definitions of the variables are provided in Table 1.1. $*$, $**$, and $***$ measure significance at the 10%, 5%, and 1% level, respectively.

	Large Patent Portfolio		Small Patent Portfolio	
	Non-self Citation Count	Patent Count	Non-self Citation Count	Patent Count
	(I)	(II)	(III)	(IV)
After-Acquisition(t+1)	0.111	0.084	0.444**	0.290
	(0.103)	(0.141)	(0.201)	(0.207)
After-Acquisition(t+2)	0.012	-0.004	0.584**	0.479***
	(0.067)	(0.080)	(0.245)	(0.162)
After-Acquisition(t+3)	-0.095	0.003	0.598**	0.424**
	(0.074)	(0.077)	(0.251)	(0.188)
After-Acquisition(t+4)	-0.056	-0.004	0.339**	0.570***
	(0.118)	(0.103)	(0.142)	(0.167)
After-Acquisition(t+5)	0.072	0.081	-0.205	-0.350***
	(0.087)	(0.076)	(0.183)	(0.132)
Ln(Total Assets)	0.562***	0.457**	-0.023	0.687***
	(0.197)	(0.202)	(0.293)	(0.129)
Ebitda/Total Assets	-0.594*	-1.155***	0.100	-0.570**
	(0.317)	(0.312)	(0.530)	(0.285)
Cash/Total Assets	-0.636	-0.555	0.223	0.496
	(0.387)	(0.568)	(0.333)	(0.323)
Ln(R&D Exp.)	0.451***	0.403*	0.694***	0.472***

	(0.166)	(0.216)	(0.173)	(0.166)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Deal Number	79	77	77	80
N	884	765	462	685

Chapter 2: Innovation and Insider Trading

2. 1. Introduction

Do insiders who know about success/failure probabilities of innovation projects ahead of outside investors trade on this private information? Both the importance of innovation for economy and the gains of insiders from trading have been stressed in several strands of the literature as reviewed below. Further, previous studies provide the evidence of a positive relationship between the success of innovation activities and the market value of the firms[13]. In light of these findings, it is argued here that by taking into account anticipated increases/declines in market value, insiders with private information about success/failure probability of the innovation projects may alter their holdings accordingly.

Therefore, this paper studies whether insiders exploit the private information they posses prior to the disclosure of important innovations. Do insiders earn significant abnormal returns on their trades prior to the important patent applications? Does the existence of stronger governance mechanisms relieve these concerns related to insider trading? How is the size of innovative firm associated with insiders' trade on private information? Do sales by insiders precede the deteriorating innovation performance? These are some of the questions examined in this paper.

[13] Hall, Jaffe, and Trajtenberg(2005), Atasannov(2013) show that patents with large numbers of citations received increase the firm value.

The uniqueness of the innovations to the firm itself makes the gap of information asymmetry between insiders and outsiders large. It also makes it costlier for outsiders to obtain relevant information. While the Securities & Exchange Commission (SEC) restricts corporate insiders making profits from their trading six months prior to important corporate events, the innovation process is generally longer than six months, and it is highly likely that insiders posses private information about the upcoming important innovations long before the SEC's six-month restriction period.

Combining patent and insider trading data on US publicly held companies between 1996- 2008, the study provides evidence that large firms increase innovation significantly following purchases by top executives and large shareholders. More specifically, the number of citations, excluding self citations, received per patent increases by 25% in the year following insider purchases. These purchases of insiders prior to the important patent applications result in significant abnormal returns especially in the long run although trades at the time of the application of the important patens do not earn positive abnormal returns. There is also strong positive association between insiders' buy decisions and subsequent application for patents which are highly successful in their fields. Consistent with the insiders' information advantage, the positive, significant, and economically large increases in the innovation that are documented in this paper are seen only in the year subsequent to the insider purchases, but not persistent afterwards. The results are robust to the inclusion of time-invariant

firm fixed effects, year fixed effects controlling for several firm-specific characteristics, and changing the empirical methodologies employed.

The paper also documents that when mechanisms of better governance exist in the firm, insiders are less able to exploit the private information they have. Specifically, when there is an institutional shareholder holding at least 10% of outstanding shares or an outside director getting paid by the firm either by option or stock grant, the predictive power of insiders is weakened. Similarly, firms which adopt better shareholder rights and fewer governance provisions exhibit less significant results. This is in line with several studies documenting lower abnormal returns for insiders from their trading on private information when their firms have better corporate governance.

Although the general tendency in insider trading studies is to exclude the sales by insiders[14], this paper also investigates whether insiders' trades predict deteriorating future innovation performance. Insiders are more likely to have a closer look at the R&D capabilities of the firm and whether there are fewer technicians, researchers than before or there are problems with the ongoing innovation processes (such as failure of passing a phase). While not as strong as the results for insider purchases, we find that stock sales by insiders precede the decreases in the innovation quality especially among the most important patents in the technological field.

The study also has policy implications. Insider trading laws restrict the trading by insiders only for six months prior to the announcement of important events.

[14] Exceptions include Chen, Nagar, and Rajan (2007), Jagolinzer(2009)

However, the results presented here indicate that asymmetric information between outsiders and insiders can prevail over a long period of time, such as in the process of innovation for patenting firms. This situation provides insiders with an opportunity to trade on private information before the restriction period starts. Several previous studies find that large firms are informationally efficient and abnormal returns from insider trading only occur for smaller firms due to higher information asymmetry related to smaller firms. The study shows that other factors also affect the degree of asymmetric information between insiders and outsiders. The results presented in this study are in line with the findings of Chen, Nagar, and Rajan (2007). They argue that there are significant declines in stock prices of large firms after the delayed disclosures of sales by insiders who exploit their ability to postpone the disclosure of Form-5 sales.

The paper contributes to two lines of thought. Starting with Titman and Wessels (1984) and Brander and Lewis (1986) finance scholars established an important linkage between product market decisions and financial decisions. In this vein, there is a growing body of literature in finance which examines the impact of financial decisions on innovation performance. Acquisitions, takeover provisions, and governance are some examples of the topics that have been investigated from an innovation perspective[15]. To the best of my knowledge, this is the first study that investigates the association between innovation and insider trading.

[15] Acquisitions (Bena and Li(2013), Sevilir and Tian(2012)), Governance(Chemmanur and Tian (2012), Atanassov(2013)), Financing(Atanassov, Nanda, and Seru (2007), Tian and Wang(2011)).

Second, it has been well documented in insider trading literature that insiders can benefit from private information they posses and can subsequently earn abnormal profits or protect themselves from losses when they trade the stock of their company around the important events[16]. This study departs from this literature due to its relation to real decisions; it contributes to this line of thought by highlighting another firm activity which insiders can take advantage of when having private information. Conceptually, Peres (2010) might be the closest to our study in terms of focusing on the relation of output market and insider trading. He shows both theoretically and empirically that firms with more market power have more insider trading and more informative stock prices. On the other hand, the study differentiates from Peres (2010) because of its focus on the relation between innovation output and insider trading.

The chapter is organized as follows. In the next section, the empirical evidence in insider trading studies, the size effect, and the studies approaching to innovation from the firm value perspective are reviewed. In Section 2.3, data sources, summary statistics, and empirical methodology are presented. In Section 2.4, the relation between the stock acquisitions of insiders and subsequent firm innovation performance is investigated empirically. In Section 2.5, several robustness checks are conducted including the previous stock return, the different econometric methods, the long run

[16] Bankruptcies(Gosnell, Keown, and Pinkerton, 1992), Dividend Initiations(John and Lang, 1991), M&As (Keown and Pinkerton (1981), Sanders and Zdanowicz (1992), Agrawal and Jaffeb(1995)), Repurchases(Vermaelen (1984), Lakonishok and Vermaelen (1990), Lee, Mikkelson, and Partch(1992), Brockman and Chung (2001), Louis and White(2007)), Babenko, Tserlukevich, and Vedrashko (2012)), Financial Crisis (Seyhun, 1990), CEO stock option rewards(Yermack, 1997), Lockups(Field and Hanka, 2001).

relation between insider trading and innovation, and so on. Section 2.6 conducts an event study for insider trades prior to important innovations and for the patent applications and grants. Section 2.7 takes into consideration the role of governance in the context of this study. An investigation of the relationship between insider sales and subsequent innovation performance is carried in Section 2.8 in a similar way as in the baseline regressions. Section 2.9 concludes.

2. 2. Literature Review

The Securities and Exchange Act of 1934 prohibits insiders[17] (defined as "directors or officers of the corporation and those holding greater than 10% of the stock") from earning profits by trading their own company's equity six months prior to important corporate events for which insiders are in possession of private information. Insiders have to disclose the information about the trade in two business days.

Previous studies have shown that insiders still earn abnormal returns from their trades which are not considered illegal by SEC. For example, SEC Rule 10b5-1 enables insiders to trade on their company's stock when they pre-plan the transactions. The findings of Jagolinzer (2000) suggest that insiders can strategically trade and earn abnormal returns from their preplanned transactions. Prior to 2002, in some cases, insiders were able to postpone the filing of Form-5 private sale transactions 45 days

[17] http://www.sec.gov/answers/form345.htm

after the end of fiscal year. Chen, Nagar, and Rajan (2007) find that insiders strategically delay these disclosures and stock price drops significantly subsequent to the disclosures. Together these findings suggest that even within the rules, insiders can make strategic trades and can gain profits.

R&D firms posses some distinctive properties which call the effectiveness of the insider trading rules into question. First, one of the characteristics of R&D intensive firms is that they often employ inputs which are intangible and unique to the firm, therefore making it relatively harder for investors/shareholders to obtain private information about them by observing more general patterns of industrial activity. This eventually makes them more difficult to monitor (Titman and Wessels, 1988). Consistent with this argument, Lorek, Stone, Willinger (1999) shows that insiders' informational advantage over outsiders will be higher if a firm's value is dependent on the success of R&D projects since, in these cases, managerial discretion will be the more important determinant of the output.

Several studies strengthen these arguments by providing evidence that the information gap between insiders and outsiders is larger in R&D firms. The findings of Barth, Kasnzik, and McNichols (1998), for instance, indicate that the greater the research and development expenses, the more analysts cover the firm, suggesting a higher information asymmetry between investors and insiders. They also document that firm size is positively associated with analyst coverage. Aboody and Lev's (2000)

finding also supports the argument. They find that the abnormal returns of insiders are significantly higher in firms with more research and development.

Patents applied and citations received per patent applied are measures of the success of R&D investments. Successful innovations affect the market value of the firm. Using citations received per patent applied as a measure of the importance of innovations, Hall, Jaffe, and Trajtenberg (2005) shows that there is a positive, significant effect of innovation and the market value of firms. On the other hand, the timing of a patent application and the progress toward the application are best known by insiders more than any other person. Therefore, considering insiders' informational advantage concerning innovation activities of firms and possible future price increases on the stock of the firm following these successful innovations, the paper investigates the question of whether insiders with substantial private information about ongoing innovation projects exploit this information and increase their holdings of the firm's equity prior to patent applications. If insiders trade on private information about innovation projects undertaken, we would expect them to do so more aggressively prior to the application of highly important innovations. Using non-self citation received per patent as a way of classifying the innovations in terms of their importance in the technological area they are in, we hypothesize that when the patent applied is an important patent relative to those applied in the for that year and industry, the results should be more significant.

2. 3. Data, Descriptive Statistics, and Empirical Methodology

2. 3.1. Data

The data for the empirical analysis is obtained from a variety of sources. Firstly, insider trading data is obtained from Thomson Reuters Insider Filing Database, which provides information extracted from SEC filings such as forms 3, 4, 5. I have followed Alldredge and Cicero (2014) and included only the observations with "cleanse code" R, H, L, C, Y" which is assigned by Thomson Reuters based on the accuracy and reasonableness of insider reports. Further, as in many studies Seyhun (1986), Lakonishok and Lee (2001), Cheng, Nagar, Rajan(2007)), I focus only on the holdings of top five executives "CEO, CFO, CO, President, Chairman of the Board" and Officer /Director holding more than 10% of a class of share. Previous studies show that those are the insiders who are more likely to have superior information compared to the average insider (Baese and Stein, (1979)). In line with several studies (Marin et al (2008) and Lakonishok and Lee (2001), Seyhun (1986)), I restrict the analysis only to the open market transactions and private sale of securities (Thomson Insider Filing Database transaction code "P","S") since they are more likely to be driven by private information compared with the transactions related to stock options awards, etc. Further, in the analysis of insider purchases, I dropped the firms which did not have at least one purchase year (the year in which the number of buyers is greater than number of sellers). The same screening is also applied when studying insider sales. However, the results are similar to the case when we include firms which do not have at least one

purchase/sale year. Finally, the observations earlier than 1996 are dropped due to very low insider trading activity.

The second important part of the data is the innovation data. As a measure of innovation quality and quantity, I use patents and citations data by National Bureau of Economic Research (NBER) Patent Database. The database covers all patents granted by the United States Patent and Trademark Office (USPTO) between 1976-2010. I employ the latest (2010) version of the database compiled by Kogan, Papanikolaou, Serut, and Stoffman (2012). As in many other studies, I use patent application year instead of grant year of patent in the study since it is more likely to show the timing of innovation (Comanor and Scherer, 1969). The patent number applied and number of self/non-self citations received for these patents are extracted from the database at the firm-year level. One drawback of the data is that it only includes granted patents, so toward the end of the sample years, there are patents applied by firms but not included in the sample since they have not been granted, yet. The average lag between patent application and patent grant is about 2-1/2 years[18]. Therefore to overcome the truncation bias, I exclude the last two years 2009, 2010 of the sample years. Further, for 2005, 2006, 2007, and 2008, I correct the total number of patents applied by using the truncation correction weights calculated from application-grant lag distribution as described in Hall, Jaffe, and Trajtenberg (2001). On the other hand, patents keep getting citations, and thus the citation number does not suffer from survivorship bias. However,

[18] http://www.uspto.gov/aia_implementation/aia_section_10_ria_doc-omb_9-6-12.pdf

as in patent count, the truncation problem is also observed in terms of citation received. Patents applied earlier in the sample have longer time horizons ahead of them compared with the patents applied later. Therefore, while it is worse for later applied patents, the total number of citations received per patent applied is biased downward in the sample. I use the fixed effects approach of Hall, Jaffe, and Trajtenberg (2001) to fix the problem. More precisely, I remove all year and technological field effects on the number of citations received by dividing them by the average number of citations received in that particular technological field and year. Also, following Hall, Jaffe, and Trajtenberg (2005), to be included in the sample, I required every firm apply at least one patent over the period I examine.

The balance sheet information for the firms in the sample comes from WRDS Compustat Database. While, I only include manufacturing firms with two digit SIC codes between 20-39 because patenting is more common in manufacturing, the results are similar when including firms outside of the manufacturing industry. Further, to obtain the information non-employee director equity-option awards, I use Compustat's Execucomp database and to get information on the holdings of institutional investors I use Thomson's Institutional Holding database. Insider abnormal returns are calculated using daily stock price from CRSP database.

2. 3.2. Descriptive Statistics

Table 2.1 provides statistics to describe the firms used in the regressions. Previous studies provide empirical evidence that trading behavior of insiders and abnormal returns of these trades change significantly among the firms of different size (Seyhun, 1986, Lakonishok and Lee, 2001). As in Lakonishok and Lee (2001), Sias and Whidbee (2010) the sample is divided into three subsamples based on the average size of the firms examined. The descriptive statistics used in this section and the results presented in the following sections are all for the firms in the top three size deciles based on their total assets[19] (Compustat Item 6). The average size of the firms in the sample is quite large, net worth around $3.5 billion. Firms on average apply for 28 patents which are granted and on average receive 13 non-self citations per patent applied. Insider trading statistics show that insiders have more sells than acquisitions, which is consistent with the previous insider trading studies (Seyhun ,1986, Rozeff and Zaman,1988).

[Table 2.1 about here]

Table 2.2 provides more details for innovation and patent variables. As noted before, the patent database suffers from the truncation problem as it can be seen more clearly in Table 2.2. The first column shows the average non-self citations received per

[19] The descriptive statistics for the middle four size deciles and bottom three deciles are provided in Appendix II. Large firms have some distinct characteristics. The average size of the large firms in top size deciles is $3.5 billion; while it is $179 million for the middle-size firms and $26 million for the smaller firms. In terms of innovation activities, the descriptive statistics indicate that the largest firms are the relevant sample for the analysis. The patenting activity is not common among firms and other size samples have low variation in terms of innovation. For instance, the patenting statistics in Table 2.1 show that the average number of patents applied is 28 for the largest firms while it is only 1.3 for the smallest firms. Therefore, our focus in this study is the largest firms.

patent applied. In 1996, the firms receive 28 non-self citations per patent applied and it decreases to 2.2 in 2008. While truncation is also a problem for patent count, it is less so due to the short average lag between application and grant date of patents (24.6 months)[20]. Average patent count was 25.5 in 1996, and increased to its highest mark of 32.5 in 2002, then dropped to 18 in 2008. Insider trading statistics show that over time, the average sell number increases greatly while the average for insider purchase moves in a smaller range.

[Table 2.2 about here]

2. 3.3. Empirical Methodology

To understand whether the insider trading of executive directors predict the future innovation performance, I set up the following panel Poisson regression model;

$$\mathrm{E}[\, Y_{it} | \text{Insider Trading}] = \exp\left[\beta After\ Insider\ Purchase_{\ it} + \gamma X_{it-1} + \tau_i + \delta_t + \varepsilon ict\right] \quad (2.1).$$

The dependent variable $[Y_{it}]$ will be either the total count of non-self citations received per patent applied in the year *t* or the total count of patent applied in the year *t* by firm *i*.

To construct our insider trading variable "*After Insider Purchase*" we follow a similar strategy as in Lee(1997), Lin and Howe (1990). *" After Insider Purchase "* will

[20] http://www.uspto.gov/main/faq/

be the main independent variable of interest, a dummy equal to one only for the year following two successive pure purchase years by top insiders ("CEO, CFO, CO, President, Chairman of the Board" and Officer /Director holding more than 10% of a class of share) without any sale. We repeat our analysis when " *After Insider Purchase* " equals to the unity for the year following one pure acquisition year of top insiders of firms, the results remain significant. The findings of Lakonishok and Lee (2001) indicate that over the longer horizons, the predictive power of insider trades increase since the laws restrict the insiders from trading and profiting six months prior to the important events. Therefore, looking at only one year prior to the important innovations does not leave enough time for insiders to act on the private information.

The positive significant coefficient on "*After Insider Purchase"* will support the signaling argument; firms' directors signal their favorable prospects by increasing their share of equity prior to the innovations; the negative significant coefficient following the sales by informed insiders will signal the possible deterioration in innovation performance. δ_t, τ_i is included to control year and firm fixed effects, respectively. X_{it-1} represents the lagged firm control variables included; Size, Research and Development Expenses, Profitability, Return on the Stock, Tobin's Q, Age. Appendix 1 provides the definitions of the variables included in the study.

2. 4. Results

2. 4.1. Baseline Results: Insider Purchases and Innovation

In this section, I investigate whether the stock purchases of top insiders precede the increases in the innovation performance of the firm. Table 2.3 presents the results from Panel Poisson Fixed Effects Regressions for the sample firms. Specifically, I examine the changes in the patent quality and quantity following the stock purchases of insiders with private information. As a dependent variable, the first two columns present results for the patent quality which is measured as the total count of non-self citations received per patent applied by firm. In the columns III and IV, the patent quantity is used as the dependent variable and measured as the total count of patents applied by firm in the year.

[Table 2.3 about here]

The first four columns provide evidence of both increased innovation quality and quantity for large firms. The first column indicates that after top insiders buy their firms' shares for two consecutive years without selling any, the total number of non-self citations received per patent applied by firm increases by 25%. Including Tobin's Q, which proves to be significantly, positively related to innovation quality, in the second column does not alter the results significantly. The economic significance of "*After Insider Purchase"* increases only marginally. Positive significant results are only valid for large firms. Repeating the same analysis for medium and small firms does not

provide any significance[21]. Compared with the empirical evidence on abnormal returns to insider trading, the results presented here stand in contrast to the several previous studies. For example, Seyhun (1986) finds that abnormal returns from insider trading decrease with the size of the firm, and smaller firms have larger bid-ask spreads. Similarly, Lakonishok and Lee (2001) shows that large firms are priced more efficiently, and insiders are better at predicting the future stock returns of smaller companies. Wang, Shin, and Francis (2012) also present results along this line. They show that CFOs earn higher abnormal returns than CEOs and the returns are more concentrated in smaller firms.

As mentioned in the data screening section above I focus on only manufacturing firms which do patenting in the sample period. Therefore, the sample firms I study here are R&D intensive firms. Aboody and Lev (2000) shows that the returns from insider trading in the R&D firms are significantly larger than those for insider trades in firms without R&D. Asset specificity in R&D firms results in more asymmetric information between insiders and outsiders. Another proxy for asymmetric information is analyst coverage, which is shown to be is positively associated with intangible assets (Barth, Kasznik, and McNichols 1998). The average R&D expense for smaller firms in this study is about $5 million, while large firms spend $144 million in research and development on average. Further, as seen in the summary statistics, while smaller firms spend a larger percentage of their assets in R&D, larger firms are the ones which

[21] The results for the middle sized and small sized firms provided in the Appendix III.

produce more patents and these patents receive more citations on average. Therefore, while in general, the information asymmetry problem is more likely to be pronounced in smaller size firms compared with the larger firms, among R&D intensive firms, other factors may play role.

In columns III and IV, the results show that after insider purchase patent quantity does not increase as much as patent quality. In both columns, the number of patents applied increases by 8% following insider purchases. The results for patent quantity imply that top insiders of large firms are not as interested in investing in their own stocks prior to the application of an ordinary patent instead of a high quality patent. This result is more understandable in the light of findings of Hall, Jaffe, and Trajtenberg (2005). They find that market value of firms is positively and significantly correlated to the existence of high-quality patents. Therefore, since the value premium on firms' stock equity is more likely to increase after high quality patents are applied, we would expect insiders to invest in their firms' stocks prior to the application of highly cited patents.

The last four columns of Table 3 provide the results from the further investigation of the issue. The previous analysis includes all patents applied by the firms in the sample. Here, I repeat the same analysis for the same firms; however, in columns V and VI, I include only the patents which received more non-self citations than the median number of non-self citations received in the year and the tech field they were applied for. In the same manner, in the last two columns, I include only the most important patents which received non-self citations above the 90th percentile. The

median and 90th percentile for non-self citations received calculated from all patents applied between 1980- 2010. For Six tech fields and every application year between 1980-2010, a median and a 90th percentile number for non-self citation received are determined and every patent is classified whether it has more non-self citations than the median or 90th percentile number of non-self citations[22]. This classification is done to identify whether the firms applied to a patent which is an important innovation in the field.

Therefore, the analysis in columns III and IV includes all patents applied, in columns V and VI the more important patents are listed, and in VII and VIII, the most important patents are included. The results show that compared with the all patents sample, the "*After Insider Purchase"* variable is statistically and economically more significant when we exclude the less important patents. Poisson regressions provide the largest coefficients on the "*After Insider Purchase"* variable when we look at the patents which received above 90th percentile number of non-self citations in their tech field. Larger coefficients and statistically more significant results after excluding less important patents indicate that top insiders purchase shares prior to the application of patents which are more important in the technological field than the other applied patents.

[22] Six tech classes; Chemical, Computers & Communications, Electrical & Electronics, Mechanical, Drugs & Medical, Others. This classification is used in Hall, Jaffe, and Trajtenberg (2001, 2005) developed by Gal Steinberg and Manuel Trajtenberg.

2.5. Robustness Checks

In the following subsections, several robustness checks are conducted. Section 5.1 provides robustness checks taking into consideration the returns on stock. Long run innovation performance of firms following insider purchases are investigated in Section 5.2. The alternative econometric methodologies are also considered in Section 5.3. Section 5.4 provides results after controlling the variables proxying corporate governance. Additional robustness checks are conducted in Section 5.5. The results are reported only for large firms in the sample, since the large firms seem to be the relevant sample for the analysis.

2. 5.1. Pre-Insider Purchase Stock Return

The trend of stock price prior to the insider purchases and sales is an important determinant of insider trading. Insiders may increase shares because of decreased stock prices following a deteriorating innovation performance or other reasons causing the stock price to decrease. Several studies provide evidence supporting the argument. Seyhun (1986), for instance, suggests that insiders wait for the stock prices to decline before purchasing shares. In this section, whether the main results presented previously are sensitive to the controlling for the stock return is investigated. Not controlling return on stock may bias our results. The real reason for insider purchases might be simply to make profits from previously dropped prices with the expectation of future price increases, instead of making profits from the future increases in stock prices related to

the important innovations. In Table 2.4, the baseline regressions for non-self citations received per patent applied are repeated after controlling for stock return. Lagged return is included in two columns of Table 2.4, showing that our results remain robust to the inclusion of stock return. The prior year's stock return appears as positively significant in the both column of Table 2.4.

[Table 2.4 about here]

2. 5.2. Dynamic Impact of Insider Trading on Innovation Performance in the Long Run

If insiders had an increased incentive after they have bought the equity, we would expect a long-lasting, better performance on the innovation. On the other hand, an increased performance valid for a short period of time would be more likely to signal the exploitation of private information. To clarify this and to examine the long-term implications of insider trades on the innovation quality and quantity, I look at the three years subsequent to the purchases.

[Table 2.5 about here]

Table 2.5 presents the results only for large firms and using Non-self Citation Received per Patent Count as the dependent variable in the first two columns and Patent Count in the last two columns. The results for both measures of innovation suggest that increased performance of innovation concentrates only on the first year following the insider purchases. Therefore, it is in line with the idea that insiders purchase shares prior

to the applications of important patents and the improved innovation performance is not a consequence of increased incentives of insiders. The coefficient on the main independent variable "*After Insider Purchase"* is almost identical to the baseline regressions for the first year following the insider purchase.

2. 5.3. Alternative Models

Patent Data is in the count data form, thus Poisson Regressions are used in the baseline regressions. Here, Ordinary Least Squares regressions are used to test whether the results presented remain significant after changing the methodology employed. The results from the Fixed-Effect Panel OLS regressions are presented in Table 2.6. The full model in the second column shows that there is a 26% increase in the non-self citations received per patent applied after insider purchases. The "*After Insider" Purchase* variable is statistically significant as in the baseline Poisson regressions, while a bit smaller magnitude economically. In the last two columns, the OLS method also provides significant (at 10%) results for Patent quantity.

[Table 2.6 about here]

As a further check on the econometric specification, we run another nonlinear regression model, panel negative binomial regressions with firm fixed effects. The results (reported in Appendix IV) provide statistically more significant coefficients on "*After Insider Purchase*" variable.

2. 5.4. Additional Robustness Checks

Following Cohen, Malloy, and Pomorski (2012), the baseline analysis is repeated, excluding the routine purchases where a purchase transaction is defined as routine if the same insider purchases the stock in the same month for three consecutive years. Cohen, Malloy, and Pomorski (2012) shows that routine transactions are not informative about future stock performance. The results (not reported, but available upon request) are robust to the exclusion of the routine transactions.

Insider incentives to innovate are highly likely related to the amount of shares they held prior. Insiders holding larger blocks of shares may have more incentives to innovate due to the expectation of larger appreciation of shares in the stock market following important innovations. Therefore, we conduct the baseline analysis, year-end total shareholdings extracted from Form-5 filings. After controlling one and two years lagged past stock holdings, our baseline results still remain highly significant (results not reported, available upon request).

Further investigation is carried for different time periods over the sample period. Unreported results indicate that the baseline results are not restricted to the short period of time over the time horizon of the study. Also, other commonly used control variables in the literature, such as HHI index, Age, Capital Expenditures, Leverage, are also included in the unreported regressions. Our results remain significant after including these extra control variables.

2.6. Event Study Analysis of Important Innovations and Insider Trading around

This section extends the previous analysis. While the results in the previous sections indicate that insider purchases predict the future innovation, it does not answer the question of whether they earn abnormal returns from their trades. Also, while the previous research in both economics and finance provides a strong positive relation between innovation success and firm value as mentioned in the previous sections, these studies lack of evidence about when the innovation success is reflected in the stock prices. Therefore, in this section, I try to address the following questions: Do insiders earn significant abnormal returns on their trades prior to the important patent applications? Does the application or the grant of outstanding patents results in abnormal stock returns? Does the distance of insider purchase to the important patent application change the abnormal returns to insider trades? How are the abnormal returns following the outstanding patents if there are no insider trades before the applications?

The results from the analysis in this section show that neither the outstanding patent application nor the outstanding patent grant results in positive abnormal stock returns. Actually, there is even negative price reaction to application or grant of outstanding patents. However, insider purchases prior to the important patent applications result in significantly positive average cumulative abnormal returns.

The additional data, stock price data from CRSP is used to examine the stock price reactions. Stock price information is collected for the same large innovative firms

in the previous chapter since both insider trading and patenting activity are more active in these large firms.

The first reason why I am looking at the most important patents is that, compared with an ordinary patent, one would expect a stronger stock price reaction to the application or the grant of these important patent applications and to the insider purchases prior the applications of the important patents. Second, since, in total, there are 82.881 patents applied by these large firms, looking at the most important patents, to some extent, we are able to overcome some possible event overlapping problems throughout the sample period.

On the other hand, the number of outstanding patents applied by these large patenting firms is 15170. There are 346 unique US publicly held firms these patens belong to. The total number of insider purchases made by these 346 firms is 2294 and out of this number 1809 insider purchase is prior to the outstanding patent applications. The average distance between the insider purchases and outstanding patent application is 338 trading days and median is 131 trading days.

The parameters used to obtain the abnormal returns are calculated using the market model below;

$$\mathrm{R_{it}} = \alpha_i + \beta R_{mt} + \varepsilon_{it} \qquad (2.2)$$

R_{it} is return on security i for period t. R_{mt} is return on CRSP value weighted index for period t[23] . The parameters of the market model are calculated using returns from -250 to -5 trading days prior to insider trades[24]. Estimated parameters then used to calculate cumulative abnormal returns for the time periods [0,+3], [0,+30], following insider purchases, or patent applications/grants. The significance of ACARs are tested using the test statistics calculated as in Fidrmuc, Goergen, and Renneboog(2006);

$$\frac{(\frac{1}{N})\sum_{i=1}^{N} CAR_i}{s(CAR)/\sqrt{N}} \qquad (2.3)$$

where s(CAR) is the sample standard deviation of the individual cumulative abnormal returns[25].

2.6.1. Insider Trades Profitability prior to the Important Innovations

The results are presented in Table 2.7 In Panel A, the average cumulative abnormal returns to insider purchases 100 days prior to the outstanding patent applications are presented. The average cumulative abnormal returns are calculated for different periods using the market model (2.2). The results show that four-days [0,+3] average cumulative abnormal returns to insider purchases accumulate to 1.4%. For the period of 31-days [0,+4]following insider purchases, ACARS increase to 6.1%.

[23] The results using CRSP equal-weighted index returns are similar and not reported due to space limitations.
[24] Changing the parameter estimation period in the market model does not change results significantly.
[25] Please see Fidrmuc, Goergen, and Renneboog(2006) for more detail

The ACARs for the both event windows show statistically very significant and positive relation between insider trading and stock returns.

[Table 2.7 about here]

Employing Fama-French 3-Factor Portfolio returns as benchmark, Panel B provide similar results to Panel A, that insiders earn abnormal returns from their trades prior to the important innovations[26]. In all panels and tables, insider trades examined are the ones prior to patents which received nonself citations more than the highest decile in the tech field and year.

In Panel C, the average abnormal returns to insider purchases 100 to 300 days prior to the application of important patent applications. For the short event window [0,+3], while the results are still positive, they are not significant when we change the distance of insider purchases to the outstanding patents. Insiders still earn positive, significant cumulative abnormal returns for 31 days following purchases.

2.6.2. Stock Price Reaction to the Application and the Grant of Important Innovations

Outsiders can easily gain information about the share purchases or sales of insiders. However, it is private information whether these trades are prior to the outstanding patents. Considering the uniqueness of innovations, it would be impossible

[26] Fama-French Three-Factor daily portfolio returns are obtained from Kenneth R. French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

or costly for outsiders to obtain this information. In addition, it is crucial for firms to keep their innovations as secret not to lose competitive advantage. Outsiders are more likely to gain information about the patents when there is an application for the patent or when the patent is granted. The results in the previous section indicate that insiders earn significant abnormal returns if they purchase shares of their company before they apply for the important patents.

This section provides an event study analysis for the timing of applications and the grants of distinguished patents. The results are presented in Table 2.8. In Panel A, ACARs are calculated for the event windows [0, +3] and [0, +30] following the outstanding patent applications. While insiders earn significant abnormal returns from their trades prior to the outstanding patent applications, the applications of these patents result in significantly negative abnormal returns for both event windows.

[Table 2.8 about here]

The ACARs to the outstanding patent grants are shown in Panel B. For the event window [0,+3] there is no significant abnormal returns accumulated and for [0,+30] the results remain similar to the important patent application results.

The next, I repeat the analysis after excluding outstanding patent applications with insiders purchasing shares 100 or 300 days prior to the application. Table 2.9 provide the results.

[Table 2.9 about here]

In both situations, excluding patents where insiders trade 100 or 300 days before, the abnormal returns are still significant and negative as in the Table 2.8. The larger size and more statistically significant coefficient indicate negative reaction to the applications is stronger if insiders do not purchase shares 100 or 300 days before the application.

In sum, the event study analysis of insider purchases shows that insiders earn significant abnormal returns from their purchases prior to the important patent applications. These abnormal returns are economically and statistically large and significant especially in the long run.

On the other hand, trades following the application or grant of important patents do not earn abnormal returns, stock prices react negatively and there is strong negative relation between the application/grant of the important patents and stock prices. In addition, the negative cumulative abnormal returns following the outstanding patent applications are more pronounced when there is no insider trading 100 or 300 days prior to the application.

2. 7. The Role of Governance, Insider Trading, and Innovation

A concern related to the baseline results presented in the previous sections is that the increase in innovation following the purchases of top insiders might be due to their escalated incentives. In that case, the change in innovation is not due to the private

information they posses about the innovation activities of the firm before anyone else, as argued in this study. While excluding insider trading due to the stock option awards or stock grants might alleviate these concerns, a more comprehensive investigation is carried in this section to address them.

Several studies in the insider trading literature show that exploitation of private information by insiders is weaker in firms which adopt better governance mechanisms. For instance, Cohen, Malloy and Pomorsk (2012) shows that opportunistic insiders are more likely to be in poorly governed firms. Similarly, Cheng, Nagar, and Rajan (2007) find that the negative association between delayed Form-5 sales by insiders and the future stock performance is weaker in better governed firms. Ravina and Sapienza (2009) also finds that abnormal returns of independent directors are nonexistent in better governed firms. Findings of Bertrand and Mullainathan (2001) suggest that CEOs are rewarded for better firm performance which is not related to their performance, and this case is more pronounced when the firm is poorly governed.

Three different measures of governance are used in this study to investigate if the ability of insiders to exploit the private information to predict the future innovation increase is not the case in the better governed firms. Institutions which hold large blocks of shares in the firms may alleviate the moral hazard problems through better monitoring (Shleifer and Visnhy, 1986). Independent directors who are not employees of the company may play a similar role of monitoring and prevent the insiders from trading on the private information. Similarly, Gompers, Ishii, and Metrick's (2003) G

index is used to classify firms in terms of governance provisions they adopt. The index ranges from 5 to 14 and firms with the highest scores are regarded as having weaker shareholder rights.

[Table 2.10 about here]

The results of the robustness checks related to governance are presented in Table 2.10. Each panel in Table 2.10 provides a separate analysis. In Panel A, the existence of an institutional investor holding at least 10% of the outstanding shares and its impact on our main results is investigated. The variable "*Institutional Holding"* is a dummy which marks the years when an institution holds at least 10% of outstanding shares of the firm. The interaction variable *"Institutional Holding* After Insider Purchase "* equals to one after the year when the institutional investor holds at least 10% of outstanding shares in a company where top insiders buys shares of the company for two successive years without selling. The results deserve attention; The "*After Insider Purchase"* variable is positive, significant, and economically larger after controlling for institutional shareholders. When it interacts with the Institutional Holding dummy, the coefficient on the interaction variable is also significant, but it is negative, which indicates that when there is an institutional investor which holds at least 10% of the shares, innovation quality does not increase after insider purchases as much as it does when there is no institutional investor. Therefore, it is in line with the argument that insiders of firm are not able to exploit the private information they have when there is a monitoring mechanism; the institutional investor in this case. In the last two columns, " *After*

Insider Purchase" is significant and economic size is quite small when Patent count is used as dependent variable. The interaction variable *"Institutional Holding* After Insider Purchase "* is significantly negative but marginally, and the coefficient is a bit larger than the coefficient on *" After Insider Purchase"*. It indicates that while post-insider purchase innovation quantity increases, if there is an institutional holder with large block of shares, post-trading innovation quantity decreases marginally. Note that the patents here include less important patents so that the coefficient on " *After Insider Purchase* " is smaller than as in Table 3.

In Panel B, a similar analysis is carried as in the main model except including the interaction variable "*Outside Director*After Insider Purchase"* and the variable "*Outside Director"*. "*Outside Director"* is a dummy which equals to one when the firm has an outside director who is not an employee of the company and gets either a stock award or stock option compensation. "*Outside Director* After Insider Purchase "* equals to one after the year when non-employee director gets equity/stock option compensation in a company where top insiders buy shares of the company two successive years without selling. The first two columns show that when there is a non-employee director, trades of top insiders do not follow an increased innovation quality. While marginal significant, the coefficient on "*Outside Director* After Insider Purchase "* is negative which implies that the existence of an outside director decreases the indicative power of insider trades. In the last two columns, "*After Insider Purchase"* variable is only marginally significant for innovation quantity. However, note that

patents considered here include all patents without taking into account the importance of the innovation in the technological area.

G index constructed by Gompers, Ishii, and Metrick (2003) is used to measure the strength of shareholder rights in a company by looking at the governance provisions a firm adopts. The more provisions that firms adopt, the lower level of shareholder protection exists in the firms. The score is called G index, which varies between 5 and 14. The higher the index, the lower the shareholder protection. I classify firms based on the G score they have. The analysis in Panel C shows that when firms have a very low G index (G<8), and therefore stronger shareholder rights, the "*After Insider Purchase* "variable is not significant, indicating the weakening predictive power of insiders' purchases. The opposite is true for firms with high G index scores. The last two columns indicate that insiders increase their shareholdings prior to the increases in patent quality in firms with weak corporate governance. Therefore, overall results in this section imply that when there are other controlling mechanisms, insiders are not able to exploit their informational advantage over outsiders as much as the case of no-controlling mechanisms.

2. 8. Are Insider Sales Informative about Future Innovation?

Several studies exclude the insider sales argument that sales are more likely to be hedging motivated (Peress (2010), Wang, Shin, and Francis (2012)) and several others conclude that insider sales are not informative (Lakonishok and Lee (2001),

Ravina and Sapienza(2009)) about the future prospects of firms. Cheng, Nagar, and Rajan (2007), on the other hand, show that when insiders delay the disclosure of sales through Form-5 filing, subsequently the stock price decreases significantly. Similarly, Jagolinzer (2009) finds that, even within the SEC's Rule 10b5-1, insiders' preplanned sales transactions precede dropping share prices and comes after price increases. Rozeff and Zaman (1998) also argues that insiders' holdings decrease significantly following jumps in the stock prices.

As seen in Table 2.1 and observed in previous studies, insider sales transactions generally are greater than the purchase transactions. For large firms, for instance, the number of sales is more than 10 times larger than the insider buys. The study here also asks the question of whether insiders sell their stake in the company prior to the decrease in the innovation prospects of the company. The results of the analysis are presented in Table 2.11. Only non-self citations received per patent count are used as the dependent variable and Poisson regressions are employed in the analysis of sales. In the first two columns, "*After Insider Sale"* is similar to the baseline regressions, it is one for the year following two successive sale years by insiders (CEO, CFO, CO, President, Chairman of the Board, Officer /Director holding more than 10% of a class of share) without any purchase. The first column shows that there is a negative but insignificant relation between the innovation quality and the sales by insiders. Controlling Tobin's Q in the second column, "*After Insider Sale"* becomes only marginally statistically significant and it is weak compared to the baseline regressions. The coefficient on

"*After Insider Sale"* indicates that, while not statistically significant, there is a 7% decrease in the total number of non-self citations received per patent applied following the sales by insiders.

If insiders sell their shares when they expect that innovation performance of the firm will deteriorate in the near future, these actions should come to the light more clearly when we look at the high quality patents. An investigation with this purpose is carried out and the results are presented in the last four columns of Table 2.8. In columns III and IV, only the patents which received non-self citations more than the median in the tech field and year are included to the sample. While economic size is a bit smaller (7% vs. 6%), statistical significance increase to 10%. In the last two columns, I exclude all patents except the ones which received non-self citations at the highest decile in their tech field and year. The results of the full model in the last column present the most statistically and economically significant results for "*After Insider Sale"*. After the sale by insiders, there is 10% decrease in the innovation quality.

While not reported, looking at the long-run impact of insider sales shows that the negative impact of insider sales on the innovation exists only the first year following the sales. Including the previous year's stock return does not change the results significantly.

[Table 2.11 about here]

Alldredge and Cicero (2014) shows that insiders in supplier firms use publicly available information about economically-linked firms and earn abnormal returns from sales based on this public information. For insider purchases however, they find that insiders earn positive abnormal returns without reported economic links. They explain the results by indicating that insiders are more likely to be faced with litigation for sale transactions based on private information. Weaker results for sales transactions compared with the results for purchases in this study might be more understandable in the light of this finding.

2. 9. Conclusion

The necessity of keeping the innovation progress a secret in order to maintain the competitive advantage against competitors enables insiders to possess a lot of private information and results in the greater asymmetric information gap with outsiders. Insiders will have information about the probability of the success and failure of the innovation progress. Furthermore, insiders will make the decision of when the information about the innovation will be disclosed. Discretionary disclosure and greater asymmetric information provide insiders a convenient environment to gain profits from their purchases and prevent losses through sales.

The study provides an initial examination of insider trading and post-trading innovation activities of publicly held US patenting firms. The results indicate that

insiders can successfully predict the future important patents. Following the insider purchases, the number of non-self citations received per patent applied increase by 25%. Moreover, the analysis shows that insider share purchases better predict the increases in the patent quantity when the patent applied is an important patent application for the technological field in which it is applied. While not as significant as the insider purchases, sales by top executives also predict the deteriorating future innovation performance. Further examination of insider trades prior to important innovations show that insiders earn significant abnormal returns from their trades while trades at the time of application of important innovations do not result in positive abnormal returns.

SEC insider trading rules prohibits sales or purchases of securities six months before the important corporate information. Innovation is a long and costly process which firms undertake. Most of the time, firms keep the innovation process a secret so as not to lose their competitive advantage. In line with this argument, several studies show that the information asymmetry between insiders and outsiders is a bigger problem for R&D firms. Therefore, together with the previous studies, this paper raises the question whether the SEC needs to differentiate the insider trading rules or establish further disclosure requirements based on the varying degrees of information asymmetry between insiders and outsiders arising from different R&D activities.

Furthermore, the analysis shows that the exploitation of private information by insiders might not be a problem in better governed firms as it is in poorly governed firms. Controlling for several different measures of governance indicates that when

firms have another source of monitoring such as institutional investors, outside directors, or when they adopt fewer governance provisions, the predictive power of insider trading is weaker.

Table 2.1- Summary Statistics

This table shows the descriptive statistics. Statistics are for firms which are in top three size deciles based on Total Assets(Compustat Item 6). Statistics for other size groups are presented in Appendix II. The definitions of the variables are provided in Appendix I.

	Obs.	Mean	Sd	Min	Max
Log(Total Assets)	3969	7.3443	1.2597	4.012	10.616
Ebitda/Total Assets	3965	0.1310	0.0876	-0.179	0.346
R&D/Total Assets	3949	0.0529	0.0584	0.001	0.327
Stock Return	3966	0.0819	0.6085	-0.855	3.200
Tobin's Q	3965	2.0275	1.2791	0.764	7.903
Nonself Citation Received per Patent Count	3969	1.8772	1.3279	0.000	4.794
Patent Count	3969	2.2026	1.6242	0.000	6.028
Number of Insider Buys	3969	1.2439	8.9420	0.000	521.000
Number of Insider Sales	3969	12.8201	55.6225	0.000	1216.000

Table 2.2-Innovation and Insider Trading Characteristics over the Sample Period
This table shows yearly statistics for both insider trading variables and innovation quality and quantity. Statistics are for firms which are in top three size deciles based on Total Assets(Compustat Item 6).The definitions of the variables are provided in Appendix I.

Year	Average Nonself Citation Received per Patent Count	Average Patent Count	Average Number of Insider Buys	Average Number of Insider Sales
1996	26.85	30.8	0.77	2.82
1997	26.15	36.64	0.86	3.52
1998	24.31	32.80	1.37	4.16
1999	20.60	33.81	1.58	4.18
2000	16.20	36.06	1.61	8.21
2001	14.12	38.56	0.78	5.67
2002	10.48	38.66	1.35	9.35
2003	8.49	38.16	0.98	17.62
2004	5.75	34.30	0.97	20.84
2005	4.44	31.74	0.69	16.10
2006	3.86	28.46	0.56	27.00
2007	2.99	25.28	0.98	31.02
2008	2.11	20.29	3.91	19.29

Table 2.3- Main Results: Innovation Quality and Quantity following Insider Purchases

This table presents estimates from panel fixed effects poisson regressions. In the first two columns, the dependent variable is the total number of non-self citations received per patent applied by firm in the year. In columns III and IV, the dependent variable is the total number of patent applied by firm in the year. In columns V and VI, the dependent variable is the total count of applied patents which received non-self citations more than the median in the tech field and year. In columns VII and VIII, the dependent variable is the total count of applied patents which received nonself citations more than the highest decile in the tech field and year. *After Insider Purchase* dummy equals to one only for the year following two successive pure purchase year by insiders(CEO, CFO, CO, President, Chairman of the Board or Officer /Director holding more than ten percent of a class of share) without any sale. Tobin's Q is the ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) .In all regressions year and firm fixed effects are included. The standard errors are robust and clustered at firm level and shown in the parentheses. The definitions of variables are provided in Appendix 1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Nonself Citation Received per Patent Count		Patent Count (All Patents)		Patent Count (nonself citation received>median)		Patent Count (nonself citation received >Q90)	
	I	II	III	IV	V	VI	VII	VIII
After Insider Purchase	0.247***	0.254***	0.070	0.081*	0.095**	0.101**	0.168**	0.180**
	(0.068)	(0.070)	(0.046)	(0.046)	(0.047)	(0.048)	(0.078)	(0.081)
Ln(Total Assets)	-0.074	-0.036	0.399***	0.377***	0.346***	0.336**	0.249**	0.222**
	(0.048)	(0.050)	(0.077)	(0.081)	(0.070)	(0.074)	(0.103)	(0.106)
Ebitda/Total Assets	-0.154	-0.208	1.014***	0.819**	0.499	0.438	0.302	0.291
	(0.314)	(0.294)	(0.351)	(0.360)	(0.327)	(0.326)	(0.471)	(0.462)

R&D/Total Assets	0.051	-0.013	2.661***	2.668***	1.201**	1.154**	0.977	0.944
	(0.505)	(0.551)	(0.958)	(1.030)	(0.536)	(0.583)	(0.840)	(0.870)
Tobin's Q		0.034**		0.027		0.019		0.026
		(0.014)		(0.020)		(0.017)		(0.025)
Firm Number	392	385	399	396	388	385	308	304
N	4107	3969	4167	4036	4068	3939	3373	3269

Table 2.4- Robustness: Return on Stock

This table presents the results from Poisson Regressions controlling the return on stock. The dependent variable is the total number of non-self citations received per patent applied by firm in the year. Ret(t-1) is lagged stock return which excludes dividends. *After Insider Purchase* dummy equals to one only for the year following two successive pure purchase years by insiders without any sale. Tobin's Q is the ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) .In all regressions firm and year fixed effects are included and standard errors are robust and clustered at firm level. The definitions of the other variables are provided in Appendix 1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Nonself Citation Received per Patent Count	
	(I)	(II)
	Poisson	
After Insider Purchase	0.260***	0.265***
	(0.069)	(0.069)
Ret(t-1)	1.083***	0.905***
	(0.286)	(0.320)
Ln(Total Assets)	-0.024	-0.022
	(0.053)	(0.053)
Ebit/Total Assets	-0.145	-0.226
	(0.302)	(0.289)
R&D/Total Assets	0.300	0.168
	(0.551)	(0.543)
Tobin's Q		0.017
		(0.016)
Firm Number	382	382
N	3858	3855

Table 2.5: Robustness: Dynamic Impact of Insider Purchases on Innovation Performance in the Long Run

This table shows the results from Poisson regressions for Large firms. The dependent variable is the total number of non-self citations received per patent applied by firm in the year for first two columns, (I)-(II), the total number of patent applied for the last two models, (III),(IV). *After Insider Purchase (t+n)* equals to one for n^{th} year following two successive pure purchase year by insiders without any sale. Tobin's Q is the ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) . In all regressions firm and year fixed effects are included and standard errors are robust and clustered at firm level. The definitions of the variables are provided in Appendix 1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively

	Nonself Citation Received per Patent Count		Patent Count	
	(I)	(II)	(III)	(IV)
	Poisson			
After Insider Purchase (t+1)	0.249***	0.258***	0.056	0.068*
	(0.068)	(0.070)	(0.037)	(0.036)
After Insider Purchase (t+2)	0.036	0.037	0.095	0.105
	(0.064)	(0.063)	(0.088)	(0.089)
After Insider Purchase (t+3)	0.135*	0.131*	0.099	0.103
	(0.071)	(0.069)	(0.111)	(0.111)
Ln(Total Assets)	-0.067	-0.029	0.405***	0.385***
	(0.048)	(0.050)	(0.079)	(0.084)
Ebitda/Total Assets	-0.162	-0.220	1.024***	0.809**
	(0.314)	(0.292)	(0.353)	(0.361)
R&D/Total Assets	0.037	-0.039	2.680***	2.677***
	(0.506)	(0.553)	(0.951)	(1.022)
Tobin's Q		0.035**		0.030
		(0.015)		(0.020)
Firm Number	392	385	399	396
N	4107	3969	4167	4036

Table 2.6- Robustness: Alternative Methods

This table presents estimates from panel ordinary least square regressions for Large firms. In the first two columns, the dependent variable is the log of the total number of non-self citations received per patent applied by firm in the year, while in the last two columns, it is the log of the total number of non-self citations received per patent applied by firm in the year. *After Insider Purchase* dummy equals to one for one year after the year when insiders purchases shares for two years without selling any shares. Tobin's Q is the ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) .In all regressions year and firm fixed effects are included and standard errors are robust and clustered at firm level. The definitions of the variables are provided in Appendix 1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Ln(Nonself Citation Received per Patent Count)		Ln(Patent Count)	
	(I) OLS	(II) OLS	(III) OLS	(IV) OLS
After Insider Purchase	0.244***	0.263***	0.105**	0.121**
	(0.066)	(0.067)	(0.048)	(0.048)
Ln(Total Assets)	0.037	0.073	0.359***	0.354**
	(0.056)	(0.059)	(0.055)	(0.059)
Ebitda/Total Assets	0.167	-0.034	0.639**	0.526*
	(0.327)	(0.328)	(0.296)	(0.318)
R&D/Total Assets	0.933	0.792	2.115***	2.102**
	(0.712)	(0.735)	(0.617)	(0.645)
Tobin's Q		0.057***		0.035**
		(0.018)		(0.017)
Constant	0.165	1.957***	-1.477***	-0.543
	(0.466)	(0.446)	(0.456)	(0.427)
Firm Number	417	416	417	416
N	4241	4111	4241	4111
R-Squared	0.3775	0.3877	0.1291	0.1263

Table 2.7: Profitability of Insider Trades prior to Important Innovations

This table presents average cumulative abnormal returns(ACAR) and test statistics of a null hypothesis of whether ACARs are different from zero. Panel A and B present ACARs to insider purchases which are 100 days prior the application of patents which received nonself citations more than the highest decile in the tech field and year. In Panel B, Abnormal Returns are calculated by using returns to Fama-French 3-factor portfolio returns as benchmark. In Panel C, Abnormal Returns are calculated for the purchases which are 100 to 300 days prior to the application of patents which received nonself citations more than the highest decile in the tech field and year.

Panel A: ACARs to insider purchases 100 days prior to top 10 percent patents

	ACAR(0,3)	*ACAR(0,30)*
ACAR	1.4%	6.1%
t_{ACAR}	4.97	8.76
Number of events(Insider Purchases prior to patent applications)	692	692

Panel B: ACARs to insider purchases 100 days prior to top 10 percent patents (Fama-French 3-Factor Portfolio Returns used as Benchmark)

ACAR	1.5%	4.8%
t_{ACAR}	5.36	7.58
Number of events(Insider Purchases prior to patent applications)	692	692

Panel C: ACARs to insider purchases 100 to 300 days prior to top 10 percent patents

	ACAR(0,3)	*ACAR(0,30)*
ACAR	0.6%	5.1%
t_{ACAR}	1.23	5.85
Number of events(Insider Purchases prior to patent applications)	348	348

Table 2.8: Average Cumulative Abnormal Returns following the Application and the Grant of Important Innovations

This table presents average cumulative abnormal returns(ACAR) and test statistics of a null hypothesis of whether ACARs are different from zero. In Panel A, ACARs are calculated for applications for patents which received nonself citations more than the highest decile in the tech field and year. Panel B presents ACARs to the grants of patents which received nonself citations more than the highest decile in the tech field and year. In Panel A, Abnormal Returns are calculated by using both Fama-French 3-factor portfolio returns and value weighted portfolio returns as benchmark. In Panel B, Abnormal Returns are calculated by using value weighted portfolio returns as benchmark.

Panel A: ACARs following top 10 percent patent applications

	Value weighted		FF as benchmark	
	ACAR(0,3)	*ACAR(0, 30)*	*ACAR(0,3)*	*ACAR(0,30)*
ACAR	-0.1%	-0.6%	-0.1	-0.8%
t_{ACAR}	2.82	5.31	3.49	7.63
Number of events(Patent Applications)	14097	14049	14097	14049

Panel B: ACARs following top 10 percent patent grants

	ACAR(0,3)	*ACAR(0,30)*
ACAR	0.0%	-0.3%
t_{ACAR}	0.09	2.32
Number of Events (Patent Grants)	11240	11136

Table 2. 9: The Average Cumulative Abnormal Returns following the Application of Important Innovations with No Insider Trading 100 or 300 days before the Application

This table presents average cumulative abnormal returns(ACAR) and test statistics of a null hypothesis of whether ACARs are different from zero. In Panel A, ACARs are calculated for applications for patents which received nonself citations more than the highest decile in the tech field and year and which did not have insider trading 100 days before the application. Panel B presents ACARs to the applications of patents with no insider trading 300 days before.

Panel A: ACARs following top 10 percent patent application with no insider trading 100 days before

	ACAR(0,3)	*ACAR(0,30)*
ACAR	-0.2%	-0.8%
t_{ACAR}	4.18	6.90
Number of Events (Patent Applications)	12574	12534

Panel B: ACARs following top 10 percent patent application with no insider trading 300 days before

	ACAR(0,3)	*ACAR(0,30)*
ACAR	-0.18%	-0.8%
t_{ACAR}	3.74	6.56
Number of Events (Patent Applications)	10450	10447

Panel C: ACARs following top 10 percent patent application with no insider trading 500 days before

	ACAR(0,3)	*ACAR(0,30)*
ACAR	-0.18%	-0.7%
t_{ACAR}	3.61	5.30
Number of Events (Patent Applications)	8895	8862

Table 2.10: Robustness: Governance

This table presents estimates from panel poisson fixed effects regressions for Large firms in all panels. *After Insider Purchase* dummy equals to one only for the year following two successive pure purchase years by insiders without any sale. In Panel A, *Institutional Blockholder* equals to one for the year when the firm has an institutional blockholder holding at least 10% of the outstanding shares. The interaction term *Institutional Holding*After Insider Purchase* equals to one after the year when both institutional investor holds at least 10% of outstanding shares and top insiders purchases shares without any sale two consecutive years. In Panel B, *Outside Director* is a dummy which equals to one for the year when the firm has an outside director with equity compensation or stock option award. The interaction term *Outside Director*After Insider Purchase* equals to one after the year when both outside director gets stock option award or equity compensation and top five executives purchases shares without any sale two consecutive years. In Panel C, Governance (G) Index by Gompers, Ishii, and Metrick (2003) is used to classify firms based on Governance Provisions. G index varies between 3 and 17. Higher the G index worse the shareholder rights. Tobin's Q is the ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) . In all regressions year and firm fixed effects are included and standard errors are robust and clustered at firm level. The definitions of the other variables are provided in Appendix 1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

Panel A: Institutional Investor holding 10% or more of outstanding shares

	Nonself Citation Received per Patent Count		Patent Count	
	(I)	(II)	(III)	(IV)
		Poisson		
After Insider Purchase	0.323***	0.328***	0.098*	0.110**
	(0.086)	(0.088)	(0.052)	(0.051)
Institutional Holding* After Insider Purchase	-0.277**	-0.274**	-0.120	-0.126
	(0.140)	(0.139)	(0.079)	(0.079)
Institutional Holding	0.009	0.018	0.066	0.067
	(0.043)	(0.044)	(0.044)	(0.045)
Ln(Total Assets)	-0.076	-0.038	0.399***	0.378***
	(0.048)	(0.050)	(0.077)	(0.081)
Ebit/Total Assets	-0.158	-0.216	1.017***	0.824**
	(0.313)	(0.292)	(0.352)	(0.362)

R&D/Total Assets	0.020	-0.036	2.690***	2.696***
	(0.506)	(0.552)	(0.957)	(1.029)
Tobin's Q		0.034**		0.028
		(0.014)		(0.020)
Firm Number	392	385	399	396
N	4107	3969	4167	4036

Panel B: Outside Director with Equity/Stock Option Compensation

	Nonself Citation Received per Patent Count		Patent Count	
	(I)	(II)	(III)	(IV)
		Poisson		
After Insider Purchase	0.412***	0.438***	0.124*	0.121*
	(0.139)	(0.142)	(0.070)	(0.071)
Outside Director* After Insider Purchase	-0.239	-0.266*	-0.071	-0.052
	(0.155)	(0.158)	(0.089)	(0.088)
Outside Director	-0.016	-0.019	0.078	0.167***
	(0.059)	(0.064)	(0.069)	(0.058)
Ln(Total Assets)	-0.073	-0.034	0.395***	0.367***
	(0.048)	(0.050)	(0.077)	(0.081)
Ebit/Total Assets	-0.157	-0.217	1.021***	0.820**
	(0.314)	(0.295)	(0.356)	(0.364)
R&D/Total Assets	0.037	-0.026	2.661***	2.644**
	(0.510)	(0.560)	(0.959)	(1.034)
Tobin's Q		0.035**		0.026
		(0.014)		(0.020)
Firm Number	392	385	399	396
N	4107	3969	4167	4036

Panel C: Governance Index

	Nonself Citation Received per Patent Count			
	Better Governance (G<8)		Worse Governance(G≥8)	
	(I)	(II)	(III)	(IV)
		Poisson		
After Insider Purchase	0.221	0.212	0.250***	0.265***
	(0.140)	(0.138)	(0.077)	(0.080)
Ln(Total Assets)	-0.093	-0.094	-0.067	-0.016
	(0.088)	(0.097)	(0.057)	(0.058)

Ebit/Total Assets	-0.396	-0.435	-0.055	-0.103
	(0.430)	(0.401)	(0.386)	(0.367)
R&D/Total Assets	0.230	0.543	-0.029	-0.311
	(0.873)	(0.971)	(0.588)	(0.616)
Tobin's Q		0.006		0.047***
		(0.026)		(0.017)
Firm Number	82	82	310	303
N	841	829	3266	3140

Table 2.11- Innovation Performance following Insider Sales

This table presents estimates from panel poisson fixed effects regressions for Large firms. *After Insider Sale* equals to to one for the year following two successive sale years by insiders without any purchase. In all columns, the dependent variable is the total count of nonself citations received per patent applied by a firm in a year In columns I and II, all patents applied by a firm are considered. In columns III and IV, only the patents which received nonself citations more than the median in the tech field and year are included to the sample. In columns V and VI, I exclude all the patens except the ones which received nonself citations more than the highest decile in the tech field and year. Tobin's Q is the ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) . In all regressions year and firm fixed effects are included and standard errors are robust and clustered at firm level. The definitions of the variables are provided in Appendix 1. $*$, $**$, and $***$ measure significance at the 10%, 5%, and 1% level, respectively.

	Nonself Citation Received per Patent Count					
	Full Patent Portfolio		Over Median Important Patents (nonself citation received>median)		Most Important Patents (nonself citation received>Q90)	
	I	II	III	IV	V	VI
After Insider Sale	-0.052	-0.071	-0.047	-0.063*	-0.098**	-0.099**
	(0.045)	(0.044)	(0.035)	(0.035)	(0.040)	(0.040)
Ln(Total Assets)	-0.078	-0.035	-0.017	0.013	0.051	0.056
	(0.049)	(0.052)	(0.042)	(0.045)	(0.052)	(0.056)
Ebitda/Total Assets	-0.120	-0.134	0.034	0.024	0.199	0.435
	(0.329)	(0.308)	(0.275)	(0.265)	(0.306)	(0.295)
R&D/Total Assets	-0.005	-0.082	0.298	0.295	0.924	1.304**
	(0.493)	(0.539)	(0.405)	(0.440)	(0.570)	(0.572)
Tobin's Q		0.033**		0.027**		0.011

		(0.015)		(0.012)		(0.018)
Firm Number	344	340	335	331	282	281
N	3774	3664	3677	3568	3182	3106

Appendix I: Variable Definitions and Data Sources

Appendix I provides the definitions of the variables used in the study and sources of the variables.

Dependent Variables	
Ln(Non-Self Citations per Patent Applied)	Logarithm of one plus The total number of non-self citations received per patent applied by firm i in year t. (NBER Patent Data Project)
Ln(Total Patent number Applied)	Logarithm of one plus The total number of patents applied by firm i in year t. (NBER Patent Data Project)
Patent Count	The total number of patents applied by firm i in year t (NBER Patent Data Project)
Non-Self Citation Count	The total number of non-self citations received for the patents applied by firm i in year t (NBER Patent Data Project)
Independent Variables	
Ln(Total Assets)	Logarithm of Total Assets(Compustat)
Ebitda/Total Assets	Earnings Before Interests, Taxes, Depreciation and Amortization divided by Total Assets (Compustat)
R&D /Total Assets	Research and Development Expenses divided by Total Assets. (Compustat)
After Insider Purchase	A dummy which equals to to one for one year after the year when top insiders(CEO, CFO, CO, President, Chairman of the Board or Officer /Director holding more than ten percent of a class of share) purchases shares for two years without selling any shares (Thomson Reuters Insider Filings Database)
After Insider Sale	A dummy which equals to one for one year after the year when top insiders(CEO, CFO, CO, President, Chairman of the Board or Officer /Director holding more than ten percent of a class of share) sell shares for two years without buying any shares (Thomson Reuters Insider Filings Database)

Ret(t-1)	Lagged holding period stock return excluding dividends and adjusted for stock splits (CRSP)
Tobin's Q	The ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) (Compustat)
Outside Director	A dummy which equals to one for the year when a non-employee director receives options/shares of stock during the year (Compustat Execucomp).
Institutional Blockholder	A dummy which equals to one for the years when an institutional blockholder holds 10% or more of the all shares outstanding (Thomson Reuters Institutional Holdings)
Number of Insider Sells	Total Number of Sales Transactions by top five insiders(Thomson Reuters Insider Filings Database)
Number of Insider Buys	Total Number of Sales Transactions by top five insiders(Thomson Reuters Insider Filings Database)

Appendix II -Summary Statistics for Other Size Groups

Middle Size Firms

This table shows the descriptive statistics. Panel consist of firms which are in middle four size deciles based on Total Assets(Compustat Item 6).The definitions of the variables are provided in Appendix I.

	Obs.	Mean	Sd	Min	Max
Log(Total Assets)	4432	4.8048	0.8158	1.919	6.394
Ebitda/Total Assets	4423	-0.0156	0.2492	-1.112	0.412
R&D/Total Assets	4415	0.1389	0.1608	0.003	0.969
Stock Return	4433	0.1487	0.9151	-0.889	5.217
Tobin's Q	4426	2.3489	1.7179	0.557	9.625
Nonself Citation Received per Patent Count	4435	1.5449	1.5109	0.000	5.147
Patent Count	4435	1.0694	0.9744	0.000	3.579
Number of Insider Buys	4435	10.2685	65.5576	0.000	2934.000
Number of Insider Sales	4435	2.0891	10.1423	0.000	508.000

Small Size Firms

Table shows the descriptive statistics. Panel consist of firms which are in bottom three size deciles based on Total Assets(Compustat Item 6).The definitions of the variables are provided in Appendix I.

	Obs.	Mean	Sd	Min	Max
Log(Total Assets)	3412	2.8927	0.9557	-0.904	4.526
Ebitda/Total Assets	3405	-0.3296	0.6544	-4.002	0.346
R&D/Total Assets	3390	0.2636	0.3760	0.000	2.583
Stock Return	3413	0.2236	1.3134	-0.917	7.882
Tobin's Q	3409	3.8093	4.5700	0.513	30.283
Nonself Citation Received per Patent Count	3414	1.1124	1.5646	0.000	5.287

Patent Count	3414	0.5261	0.6890	0.000	2.639
Number of Insider Buys	3414	2.2513	9.5886	0.000	380.000
Number of Insider Sales	3414	2.1933	9.8282	0.000	193.000

Appendix III- Baseline Results for Middle and Small Size Firms

Middle Size Firms

	Nonself Citation Received per Patent Count		Patent Count	
	(I)	(II)	(I)	(IV)
		Poisson		
After Insider Purchase	-0.017	-0.013	0.013	0.035
	(0.078)	(0.078)	(0.065)	(0.063)
Ln(Total Assets)	-0.104**	-0.070	0.242***	0.257***
	(0.050)	(0.066)	(0.052)	(0.070)
Ebitda/Total Assets	0.313**	0.385**	0.058	0.207
	(0.149)	(0.174)	(0.170)	(0.195)
R&D/Total Assets	0.015	-0.015	0.809***	0.741**
	(0.244)	(0.293)	(0.247)	(0.293)
Tobin's Q		-0.017		0.018
		(0.015)		(0.014)
Firm Number	542	522	563	537
N	4814	4435	4956	4549

Small Firms

	Nonself Citation Received per Patent Count		Patent Count	
	(I)	(II)	(I)	(II)
		Poisson		
After Insider Purchase	-0.121	-0.096	-0.042	-0.016
	(0.126)	(0.127)	(0.090)	(0.084)
Ln(Total Assets)	0.202***	0.276***	0.336***	0.435***
	(0.064)	(0.092)	(0.056)	(0.069)
Ebitda/Total Assets	-0.122	-0.062	-0.091	-0.113
	(0.127)	(0.143)	(0.090)	(0.096)

R&D/Total Assets	0.080	0.071	0.112	0.054
	(0.176)	(0.186)	(0.130)	(0.132)
Tobin's Q		0.021*		0.015**
		(0.011)		(0.007)
Firm Number	416	388	446	415
N	3687	3414	3908	3619

Appendix IV- Baseline Results using Negative Binomial Regressions

This table presents estimates from panel negative binomial regressions. In the first two columns, the dependent variable is the total number of non-self citations received per patent applied by firm in the year. In columns III and IV, the dependent variable is the total number of patent applied by firm in the year. *After Insider Purchase* dummy equals to one only for the year following two successive pure purchase year by insiders(CEO, CFO, CO, President, Chairman of the Board or Officer /Director holding more than ten percent of a class of share) without any sale. Tobin's Q is the ratio of book value of assets (data6) minus book value of equity (data60) plus market value of equity (data25*data199) to the book value of total assets (data6) .In all regressions year and firm fixed effects are included. The standard errors are shown in the parentheses. The definitions of variables are provided in Appendix 1. ∗, ∗∗, and ∗∗∗ measure significance at the 10%, 5%, and 1% level, respectively.

	Nonself Citation Received per Patent Count		Patent Count	
	(I)	(II)	(I)	(IV)
		Poisson		
After Insider Purchase	0.233***	0.237***	0.084*	0.106**
	(0.056)	(0.056)	(0.049)	(0.049)
Ln(Total Assets)	0.431***	0.440***	0.287***	0.286***
	(0.022)	(0.022)	(0.019)	(0.020)
Ebitda/Total Assets	0.518**	0.303	0.797***	0.539***
	(0.212)	(0.230)	(0.181)	(0.201)
R&D/Total Assets	4.737***	4.444***	2.354***	2.340***
	(0.333)	(0.359)	(0.336)	(0.350)
Tobin's Q		0.036***		0.044***
		(0.013)		(0.012)
	-5.174***	-5.219***	-2.313***	-2.346***

	(0.206)	(0.209)	(0.175)	(0.181)
Firm Number	392	385	399	396
N	4107	3969	4167	4036

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