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Insider Trading and the Patent Application Process

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Abstract

The patent application process produces asymmetric information between insider to the firms applying for a patent and other market participant. We investigate whether insiders trade upon such private information that emerges during to patent application process. Our results show that insiders in R&D intensive industries trade on this private information before the patent grant is publicly disclosed. We also investigate insider trading after the official patent grant date, that is, after information asymmetry between insiders and outsiders is presumably dissolved. In case the stock market reacts favorably to the patent disclosure we expect and find insiders to sell shares subsequent to the grant in order to cash in on their equity holdings at a higher share price.

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Insider Trading and the Patent Application Process

Abstract

Although prior research finds that insider trades generate abnormal returns, evidence on the nature of information that insiders use in their trading decisions is scant. Extant studies examining whether insider transactions are associated with significant future corporate events assume that insiders have foreknowledge of these events ex-ante when trading. The patent application process provides a powerful research setting since we can exploit knowing exactly when insiders receive private information about future grants of high impact patents. Arguing that insiders try to exploit the resulting information asymmetry, we predict and find that insiders in R&D intensive industries trade on this private information before the patent grant is publicly disclosed. Further analyses show that this trading behavior is concentrated in firms with a relatively weaker information environment proxied by low analyst coverage.

We also investigate insider trading after the official patent grant date, that is, after information asymmetry between insiders and outsiders is presumably dissolved. In case the stock market reacts favorably to the patent disclosure we expect and find insiders to sell shares subsequent to the grant in order to cash in on their equity holdings at a higher share price.

The results have implications for three distinct streams of the literature. First, we contribute to the discussion on the sources of insider trading profits by documenting that insiders trade on information asymmetries arising during the patent application process. Second, we complement studies which show that equity incentives motivate managers to invest in R&D by documenting that insiders cash in on their equity packages once R&D activities result in patentable inventions. Third, we contribute to a discussion on the uncertainties and information asymmetries that accompany the patent application process by showing that corporate insiders exploit these information asymmetries for their personal trading decisions.

1. Introduction

In this paper, we document that corporate insiders in research and development (R&D) intensive industries use their foreknowledge of high impact patent grants for their personal trading decisions. Although prior literature shows that insider transactions yield abnormal returns (Seyhun 1986; Rozeff & Zaman 1998; Cohen *et al.* 2012), the nature of the information by which these transactions are informed is still an open question. We find that private communication between the firm and the United States Patent Office (USPTO) during the patent application process represents an important source of private information that insiders trade on. In addition, we find that insiders trade against stock market underreaction and overreaction once information about the patent reaches the market.

Prior research investigating the question whether insiders trade on private information necessarily *assumes* that insiders have foreknowledge of future corporate events that will have a significant impact on share price. For example, Ke et al. (2003) find that insider trades are associated with future breaks in strings of consecutive earnings increases up to nine quarters before these breaks and assume that executives have this knowledge ex-ante when trading. The patent application process provides a powerful research setting since we can exploit knowing exactly when information asymmetry between insiders and outsiders with respect to future patent grants is greatest.

As soon as the USPTO decides that it will grant a patent and for how many of the patent claims it provides legal protection, it *privately* sends a notice of allowance to the applicant which specifies the USPTO's granting decision.[1] Patent applications filed before November 2000 were not *publicly* disclosed until the patent grant date, which means that outsiders only learned at the grant date that a patent application existed and that it was granted. Thus, insiders enjoyed a

[1] In the US, one patent can ask protection for several patent claims. Patent claims are inventions that the applicant considers innovative enough to receive legal protection. The number and nature of claims constitutes the scope of the patent.

significant information advantage over outsiders. Due to the American Inventors Protection Act of 1999, patents applied for on or after November 29, 2000 are now disclosed within 18 months of the patent application date (USPTO 1999).[2] Thus, if the USPTO sends the notice of allowance later than 18 months after patent application, then, under new regulation, information asymmetry between insiders and outsiders is reduced because outsiders can use the patent publication to assess the probability that the patent will be granted and which claims will receive protection. We therefore select as our sample period the time before the change in regulation so as to be able to exactly identify when corporate insiders have private knowledge about future patent grants, namely at the date the allowance is sent.

Using detailed data on insider trading behavior and high impact patents granted to R&D intensive firms between 1994 and 1999, we predict and find evidence for strategic insider trading behavior during the patent application process.[3] Specifically, our empirical results show that insiders purchase significantly more shares in weeks three and four after the patent allowance. This finding implies that insiders indeed trade on foreknowledge of patent grants but are concerned about the legal jeopardy that might be associated with insider trading right after the acquisition of significant private information. Further analyses indicate that this trading behavior is concentrated in firms with a weaker information environment. This suggests that insiders in R&D intensive firms can better use their foreknowledge of patent grants when patent information is less likely to be picked up by or communicated to analysts.

Next, we examine insider trading behavior after the patent grant date, that is, after information asymmetry between insiders and outsiders is presumably dissolved. If, at the official grant date, the stock market incorporates the value of the patent into the share price, insiders will,

[2] American Inventors Protection Act of 1999; Public Law 106-113, 113 Stat. 1501

[3] We focus on high-impact patents because patents have been shown to have an extremely skewed value distribution (Jaffe *et al.* 2005). We classify patents as high impact based on the number of forward citations a patent receives.

ceteris paribus, generate paper gains on their existing equity portfolio. By timing share disposals after the grant date, insiders can realize these paper gains. We expect and find that insider selling after the official patent grant date is significantly positively associated with cumulative abnormal stock returns around the grant date.

We make contributions to at least three distinct literature streams. First, we contribute to the discussion on the sources of insiders' trading profits (Aboody & Lev 2000; Ke *et al.* 2003; Bartov & Mohanram 2004; Ahuja *et al.* 2005; Piotroski & Roulstone 2005; Cheng *et al.* 2007; Huddart *et al.* 2007; Cohen *et al.* 2012; Veenman 2012) by documenting that insiders exploit information asymmetries that are generated by the nature of the patent application process. In that respect, this paper is most closely related to studies by Ahuja et al. (2005) and Aboody and Lev (2000). Ahuja et al. find that insiders purchase more shares in the years that precede patent applications. Hence, Ahuja et al. make the assumption that insiders know that the firm will apply for a patent, that the patent will be granted, how many claims the patent grant will protect and how the patent grant will influence share price performance. Our study is different in at least two ways. First, we take advantage of the powerful research setting by exploiting our knowledge of the exact timing when information asymmetry between insiders and outsiders is greatest. Second, in contrast to Ahuja et al. we also investigate insiders' trading strategies once the patent has been officially granted. This is important because we shed light on insider trading behavior once information asymmetry between insiders and outsiders is presumably dissolved. We show that insiders cash in on their existing equity holdings after information asymmetry dissolves at the grant date if the market impounds the economic value of high impact patents into the share price. We complement the results presented in Aboody and Lev (2000) who show that insider trading profits are greater in R&D intensive firms. While Aboody and Lev explain their result with increased information asymmetry between insiders and outsiders, created by the uncertain nature of R&D investments, we shed light on the trading strategies and the timing of the trades through which insiders in R&D intensive firms generate the abnormal trading profits reported in Aboody and Lev.

The second stream of literature that we contribute to is a young but rapidly growing one which examines whether equity compensation mitigates insiders' risk aversion and horizon problems and motivates them to pursue strategies that foster innovation (Lerner & Wulf 2007; Beyer *et al.* 2011; Francis *et al.* 2011; Manso 2011; Ederer & Manso 2012). While these studies establish a link between ex-ante equity incentives and innovation output, we document a relationship between innovation output and insiders' subsequent equity portfolio decisions. This link is important because if insiders were not able to trade on their knowledge of future patent grants, their equity incentives would trigger less innovation efforts in the first place (cf. Bebchuk & Fershtman 1994). Thus, we complement these studies by providing insights into the trading strategies that insiders follow to cash in on their equity holdings once R&D activities have generated patentable inventions.

Finally, we contribute to a discussion on the uncertainties and information asymmetries created by the US patent application process. While most patent applications will be granted in some form, there is substantial uncertainty regarding the nature and number of claims that will be granted (USPTO 2011). Gans *et al.* (2008) show that this uncertainty delays the licensing of patent rights until the patent allowance is communicated to the applicant who can then credibly demonstrate the value of the patent to potential licensees. Thus, while they find that the patent allowance decreases information asymmetry between the patent applicant and the licensee, we show that insiders use the *increased* information asymmetry between themselves and external market participants for insider trading.

In this regard, the results reported in this paper also point to a potentially beneficial side effect of the American Inventors Protection Act (USPTO 1999). The act was intended to decrease information asymmetries between applicants and related parties, and, hence, stimulate faster knowledge dispersion (cf. Johnson & Popp 2003). Since our sample spans the time before the act came into force, the results imply that one consequence of the act is that it limits corporate insiders in their ability to trade on private information regarding future patent grants. This is because the date when the USPTO privately communicates the allowance to the patent applicant is likely to take place after the patent application has been published. Publication of patent application before the allowance date substantially reduces information asymmetries between insiders and outsiders.

We proceed as follows: Section 2 provides an overview over the patent application process, reviews the relevant literature and develops our hypotheses. Section 3 describes the sample selection procedure and methodology. Section 4 discusses the main empirical results. Section 5 presents additional analyses and robustness tests and Section 6 concludes.

2. Background and hypothesis development

In this section we give an overview of the United States patent application process and elaborate on how the nature of the process might influence insider trading strategies in patenting firms. As discussed above, there are incentives for insiders to trade both when information asymmetry is greatest, that is when the allowance is privately communicated, and when it is presumably resolved at the grant date. Figure 1 provides a graphical illustration of the chronology of the patent application process and the resulting opportunities for insider trading. The two hypotheses, which we test to examine the timing of insider trades, are reflected in this illustration.

--- Insert Figure 1 about here ---

2.1. Insider buying after the allowance date

The patent application process commences when an individual or corporation files an application with the USPTO. The application contains a detailed description of the invention, all prior art, and the number and nature of the claims for which the applicant seeks protection. Although about 90% of patents applied for in the US eventually get granted in some form, there is significant uncertainty about the number of claims that will be granted. Only very few patents are granted as filed (USPTO 2011). Once the patent examiner has decided that the patent will be granted and which claims will receive protection, the USPTO sends a notice of allowance to the applicant. In the following, we refer to the day on which the USPTO sends the notice of allowance as the allowance day. For our sample of high impact patents, the median time span between the allowance date and the application date is about 17 months. Although the notice of allowance is not the official grant, this private communication from the USPTO to the applicant significantly reduces the applicant's uncertainty about the claims that will receive protection (Gans *et al.* 2008). Since this communication between the USPTO and the applicant is private, outsiders only learn at the grant date about the patent application and the nature of the claims granted. This is when patent information is publicly disclosed and information asymmetry between insiders and outsiders presumably dissolves. For our sample of high impact patents, the median time span between the grant date and the allowance date is about six months. Hence, corporate insiders enjoy a substantial information advantage over outsiders which they can use to increase their insider trading profits. As discussed above, the American Inventors Protection Act mandates early publication of patent applications for all patents applied for on or after November 29, 2000. Hence, for these patents information asymmetry between insiders and outsiders is likely to be smaller.

Since there is great heterogeneity in the economic value of patented inventions (Hall *et al.* 2005), we will focus on high impact patents, measured by the number of forward citations during our analyses. We expect insiders to trade only on these high impact patents since they are likely to have significant consequences for future firm performance (Ahuja *et al.* 2005).

The setting described above is a powerful one to test for insider trading based on private information because we know precisely when the information asymmetry between insiders and outsiders is greatest, which is on the allowance day. In contrast, prior literature investigating insider trading in advance of events such as annual earnings innovations or analyst earnings forecast changes *assumes* that insiders have knowledge of these events well in advance of their realization (Ke *et al.* 2003; Piotroski & Roulstone 2005; Cheng *et al.* 2007; Cohen *et al.* 2012). Our setting allows for a detailed analysis of insider trading behavior when information asymmetry is greatest and when it supposedly dissolves. Thus, with the first hypothesis, we test whether insiders trade on their private information about future patent grants. We expect that insider buying is more pronounced during the weeks after the day a notice of allowance is sent for a high impact patent. More formally:

H1. Insider buying is higher if it is preceded by the receipt of a notice of allowance for a high impact patent.

2.2. Insider selling after the patent grant

Insiders also have incentives to trade after the patent grant date, that is, after information asymmetry between insiders and outsiders is presumably resolved. As discussed above, the stock market ultimately learns at the patent grant date about the existence of a patent application and the nature of the rights that receive protection. This is especially the case for firms with low analyst coverage. When analyst coverage and, hence, the information environment is strong, the market might learn about the existence of pending patent applications in advance of the grant date.[4] Even for firms with high analyst coverage there remains some uncertainty about the patent application which is only resolved at the grant date. If the stock price increases in response to the information presented in the patent disclosure at the grant date, insiders can sell their shares at higher prices. Thus, we expect that insider selling is increasing in the abnormal returns around the patent grant date.

H2. Insider selling after the grant of high impact patents is an increasing function of abnormal returns around the grant date.

3. Sample selection, data, and methodology

In this study we use data on high impact patents granted by the USPTO to US corporate applicants in R&D intensive industries between 1994 and 1999. Patents granted during that time period are unaffected by the American Inventors Protection Act which came into force in November 2000. We identify Chemicals and Allied Products (SIC code 28), Industrial Machinery and Equipment (35), Electronic and Electrical Equipment (36), Transportation Equipment (37), and Instruments and Related Products (38) as R&D intensive industries. We focus only on high impact patents because there is great heterogeneity and skewness in the economic value of patented inventions (Harhoff *et al.* 1999; Hall *et al.* 2005; Jaffe *et al.* 2005). We identify high impact patents based on the number of forward citations that a patent receives. Several studies show that the number of forward citations is a suitable indicator of the economic value of patents (Hirschey & Richardson 2004; Hall *et al.* 2005; Czarnitzki *et al.* 2011).

[4] In additional analyses, we show that the market reaction to the disclosure of patent grants is significantly greater for firms with low analyst coverage than for firms with high analyst coverage.

Hall *et al.* (2001) find that in the first five years after the grant date, patents receive up to a third of their life-time forward citations. Hence, in order to reliably identify high impact patents, we require at least five years of citation data subsequent to the patent grant date. Since the National Buro of Economic Research (NBER) patent citations database (cf. Hall *et al.* 2001; Jaffe *et al.* 2005) only extends until 2006, the latest point in time for which we can reliably identify high impact patents before the American Inventors Protection Act came into force would be October 2000. However, we choose not to include the year 2000 in our sample period because the burst of the dotcom bubble and its effect on stock market sentiment might confound the insider trading data. Thus, we restrict the population of patents to those granted between 1994 and 1999. We sort these patents into categories based on grant year and patent technology class.[5] From each category, we select the top 1% patents in terms of forward citations received. In total, we identify 2,333 high impact patents that were granted to US corporate applicants. After restricting the sample to firms in R&D intensive industries and matching the patent data to accounting data from Compustat, stock market data form the Centre for Research in Security Prices (CRSP), and insider trading data from ThomsonReuters, we are left with 1,279 patents granted to 159 firms. For each of these patents, we manually collect the date on which the USPTO sent the notice of allowance to the applicant. This information can be gathered from the Patent Application Information Retrieval (PAIR) system on the USPTO website.[6] Around the allowance and grant dates of the 1,279 high impact patents we construct two datasets, one in order to analyze insider trading after the allowance date (Hypothesis 1) and one to analyze insider trading after the grant date (Hypotheses 2).

3.1. Insider trading after the allowance date

[5] We perform this double sort because citation frequency differs across years and technology classes (Hall *et al.* 2001).
[6] The PAIR system can be accessed via the following link: http://portal.uspto.gov/external/portal/pair/

Hypothesis 1 predicts that insiders buy more shares in the weeks following the allowance date. In order to examine when exactly after this date insiders trade, we use firm-trading days as the unit of analysis. Thus, the dataset for Hypothesis 1 consists of a panel of daily observations for 159 firms over the years 1992 and 1999.[7] We drop firm-days if they are part of a firm-year in which no allowance took place.

We divide the first 40 trading days including and following each allowance date into four biweekly windows, where the first window starts on the day on which the allowance is communicated. Thus, the independent variables of interest are four indicator variables. The first is equal to one if a firm-day is between *t* and *t+9* of an allowance date (WIN1), the second is one if a firm-day is between *t+10* and *t+19* of an allowance date (WIN2), the third is one if a firm-day is between *t+20* and *t+29* of an allowance date (WIN3), and the third is one if a firm-day is between *t+30* and *t+39* days of an allowance date (WIN4). These trading windows are graphically depicted in Figure 1.

To construct the dependent variable we collect open market purchases conducted by all officers and directors of the sample firms from Thomson Reuters Insider Filing Data Feed which provides detailed information on insider transactions reported to the SEC on Form 4 starting January 1986. In order to eliminate potentially problematic cases, we drop transactions whose trade price was not within 20% of the CRSP closing price on that day. In addition, we remove trades for which the number of shares traded exceeded 20% of the number of shares outstanding (Lakonishok & Lee 2001). We aggregate open market purchases at the firm-day level and construct two dependent variables. LNVALUE_BUY is the natural logarithm of the number of shares bought on a particular day times the purchase price while INDBUY is an indicator variable equal to one if there is insider purchasing on a particular day and zero otherwise.

[7] Although we only consider patents granted between 1994 and 1999, the earliest patent allowance for the patents granted between 1994 and 1999 takes place in 1992.

3.2. Insider trading after the grant date

Hypothesis 2 predicts that insider selling after the official patent grant is positively related to abnormal returns around the grant date. To test this hypothesis, we construct a second dataset around the patent grant date such that each high-impact patent represents one unit of analysis. The firms and patents which enter this dataset are the same as those used in tests of Hypothesis 1. Hence, the sample consists of 1,279 observations, one for each high impact patent.

In order to generate the dependent variable for Hypothesis 2, we collect open market sales from Thomson Reuters. We use the same procedures to check for inconsistencies in the data as outlined in Section 3.1. We aggregate insider sales for each firm over days t until $t+9$ starting with the patent grant date. We chose this trading window because it gives insiders sufficient time to evaluate whether the market responded to the patent disclosure as she expected. The dependent variable for Hypothesis 2 is SELL which is an indicator variable that is equal to one if we observe insider selling in the window of ten trading days starting with the patent grant date. We choose a window right after the grant date because we expect insiders to trade as soon as they have evaluated the stock market reaction to the patent disclosure. Since in this case insiders trade *after* all information regarding the patent is public, there is less concern over legal jeopardy than for example right after the allowance date.

In Hypothesis 2, the independent variable of interest is the cumulative abnormal stock return (CAR) around the patent grant date. To validate the robustness of the results, we measure CAR using three different benchmark expected returns. The first one comes from the Capital Asset Pricing Model (CAPM) which assumes that the expected return on a security can be explained by its sensitivity to the excess market return (Sharpe 1964; Lintner 1965). The second benchmark that we use is the Fama and French (1993) three factor model, an extension of the CAPM, in which the expected return on a security is explained by its sensitivity to three risk factors, namely the excess market return and the returns on zero-investment portfolios for size and book-to-market equity, respectively. Third, we use the Fama and French (1993) and Carhart (1997) four factor model which extends the three factor model by a risk factor that captures the returns on zero-investment portfolios for one-year momentum in stock returns. An overview over the three different models that we use to estimate benchmark returns can be found in Appendix 1. We allow the stock market to incorporate the information in the patent grant disclosure into the stock price a few days after the grant date. Thus, we calculate CAR over the days *t-1* to *t+5* around the grant date.

3.3. Control variables

Following prior research, we use several firm-level control variables that have been shown to be associated with insider trading. First, we control for firm size which we calculate as the natural logarithm of market capitalization (LNMARKETCAP). Prior studies show that managers in larger firms receive more equity-based compensation (Core & Guay 1999). Thus, managers in larger firms might be more inclined to sell shares and less likely to buy additional shares for portfolio diversification reasons. Next, we control for a firm's growth opportunities with the book-to-market ratio (BTM). Prior research shows that insiders are more likely to buy (sell) when the book-to-market ratio is high (low), possibly because the book-to-market ratio is an indicator for under- or overvaluation (Rozeff & Zaman 1998; Piotroski & Roulstone 2005). Since Huddart and Ke (2007) show that insider trading volume is increasing in R&D intensity, we include R&D expenditures scaled by total assets (R&D) in all regressions. Although our sample only consists of firms in RD intensive industries, Panel A of Table 1 shows that there still is cross-sectional variation in R&D spending. We also control for past and future six-month cumulative stock returns (PAST6RET, FUT6RET). Insiders are more likely to sell when past returns are high, either because they want to cash in on the appreciation of their shareholdings or because they take the stock price increase as an indication of overvaluation (Piotroski & Roulstone 2005). Future returns have been shown to be lower (higher) following insider sales (purchases) which is seen as an indication that insiders are able to predict share price development (Seyhun 1992; Lakonishok & Lee 2001). In addition, we create two indicator variables (SAFE, BAN) which control for the presence of insider trading restrictions. Bettis et al. (2000) find that over 90% of firms have some form of self-imposed insider restriction in place and that many firms allow insider trading only in a short window after a quarterly earnings announcement. Following Roulstone (2003), we define SAFE as an indicator which is equal to one in the month following a quarterly earnings announcement, and zero otherwise. In addition, since many firms forbid insider trading in the period leading up to the earnings announcement, we define BAN as an indicator which is equal to one in the month leading up to an earnings announcement, and zero otherwise. Finally, we control for year fixed effects (YEARFE) and industry fixed effects based on two-digit Standard Industry Classification (SIC) codes (SICFE).

4. Empirical results

4.1. Descriptive statistics

Table 1 presents descriptive statistics regarding the high impact patents that we use in this study (Panel A) and the variables that we use the analyses of Hypothesis 1 (Panel B) and Hypothesis 2 (Panel C).

--- Insert Table 1 about here ---

Panel A of Table 1 shows that the median high impact patent collects about 100 forward citations and receives protection for 20 claims.[8] As discussed above, the median high impact patent takes 509 days or about 17 months to receive an allowance and the median time lag between the allowance date and the official grant date is 181 days (about 6 months).

The accounting information in Panels B and C reveal that the median firm in our sample has a book-to-market ratio of about 0.27 which indicates that these firms have significant growth options in form of their R&D and patenting activities. For the median firm, R&D expenditures make up roughly 9% of total assets. The descriptive statistics in Panels B and C indicate that insider buying is a rare event and that insiders in general sell more than they buy. This can be explained by equity grants as a form of employee compensation. We do not consider these grants as purchases because the insider does not have an influence on their timing. However, when the insider sells the shares that he was granted, these sales do enter the sample because the insider can determine the timing of these sales. Insiders in general do not frequently purchase shares in their own firms because of diversification concerns.

4.2. Insider buying after the allowance date

To test Hypothesis 1 which predicts that insider trading is higher after the allowance date, we specify the following equation which we test pooled. BUYING is either the natural logarithm of the value of shares bought (LNVALUE_BUY) or an indicator variable equal to one if insider purchasing took place and zero otherwise (INDBUY). In the former case we use a tobit specification and in the latter case logit. Subscript *i* refers to the dimension in the cross section

[8] The number of forward citations is corrected for truncation of the patent data. For example, a patent granted in 2005 only has one year to collect forward citations because the NBER patent citation dataset does not go beyond 2006. Thus, the weight on the number of forward citations received by patents granted in later years is higher than the weight on the number of forward citations received by patents which were granted in earlier years (Hall *et al.* 2001).

which is the firm. Subscript *t* refers to the time dimension which is the trading-day. All variables are generated as outlined in Sections 3.1 and 3.3.

$$BUYING_{i,t} =$$
$$\alpha + \beta_1 WIN1_{i,t} + \beta_2 WIN2_{i,t} + \beta_3 WIN3_{i,t} + \beta_4 WIN4_{i,t} + \beta_5 LNMARKETCAP_{i,t} + \beta_6 BTM_{i,t} +$$
$$\beta_7 R\&D_{i,t} + \beta_8 PAST6RET_{i,t} + \beta_9 FUT6RET_{i,t} + \beta_{10} SAFE_{i,t} + \beta_{11} BAN_{i,t} +$$
$$\sum_{y=12}^{17} \beta_y YEARFE_{y,i,t} + \sum_{z=18}^{21} \beta_z SICFE_{z,i,t} + \varepsilon_{i,t} \quad (1)$$

--- Insert Table 2 about here ---

The results of the four models presented in Table 2 lead to similar inferences. Across the logit and tobit specifications with and without control variables, we find that insider buying on days *t+10* through *t+19* (WIN2) after a given day *t* is greater if day *t* is an allowance day than when it is not. In addition, Models 1 through 4 reveal that insider buying on days *t* through *t+9* (WIN1) after a given day *t* is lower if day *t* is an allowance day than when it is not, possibly in order to avoid adverse consequences related to insider trading litigation (cf. Huddart *et al.* 2007). Collectively, these results provide support for Hypothesis 1 and confirm the expectation that insiders make use of their private foreknowledge of patent grants in their trading decisions, taking into consideration the risk of litigation.

Most of the coefficients on the control variables are in line with findings in prior research. Specifically, past returns are significantly negatively related to insider buying and the coefficients on future returns are in the expected direction but are not statistically significant. Most of the coefficients on the book-to-market ratio are positive as expected but none is statistically significant. Nevertheless, the coefficients on PAST6RET, FUT6RET, and BTM suggest that insiders trade contrarian, that is they buy (sell) if they believe that the stock is undervalued (overvalued) (Rozeff & Zaman 1998; Piotroski & Roulstone 2005). In addition, the coefficients on SAFE and BAN indicate that there is more insider buying in periods during which many firms allow insider trading and less insider buying in periods during which most firms forbid insider trading (Bettis *et al.* 2000).

4.2.1. The information environment and insider buying after the allowance date

Information about patent applications might enter the stock market even before the USPTO privately communicates the patent allowance to the applying firm. Regarding the demand side for information, analysts specialized in R&D intensive industries might actively seek information about patent applications. In this respect Barth *et al.* (2001) show that analysts exhibit a higher level of information search in R&D intensive firms than in others. With respect to the supply side, firms are free to communicate to analysts that patent applications have been filed. While firms generally have an incentive to keep the patent application secret[9], before the advent of Regulation Fair Disclosure (Reg FD) firms were able to privately communicate information to analysts.

The above discussion suggests that, depending on the information environment of the firm, information about pending patent applications might already be impounded in the applying firm's share price. Hence, we rerun Equation 1 separately for firms with a weak information environment and strong information environment. We classify firms below the sample-median in terms of analyst following as 'Low Coverage' (i.e. week information environment) and firms

[9] First, voluntary disclosure of the patent gives competitors more time to invent around the patent which means inventing a process that serves the same practical function as the patent without infringing it. Second, firms do not have the right to litigate for infringement until the patent is officially granted.

above the sample-median in terms of analyst following as ‘High Coverage’ (i.e. strong information environment). Table 3 presents the results.

--- Insert Table 3 about here ---

Insider buying in weeks three and four after the allowance date (WIN2) is significant when analyst coverage is low (Models 1 and 3) and insignificant when analyst coverage is high (Models 2 and 4) implying that insiders take into account patent allowances for their personal trading strategies only when the information environment of the firm is relatively weak. Assuming that insiders buy shares in their own firm with the aim of generating trading profits (Frankel & Li 2004), this suggests that by the time of the patent allowance, some information about the patent application is already impounded into the share price.

4.3. Insider selling after the grant date

To test Hypothesis 2 which predicts a positive relationship between CAR around the patent grant date and insider selling subsequent to the patent grant date, we specify the following equation where the subscript *p* reflects that the unit of analysis is the high impact patent:

$$SELL_p = \alpha + \beta_1 CAR_p + \beta_2 LNMARKETCAP_p + \beta_3 BTM_p + \beta_4 R\&D_p + \beta_5 PAST6RET_p + \beta_6 FUT6RET_p + \beta_7 SAFE_p + \beta_8 BAN_p + \sum_{y=9}^{14} \beta_y YEARFE_{y,p} + \sum_{z=15}^{18} \beta_z SICFE_{z,p} + \varepsilon_p \qquad (2)$$

The results presented in Table 4 indicate that insider selling after the patent grant is an increasing function of abnormal stock returns around the grant date. Across the three different benchmarks (4 factor model, 3 factor model, CAPM) we find a positive and significant relationship between abnormal returns and the likelihood of insider selling.[10] This finding provides support for Hypothesis 2 by showing that higher market reactions to the patent grant disclosure result in a higher likelihood of insider selling after the patent grant date. This implies that when the market has not impounded the value of the patent into the share price *before* the grant date, insiders wait until after the grant date to divest of some of their equity holdings at higher prices.

--- Insert Table 4 about here ---

The coefficients on the control variables are in line with prior research. The likelihood of insider selling is higher in larger firms, possibly because larger firms provide their employees with more equity-based compensation (Core & Guay 1999). Past returns are positively and significantly related to insider selling, suggesting that insiders trade contrarian (Piotroski & Roulstone 2005). In addition, we find less (more) insider selling in periods when many corporate insider trading rules forbid (allow) insider trading (Bettis *et al.* 2000).

5. Additional analyses and robustness tests

5.1. Insider buying after the patent allowance – econometric adjustments for excess zeros in the dependent variable

Prior studies that use insider buying aggregated at the firm-day, firm-month, or firm-quarter as the dependent variable suffer from a probability mass at zero in the dependent variable (Noe 1999; Ke *et al.* 2003; Kallunki *et al.* 2009). Since the unit of analysis in tests of Hypothesis 1 is the firm-day, the issue of excess zeros in the dependent variable also applies in the study at hand

[10] The results are similar in significance and magnitude when using a shorter window from t-1 through t+4.

as can be seen from the descriptive statistics in Table 1. To alleviate concerns regarding this issue, in Table 5 we rerun Equation 1 using count models that are more suitable for data with a probability mass at zero in the dependent variable.

--- Insert Table 5 about here ---

Model 1 uses the negative binomial model which is appropriate for count data, that is data where the dependent variable only takes non-negative integer values (Hausman *et al.* 1984; Cameron & Trivedi 1986). Model 2 uses a zero-inflated negative binomial model. Zero-inflated negative binomial models are suitable for count data with a probability mass at zero (Cameron & Trivedi 2010). In both models the dependent variable is the value of shares bought scaled by 10,000 since count models are more suitable for predicting small values (VALUE_BUY).

The results in Table 5 reveal that we still observe significantly more insider purchasing in weeks three and four after a patent allowance date. That is the coefficient on WIN2 is positive and significant across both specifications. These results are in line with those presented in Table 2 and provide further support for Hypothesis 1. The coefficients on WIN1 are not significant.

5.2. Insider buying after the patent allowance – matched-pairs design based on insider purchases

In order to verify that the results are not driven by the large number of firm-days on which there is no insider trading, we perform another robustness checks. We rerun the analysis of Hypothesis 1 on a matched-pairs sample as in Noe (1999) and Kallunki *et al.* (2009). Specifically, for each day on which there is an insider transaction for a given firm, we randomly match one day without an insider transaction for that firm. We draw 30 sample in this way and Table 6 presents the average coefficients and standard errors from the analysis.

--- Insert Table 6 about here ---

Corroborating the findings from Tables 2 and 5, we continue to observe that WIN2 is positively and significantly related to insider buying. The coefficients on WIN1 are not significant.

5.3. Trading profits to insider purchases that are conducted after an allowance date

Throughout this study, we assume that insiders buy shares of their own firms in order to generate trading profits (Frankel & Li 2004). Hence, if insiders trade on private information regarding future grants of high impact patents, we expect insiders to generate abnormal trading profits. We follow the methodology of Barber and Lyon (1997) in estimating the profitability of firm-specific events and calculate the buy-and-hold abnormal stock returns over the six months following those insider purchases that were conducted during the first four weeks after a patent allowance date. Our benchmark for estimating 'abnormal' returns is the four factor model of Fama and French (1993) and Carhart (1997). In untabulated tests, we find that the mean abnormal return to those insider purchases is 4.18% over the six months while the median abnormal return is 3%. Under the null hypothesis of market efficiency these returns should not be significantly different from zero. However, a one sample t-test with 183 insider purchase observations reveals that these returns are larger than zero (p-value 0.08, one-tailed).[11] While the rather short sample period and the limited number of observations make it difficult to interpret and compare the magnitude of

[11] When the horizon is twelve months instead of six months, the magnitude and statistical significance of the results become stronger with mean (median) abnormal returns of 10.7% (7.7%) and a p-value of 0.044 (two-tailed).

these trading profit estimates, they do give an indication that insiders are indeed successful in exploiting their foreknowledge of future grants of high impact patents for their personal trading decisions.

5.4. Market reaction to patent grant disclosures for firms with high and low analyst coverage

If a company keeps pending applications of high impact patents secret until the day when the grant of the patent is officially disclosed by the patent office, we expect the market reaction at the grant date to be strong. However, in Sections 4.2.1 and 4.3 we argue that for firms with strong information environments (i.e. high analyst coverage) information about pending patent applications might reach the stock market prior to the grant date. For these firms, we expect the market reactions to patent grant disclosure to be weaker. In untabulated tests, we show that the market reaction to the disclosure of high impact patents is significantly stronger (p-value 0.03 one-tailed) in firms with below-median analyst coverage than in firms with above-median analyst coverage.[12] The magnitude of the average market reaction to patent grants in low coverage firms is 65 basis points which is significantly different from zero (p-value 0.038, two-tailed). In high coverage firms, the average market reaction to patent grants is not significantly different from zero (p-value 0.59 two-tailed). These results supports the notion that the information asymmetry between insiders and outsiders regarding pending patent applications is less severe in firms with high analyst coverage than in firms with low analyst coverage which has implications for insider trading decisions.

6. Conclusion

[12] Similar to the analysis in Table 4, we proxy for the market reaction with the cumulative abnormal returns based on the Fama and French (1993) and Carhart (1997) four factor model from days t-1 through t+5 around the grant date. The results are similar in significance and magnitude when using a shorter window from t-1 through t+4.

In this paper we show that corporate insiders trade on information asymmetries created by the nature of the US patent application process. Specifically, we show that insiders in R&D intensive industries buy shares after the USPTO privately communicates to the applying firm that a pending high impact patent will be granted. This trading behavior is driven by firms with a weak information environment. In addition, we find that insiders sell shares after the official patent grant date, if the stock market reacts positively to the disclosure of the patent grant.

This study makes contributions to at least three distinct streams of the literature. First, we contribute to the discussion on the sources of insider trading profits. While prior studies investigating insider trading based on private information have to assume that insiders are better informed than other market participants (e.g. Ke *et al.* 2003), we know exactly when information asymmetry between insiders and outsiders arises. We complement Aboody & Lev (2000) who show that insiders in R&D intensive firms generate greater trading profits than insiders in other firms.

Next, we contribute to a young but growing stream of the literature which shows that equity-based management compensation encourages managers to spur innovation efforts (Lerner & Wulf 2007; Beyer *et al.* 2011; Francis *et al.* 2011; Manso 2011; Ederer & Manso 2012). While these studies establish a link between ex-ante equity incentives and innovation output, we document a relationship between innovation output and insiders' subsequent equity portfolio decisions. This link is important because if insiders were not able to trade on their knowledge of future patent grants, their equity incentives would trigger less innovation efforts ex-ante.

Lastly, we contribute to a discussion on the costs and benefits of the American Inventors Protection Act which was enacted in November 1999 (Johnson & Popp 2003). The act requires publication of patent applications applied for on or after November 29, 2000, no later than 18 months after the application date (USPTO 1999). The reported results point to a supposedly beneficial side effect of this act, namely that it reduces insiders' ability to trade on private information generated by the patent application process. Specifically, if mandatory disclosure of the patent application by the USPTO takes place before the allowance date, then information asymmetry between insiders and outsiders will be substantially reduced.

Appendix 1

Capital Asset Pricing Model (Sharpe 1964; Lintner 1965)*:*

The CAPM assumes that the expected return on a security *i* [$E(R_i)$] can be explained by the risk-free rate [R_f] and its sensitivity [β_i] to the excess market return [MKTRF]:

$$E(R_i) - R_f = \alpha + \beta_i MKTRF$$

We estimate b_i over the prior 60 months. Security prices are collected from CRSP and data on the excess market return (as well as on the additional risk factors in the three- and four factor models discussed later) are obtained from Kenneth French's website.[13] To obtain CAPM CAR around the patent grant date, for example from date t-1 through t+5 around the grant, we cumulate daily abnormal returns in the following manner:

$$CAR_{i,t} = \sum_{t-1}^{t+5} R_{i,t} - R_f - \beta_i MKTRFE_{i,t} = \sum_{t-1}^{t+5} \alpha_{i,t}$$

Fama and French (1993) three factor model:

The three factor model assumes that expected returns can be explained by the excess return on the market [MKTRF], the returns on zero-investment portfolios which are long in small stocks and short in big stocks [SMB], and the returns on zero-investment portfolios which are long in high book-to-market stocks and short in low book-to-market stocks [HML].

$$E(R_i) - R_f = \alpha + \beta_{1i} MKTRF + \beta_{2i} SMB + \beta_{3i} HML$$

As before, we estimate the betas over the prior 60 months. Cumulative abnormal returns for the window *t-1* to *t+5* are calculated as follows:

[13] Kenneth French's data collection is available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

$$CAR_{i,t} = \sum_{t-1}^{t+5} R_{i,t} - R_f - \beta_{1i}MKTRFE_{i,t} - \beta_{2i}SMB_{i,t} - \beta_{3i}HML_{i,t} = \sum_{t-1}^{t+5} \alpha_{i,t}$$

Fama and French (1993) and Carhart (1997) four factor model:

The four factor model assumes that expected returns can be explained by the excess return on the market [MKTRF], the returns on portfolios which are long in small stocks and short in big stocks [SMB], the returns on portfolios which are long in high book-to-market stocks and short in low book-to-market stocks [HML], and the returns on portfolios which go long in stocks that experience positive momentum and short in stocks with negative momentum [UMD].

$$E(R_i) - R_f = \alpha + \beta_{1i}MKTRF + \beta_{2i}SMB + \beta_{3i}HML + \beta_{4i}UMD$$

As before, we estimate the betas over the prior 60 months. Cumulative abnormal returns for the window *t-1* to *t+5* are calculated as follows:

$$CAR_{i,t} = \sum_{t-1}^{t+5} R_{i,t} - R_f - \beta_{1i}MKTRFE_{i,t} - \beta_{2i}SMB_{i,t} - \beta_{3i}HML_{i,t} - \beta_{4i}UMD_{i,t} = \sum_{t-1}^{t+5} \alpha_{i,t}$$

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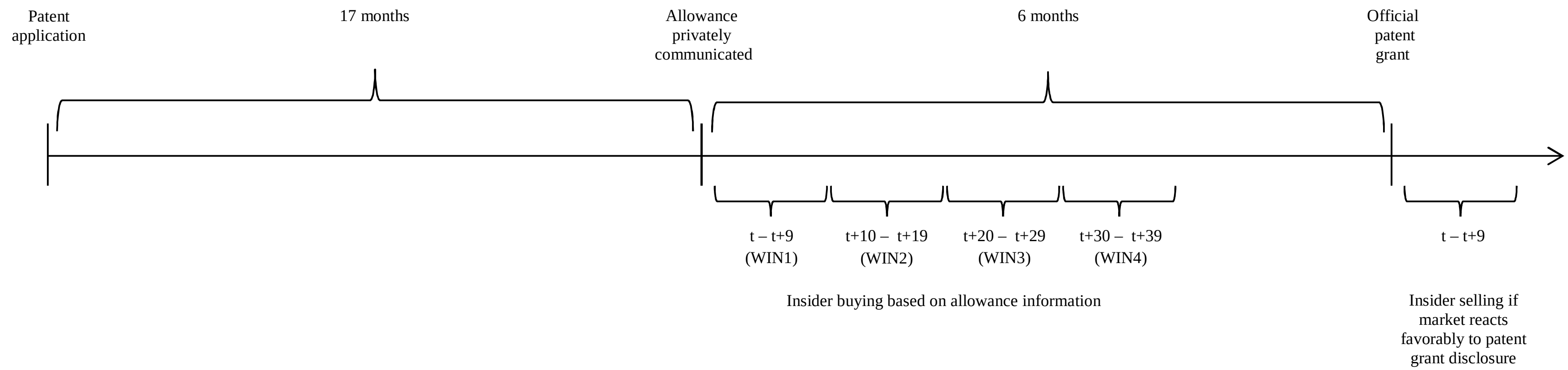
Figure 1



Patent application
17 months
Allowance privately communicated
6 months
Official patent grant
t – t+9 (WIN1)
t+10 – t+19 (WIN2)
t+20 – t+29 (WIN3)
t+30 – t+39 (WIN4)
t – t+9
Insider buying based on allowance information
Insider selling if market reacts favorably to patent grant disclosure

Table 1: Summary statistics of main variables

	Mean	SD	Min	25	Median	75	Max
Panel A: Patent characteristics (n=1,279)							
FORWARD CITATIONS	112.21	48.43	41.00	81.00	100.00	131.00	526.00
CLAIMS	23.38	17.27	1.00	13.00	20.00	29.00	309.00
ALLOWLAG	548.77	282.25	48.00	371.00	509.00	693.00	4263.00
GRANTLAG	193.36	75.10	71.00	153.00	181.00	215.00	1155.00
Panel B: Analysis of insider purchasing after the patent allowance (n=100,738)							
LNVALUE_BUY	0.113	1.110	0.000	0.000	0.000	0.000	13.659
INDBUY	0.010	0.102	0.000	0.000	0.000	0.000	1.000
WIN1	0.113	0.316	0.000	0.000	0.000	0.000	1.000
WIN2	0.112	0.316	0.000	0.000	0.000	0.000	1.000
WIN3	0.112	0.316	0.000	0.000	0.000	0.000	1.000
WIN4	0.112	0.315	0.000	0.000	0.000	0.000	1.000
LNMARKETCAP	8.231	2.021	2.480	6.800	8.383	9.833	12.522
BTM	0.328	0.210	-0.152	0.184	0.279	0.437	1.831
R&D	0.104	0.100	0.000	0.043	0.092	0.132	1.359
PAST6RET	0.083	0.325	-0.992	-0.084	0.095	0.265	0.946
FUT6RET	0.109	0.334	-1.021	-0.070	0.116	0.293	0.948
SAFE	0.324	0.468	0.000	0.000	0.000	1.000	1.000
BAN	0.353	0.478	0.000	0.000	0.000	1.000	1.000
NUMBER OF ANALYSTS	15.731	12.124	0.000	5.000	15.000	24.000	46.000
Panel C: Analysis of insider purchasing and selling after the grant date (n=1,279)							
SELL	0.276	0.447	0.000	0.000	0.000	1.000	1.000
4F CAR	0.003	0.077	-0.230	-0.039	0.004	0.044	0.270
3F CAR	0.002	0.077	-0.228	-0.036	0.004	0.038	0.263
CAPM CAR	0.002	0.076	-0.230	-0.039	0.003	0.039	0.263
LNMARKETCAP	9.146	1.798	2.237	8.319	9.403	10.445	12.522
BTM	0.293	0.186	-0.322	0.172	0.267	0.398	1.831
R&D	0.093	0.070	0.000	0.046	0.089	0.119	1.359
PAST6RET	0.118	0.344	-0.992	-0.070	0.125	0.326	0.946
FUT6RET	0.156	0.349	-1.021	-0.050	0.141	0.355	0.948
SAFE	0.485	0.500	0.000	0.000	0.000	1.000	1.000
BAN	0.493	0.500	0.000	0.000	0.000	1.000	1.000

FORWARD CITATIONS is the number of forward citations received by a patent. CLAIMS is the number of claims protected in a patent. ALLOWLAG is the number of days between the allowance date and the application date. GRANTLAG is the number of days between the grant date and the allowance date. LNVALUE_BUY is the natural logarithm of the value of insider purchases. INDBUY is an indicator variable equal to one if there is insider buying on a particular trading day and zero otherwise. WIN1 is an indicator equal to one if a firm-day is between t and t+9 of an allowance date and zero otherwise. WIN2 is equal to one if a firm-day is between t+10 and t+19 of an allowance date and zero otherwise. WIN3 is one if a firm-day is between t+20 and t+29 of an allowance date and zero otherwise. WIN4 is one if a firm-day is between t+30 and t+39 days of an allowance date and zero otherwise. LNMARKETCAP is the natural logarithm of the value of market capitalization. BTM is book value of equity divided by market value of equity. R&D is research and development expenditures scaled by total assets. PAST6RET (FUT6RET) is past (future) six-month continuously compounded cumulative stock returns. SAFE (BAN) is an indicator variable equal to one in the month following (prior to) a quarterly earnings announcement and zero otherwise. SELL is an indicator variable equal to one if there is insider selling on days t to t+9 after the grant date and zero otherwise. CAR measures cumulative abnormal returns over a window of t-1 to t+5 around the official patent grant date. The benchmark expected returns are estimated via the Capital Asset Pricing Model (CAPM CAR), three factor model (3F CAR), and four factor model (4F CAR).

Table 2: Insider buying after the allowance date

	(1)	(2)	(3)	(4)
	TOBIT	TOBIT	LOGIT	LOGIT
	LNVALUE_BUY	LNVALUE_BUY	INDBUY	INDBUY
Intercept	-66.825***	-79.465***	-4.582***	-6.032***
	(2.387)	(6.956)	(0.138)	(0.751)
WIN1	-2.630*	-2.130*	-0.245*	-0.215*
	(1.456)	(1.291)	(0.139)	(0.124)
WIN2	2.711*	2.909**	0.251*	0.286**
	(1.407)	(1.338)	(0.131)	(0.131)
WIN3	-0.105	-0.372	-0.004	-0.044
	(2.169)	(1.870)	(0.206)	(0.176)
WIN4	2.476	1.780	0.227	0.172
	(1.688)	(1.436)	(0.156)	(0.127)
LNMARKETCAP		1.047		0.096
		(0.681)		(0.070)
BTM		5.487		0.516
		(5.422)		(0.540)
R&D		-1.738		-0.426
		(10.682)		(1.256)
PAST6RET		-14.385***		-1.425***
		(3.259)		(0.338)
FUT6RET		2.136		0.202
		(1.889)		(0.187)
SAFE		6.725***		0.631***
		(1.495)		(0.158)
BAN		-6.108***		-0.619***
		(1.649)		(0.168)
Year FE	NO	YES	NO	YES
Industry FE	NO	YES	NO	YES
n	100,738	100,738	100,738	100,738
Pseudo R-squared	0.000975	0.0335	0.00154	0.0542

Standard errors clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1 (two-tailed)
LNVALUE_BUY is the natural logarithm of the value of insider purchases. INDBUY is an indicator variable equal to one if there is insider buying on a particular trading day and zero otherwise. WIN1 is an indicator equal to one if a firm-day is between t and t+9 of an allowance date and zero otherwise. WIN2 is equal to one if a firm-day is between t+10 and t+19 of an allowance date and zero otherwise. WIN3 is one if a firm-day is between t+20 and t+29 of an allowance date and zero otherwise. WIN4 is one if a firm-day is between t+30 and t+39 days of an allowance date and zero otherwise. LNMARKETCAP is the natural logarithm of the value of market capitalization. BTM is book value of equity divided by market value of equity. R&D is research and development expenditures scaled by total assets. PAST6RET (FUT6RET) is past (future) six-month continuously compounded cumulative stock returns. SAFE (BAN) is an indicator variable equal to one in the month following (prior to) a quarterly earnings announcement and zero otherwise. Industry fixed effects are based on two-digit SIC codes.

Table 3: Insider buying after the allowance date in firms with high and low analyst coverage

	(1)	(2)	(3)	(4)
	TOBIT	TOBIT	LOGIT	LOGIT
	LNVALUE_BUY	LNVALUE_BUY	INDBUY	INDBUY
	Low Coverage	*High Coverage*	*Low Coverage*	*High Coverage*
Intercept	-85.377***	-87.432***	-6.745***	-6.834***
	(8.413)	(17.764)	(0.926)	(1.777)
WIN1	-2.237	-2.383	-0.239	-0.228
	(1.845)	(1.621)	(0.180)	(0.155)
WIN2	4.028*	1.599	0.378*	0.145
	(2.242)	(1.591)	(0.222)	(0.153)
WIN3	-2.419	0.769	-0.235	0.074
	(2.166)	(2.114)	(0.206)	(0.203)
WIN4	0.216	2.749	0.031	0.268
	(1.663)	(1.802)	(0.159)	(0.166)
LNMARKETCAP	1.688*	2.376	0.158*	0.229
	(0.918)	(1.765)	(0.095)	(0.174)
BTM	7.555	0.691	0.718	0.100
	(5.848)	(7.131)	(0.608)	(0.668)
R&D	10.258	-69.459*	0.851	-7.226*
	(7.194)	(38.313)	(0.784)	(4.150)
PAST6RET	-14.791***	-15.372***	-1.468***	-1.514***
	(3.797)	(4.528)	(0.399)	(0.497)
FUT6RET	5.145**	-3.880	0.471*	-0.393
	(2.384)	(2.588)	(0.246)	(0.272)
SAFE	6.131***	7.774***	0.566**	0.746***
	(2.196)	(1.287)	(0.236)	(0.119)
BAN	-8.081***	-3.418	-0.817***	-0.338
	(1.825)	(2.264)	(0.191)	(0.230)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
n	53,480	47,258	53,480	47,258
Pseudo R-squared	0.009	0.005	0.008	0.004

Standard errors clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1 (two-tailed)
Low Coverage (High Coverage) firms are those with the number of analysts following the firm below (above) the sample median. LNVALUE_BUY is the natural logarithm of the value of insider purchases. INDBUY is an indicator variable equal to one if there is insider buying on a particular trading day and zero otherwise. WIN1 is an indicator equal to one if a firm-day is between t and t+9 of an allowance date and zero otherwise. WIN2 is equal to one if a firm-day is between t+10 and t+19 of an allowance date and zero otherwise. WIN3 is one if a firm-day is between t+20 and t+29 of an allowance date and zero otherwise. WIN4 is one if a firm-day is between t+30 and t+39 days of an allowance date and zero otherwise. LNMARKETCAP is the natural logarithm of the value of market capitalization. BTM is book value of equity divided by market value of equity. R&D is research and development expenditures scaled by total assets. PAST6RET (FUT6RET) is past (future) six-month continuously compounded cumulative stock returns. SAFE (BAN) is an indicator variable equal to one in the month following (prior to) a quarterly earnings announcement and zero otherwise. Industry fixed effects are based on two-digit SIC codes. Industry fixed effects are based on two-digit SIC codes.

Table 4: Insider selling after the grant date

	(1)	(2)	(3)
	LOGIT	LOGIT	LOGIT
	SELL	SELL	SELL
Intercept	-4.313***	-4.305***	-4.300***
	(0.921)	(0.919)	(0.917)
4F CAR	1.553*		
	(0.925)		
3F CAR		1.558*	
		(0.922)	
CAPM CAR			2.174**
			(1.024)
LNMARKETCAP	0.223***	0.222***	0.221***
	(0.064)	(0.064)	(0.063)
BTM	0.200	0.220	0.231
	(1.031)	(1.023)	(1.019)
R&D	0.928	0.907	0.869
	(1.639)	(1.624)	(1.626)
PAST6RET	1.011***	1.017***	1.011***
	(0.277)	(0.277)	(0.277)
FUT6RET	0.007	0.009	0.005
	(0.251)	(0.251)	(0.251)
SAFE	1.693***	1.692***	1.690***
	(0.258)	(0.258)	(0.257)
BAN	-0.349	-0.350	-0.355*
	(0.217)	(0.216)	(0.215)
Year FE	YES	YES	YES
Industry FE	YES	YES	YES
n	1,279	1,279	1,279
Pseudo R-squared	0.165	0.165	0.166

Standard errors clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1 (two-tailed)
SELL is an indicator variable equal to one if there is insider selling on days t to t+9 after the grant date and zero otherwise. CAR measures cumulative abnormal returns over a window of t-1 to t+5 around the official patent grant date. The benchmark expected returns are estimated via the Capital Asset Pricing Model (CAPM CAR), three factor model (3F CAR), and four factor model (4F CAR). LNMARKETCAP is the natural logarithm of the value of market capitalization. BTM is book value of equity divided by market value of equity. R&D is research and development expenditures scaled by total assets. PAST6RET (FUT6RET) is past (future) six-month continuously compounded cumulative stock returns. SAFE (BAN) is an indicator variable equal to one in the month following (prior to) a quarterly earnings announcement and zero otherwise. Industry fixed effects are based on two-digit SIC codes.

Table 5: Insider buying after the allowance date - count models

	(1)	(2)
	NEGATIVE BINOMIAL	ZERO-INFLATED NEGATIVE BINOMIAL
	VALUE_BUY	VALUE_BUY
Intercept	-4.184***	-3.141***
	(0.814)	(0.873)
WIN1	-0.023	-0.029
	(0.223)	(0.198)
WIN2	0.433**	0.521***
	(0.202)	(0.177)
WIN3	-0.193	-0.048
	(0.178)	(0.188)
WIN4	0.345	0.342
	(0.263)	(0.263)
LNMARKETCAP	0.194***	0.155**
	(0.070)	(0.070)
BTM	1.109	0.663
	(0.799)	(0.768)
R&D	-0.540	-0.945
	(0.823)	(0.869)
PAST6RET	-0.825***	-0.928***
	(0.294)	(0.305)
FUT6RET	0.027	0.078
	(0.262)	(0.246)
SAFE	0.600***	-0.103
	(0.156)	(0.224)
BAN	-0.873***	-0.328
	(0.250)	(0.292)
Year FE	YES	YES
Industry FE	YES	YES
n	100,738	100,738

Standard errors clustered by firm in parentheses. *** p<0.01, ** p<0.05, * p<0.1 (two-tailed)
VALUE_BUY is the value of insider purchases scaled by 10,000. WIN1 is an indicator equal to one if a firm-day is between t and t+9 of an allowance date and zero otherwise. WIN2 is equal to one if a firm-day is between t+10 and t+19 of an allowance date and zero otherwise. WIN3 is one if a firm-day is between t+20 and t+29 of an allowance date and zero otherwise. WIN4 is one if a firm-day is between t+30 and t+39 days of an allowance date and zero otherwise. LNMARKETCAP is the natural logarithm of the value of market capitalization. BTM is book value of equity divided by market value of equity. R&D is research and development expenditures scaled by total assets. PAST6RET (FUT6RET) is past (future) six-month continuously compounded cumulative stock returns. SAFE (BAN) is an indicator variable equal to one in the month following (prior to) a quarterly earnings announcement and zero otherwise. Industry fixed effects are based on two-digit SIC codes.

Table 6: Insider buying after the allowance date - random sampling based on insider purchases

	(1) TOBIT LNVALUE_BUY	(2) LOGIT INDBUY
Intercept	-26.160***	-2.375***
	(6.539)	(0.759)
WIN1	-1.586	-0.194
	(1.157)	(0.130)
WIN2	2.725**	0.302**
	(1.219)	(0.132)
WIN3	-0.053	-0.030
	(1.852)	(0.201)
WIN4	1.758	0.164
	(1.484)	(0.148)
LNMARKETCAP	-0.261	-0.033
	(0.606)	(0.069)
BTM	9.652**	0.977**
	(3.822)	(0.390)
R&D	-3.942	-0.641
	(13.140)	(1.744)
PAST6RET	-16.308***	-1.834***
	(2.478)	(0.301)
FUT6RET	1.588	0.180
	(1.826)	(0.197)
SAFE	1.553	0.184
	(1.305)	(0.150)
BAN	-3.619**	-0.410**
	(1.671)	(0.184)
Year FE	YES	YES
Industry FE	YES	YES
n	12880	12880
Pseudo R-squared	0.042	0.085

For this analysis, every firm-day with an insider purchase is randomly matched to one day within the same firm without an insider purchase. 30 random samples are drawn and the average coefficients and average standard errors (in parentheses) from these 30 regressions are presented here. Standard errors are clustered by firm. *** p<0.01, ** p<0.05, * p<0.1 (two-tailed). LNVALUE_BUY is the natural logarithm of the value of insider purchases. INDBUY is an indicator variable equal to one if there is insider buying on a particular trading day and zero otherwise. WIN1 is an indicator equal to one if a firm-day is between t and t+9 of an allowance date and zero otherwise. WIN2 is equal to one if a firm-day is between t+10 and t+19 of an allowance date and zero otherwise. WIN3 is one if a firm-day is between t+20 and t+29 of an allowance date and zero otherwise. WIN4 is one if a firm-day is between t+30 and t+39 days of an allowance date and zero otherwise. LNMARKETCAP is the natural logarithm of the value of market capitalization. BTM is book value of equity divided by market value of equity. R&D is research and development expenditures scaled by total assets. PAST6RET (FUT6RET) is past (future) six-month continuously compounded cumulative stock returns. SAFE (BAN) is an indicator variable equal to one in the month following (prior to) a quarterly earnings announcement and zero otherwise. Industry fixed effects are based on two-digit SIC codes.