Innovation, Institutional Development, and Insider Trading

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ABSTRACT

A positive stock market valuation of a firm's innovative assets grants the firm credibility as an innovator, facilitates the financing of future R&D, and is, therefore, an important step towards a firm's ability to create and sustain a competitive advantage. Using a dataset of publicly listed firms in China, we show that in weak institutional environments innovative assets face a lower market valuation. We, further, show that insider trading acts as a signal for the value of innovative assets and increases the stock market valuation of innovative assets.

Keywords:

Innovation; Market valuation; Institutional development; Insider trading; Developing economies

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INTRODUCTION

The resource-based view (hereafter, RBV) explains heterogeneity among firms as a result of their different resource endowment (Barney, 1986a, 1991). Whenever a firm is capable of obtaining and utilizing valuable and rare resources and capabilities, which are in addition difficult to imitate, it can extract value, gain and sustain a competitive advantage, and generate abnormal returns (Amit & Schoemaker, 1993; Barney, 1986a, 1991; Collis & Montgomery, 1995; Peteraf, 1993; Teece, Pisano & Shuen, 1997; Wernerfelt, 1984). Innovative assets have been identified as those resources with the greatest potential for generating a competitive advantage (Barney & Arikan, 2001; Crook, Ketchen Jr, Combs & Todd, 2008; Kogut & Zander, 1992; McGrath, Tsai, Venkataraman & MacMillan, 1996). Including research and development (R&D) and patents, innovative assets are key strategic resources thanks to their uniqueness, novelty, tacitness, and firm specificity (Amit & Schoemaker, 1993; Grant, 1991; He & Wang, 2009).

Given these characteristics, innovative assets are often surrounded by a high degree of information asymmetry and uncertainty (Arrow, 1963; Czarnitzki & Toole, 2011; Gans, Hsu, & Stern, 2008; Hussinger & Pacher, 2019; Nemlioglu & Mallick, 2020), which can compromise their value assessment by external parties. The acknowledgement of the value of the firm's innovation assets by outsiders is, however, of utmost importance (Bowman & Ambrosini, 2001; Priem & Butler, 2001; Srivastava, Fahey & Christensen, 2001). A positive market valuation of a firm's innovative assets reduces asymmetric information between insiders and outsiders therefore granting the firm credibility as an innovator (Arora, Fosfuri & Gambardella, 2001a; Long, 2002) and signals the firm's ability to transform research investments into new and potentially valuable knowledge (Levitas & McFadyen, 2009). In addition, a positive market valuation of a firm's innovative assets facilitates the financing of future R&D by reducing the costs of capital which helps generating

future profits and growth (Hottenrott, Hall & Czarnitzki, 2016; Lev, Sarath & Sougiannis, 2005). In other words, a positive evaluation of a firm's innovative assets is an important step towards the firm's ability to create and sustain a competitive advantage from innovation.

While in developed institutional environments, stock market valuations reflect the value of innovative assets positively (Bloom & Van Reenen, 2002; Griliches, 1981; Hall, Jaffe & Trajtenberg, 2005; Shleifer & Vishny, 1997; Toivanen, Stoneman & Bosworth, 2002), this cannot be taken for granted when the institutional context of a firm is continuously evolving, unstable, and characterized by weak institutions including poor enforcement of property rights, investors' protection, and information disclosure laws. Our first research question, therefore, reads: are innovative assets of firms operating in a weak institutional environment valued less by the market compared to the innovative assets of firms operating in a stronger institutional context? We argue that in a weak institutional environment, the higher degree of uncertainty can lead to a lower market valuation of firms' innovative assets therefore increasing information asymmetries, raising the costs of capital for the firm, and thereby hindering future profits and growth (Hottenrott et al., 2016; Lev et al., 2005). Since firms' strategic choices are deeply entangled and depending on the institutional framework (Peng, Wang & Jiang, 2008), this effect can perpetuate, implying that firms in weak institutional environments decide to invest less in innovative assets (Alam, Uddin & Yazdifar, 2019; Choi, Yoshikawa, Zahra & Han, 2014; Seitz & Watzinger, 2017).

In this paper, we investigate the market value of innovative assets for firms operating in different institutional contexts by exploiting the variation in the level of institutional development of the 31 provinces, cities, and independent regions of China. We define innovative assets as R&D investment, which is a proxy for highly skilled employees and specialized equipment (Edworthy & Wallis, 2008), and patent applications (Christensen, 1995; Hussinger & Pacher, 2019). While

patents, on the one hand, serve as intellectual property means, they have been shown to be also an effective instrument for signaling successful innovation and for reducing information asymmetries between the patenting firm and outside investors (e.g. Harhoff, 2009; Heger & Hussinger, 2017; Long, 2002). We show that the market value of patents of firms operating in a weak institutional environment is still negatively affected by the surrounding context, which indicates that their signaling value is limited when institutions are weak. For this reason, we consider insider trading as an alternative means that qualifies as a strong signaling devise in the sense of Spence (1973)[1] in weak institutional contexts. More specifically, we inquire: can insider trading signal the value of innovative assets therefore mitigating their lower market valuation in weak institutional contexts? Insider trading is a fiercely debated practice in developed institutional contexts (e.g. Bebchuk & Fershtman, 1994; Bhattacharya & Nicodano, 2001; Fischer, 1992; Leland, 1992; Manove, 1989; see also Bhattacharya, 2014 for a complete review of the debate on insider trading). Referring to the trading of shares by corporate officers, directors, and large stockholders of the traded company (Jaffe, 1974),[2] insider trading can transmit credible signals to external investors because insiders risk their private wealth (Bagnoli & Khanna,1992; Coff & Lee, 2003; John & Lang, 1991; John & Mishra, 1990). Especially for innovative assets, investors can view insider trading as a positive signal of the quality of the firm's resources and their future prospect (Coff & Lee, 2003). Our results confirm that firm insiders' purchases of their own firm's shares have a positive signaling effect counteracting the lower market valuation of R&D investment in weak institutional contexts.

Our contribution is twofold. First, we add to the RBV by clarifying an implicit, often overlooked

[1] Insider trading qualifies as a strong signal because it is costly for the insiders and is credible to outsiders, who can easily verify insider trading transactions (this is explained more in detail in the next section).

[2] Insider trading is a standard practice that becomes illegal only once it is proven that insiders have traded based on special, private information yet undisclosed to the public. Most insider trading, in fact, is "routine, legal, and far removed from headlines" (Coff & Lee, 2003). For a current overview on insider trading regulations see Bainbridge (2021).

assumption. Many studies drawing from the RBV fall short of acknowledging the importance of the recognition of the value of innovative assets by external parties in order to generate a sustainable competitive advantage from those assets (see Armstrong & Shimizu, 2007 for a review of empirical studies on the RBV). In other words, if the future value of innovative assets is not reflected in the market valuation of firms, it hinders their ability to generate profits from these assets (Ceccagnoli, 2009). By showing that firms operating in a weak institutional environment receive a lower stock market valuation for their innovative assets, we close the gap to prior literature that shows that firms in weak institutional settings experience performance shortfalls (Qian, Wang, Geng & Yu, 2017).

Second, we add to the literature that investigates the interplay between institutional context and innovation (see He & Tian, 2020, for a recent survey). This literature establishes that the institutional framework impacts firms' strategic choices and success (Peng, 2002; Peng, Sun, Pinkham & Chen, 2009), but it has mainly focused on the impact of institutions on R&D investment. Our study extends to the effect of institutions on the market valuation of innovative assets in developing, weak institutional contexts. We contribute by showing that certain managerial actions can have a different effect in environments of different levels of institutional development. The finding that outside investors interpret the controversial measure of insider trading (Carlton & Fischel, 1982; Dye, 1984; Glosten, 1989; Leland, 1992; Levine, Lin, Wei, 2017; Manne, 1966; Merton, 1987) as a positive signal concerning firm's innovative assets when institutions are weak, suggests that unconventional measures can be supportive of innovation in weak institutional environments.

THEORY AND HYPOTHESES

Institutions and the Market Valuation of Innovative Assets

The RBV sees firms as bundles of assets and asserts that those resources which are valuable, rare, and costly to imitate are most likely to generate a sustainable competitive advantage (Barney, 1991; Wernerfelt, 1984). Among firms' strategic assets, innovative assets such as R&D and patents have the greatest potential for generating future profits (Crook et al., 2008; Grant, 1996; Kogut & Zander, 1992). The tacitness, ambiguity, complexity, and firm specificity that make knowledge resources highly strategic lead, at the same time, to a substantial level of information asymmetry between firm insiders and outside investors which makes it difficult for the latter to assess their value (Arrow, 1963).

The acknowledgment of the value of innovative assets by the market is, however, an essential stage in the process of generating a sustainable competitive advantage from innovative assets (Bowman & Ambrosini, 2001, Priem & Butler, 2001; Srivastava et al., 2001). The recognition of innovative assets by the stock market grants the firms credibility as an innovator (Chauvin & Hirschey, 1993; Henard & Dacin, 2010), helps generating future profits from the innovative assets (Arora et al., 2001a; Long, 2002), and facilitates the financing of future R&D (Hottenrott et al., 2016; Lev et al., 2005). When showing that stock market valuations reflect the positive value of innovative assets, previous literature has mainly focused on developed countries with stable institutional structures (e.g. Bloom & Van Reenen, 2002; Chan, Lakonishok & Sougiannis, 2001; Griliches, 1981; Hall et al., 2005; Toivanen et al., 2002; Pindado, De Queiroz & De La Torre, 2010; see Czarnitzki, Hall & Oriani, 2006, for a survey).[3] Within those studies, a well-developed institutional context is taken

[3] To the best of our knowledge there exist only two exceptions which focus on India (Chadha & Oriani, 2010; Kanwar & Hall, 2015).

for granted, but already Barney (2001, p.51) noted that "the value of a firm's resources must be understood in the specific market context within which a firm is operating". Especially in emerging markets, the constant institutional development is a crucial factor contributing to the heterogeneity among firms by impacting firms' ability to transform strategic resources into a sustainable competitive advantage (Oliver, 1997; Peng et al., 2008; Scott, 1995).

A well-developed institutional context is characterized by strong enforcement of property rights, including intellectual property rights (IPRs), a functioning system of laws, rules, and contract enforcement, has efficient intermediary and financial institutions, reliable access to information, access to capital, developed capital markets, and efficient capital allocation systems, well-developed fiscal, monetary, and financial policies, developed banking and regulatory system (see, for example, Fernandez & Tamayo, 2017; Hsu, Tian & Xu, 2014; Kumar, Rajan & Zingales, 1999). While all these aspects of the institutional context influence innovation, the financial and the legal dimensions of the institutional development are the most relevant institutional factors for innovation (Brown, Martinsson & Petersen, 2017; Qian et al., 2017).[4]

The degree of financial development affects the acknowledgement of innovative assets in several ways (Fernandez & Tamayo, 2017; King & Levine, 1993a; Levine, 1997). First, more developed equity markets provide firms with greater access to external financing for innovation (Hsu et al., 2014). Considering the difficulties intrinsic to the valuation of innovative assets, developed equity markets allow information about such assets to reach investors more rapidly providing timely and accurate securities' prices and assets' valuations. Second, a more liberalized stock market improves innovation via relaxation of financial constraints, enhanced risk-sharing, and improved

[4] We also focus exclusively on formal institutions which include laws and regulations, while informal institutions such as the set of cultural norms and ethical guidelines common to a group of people are not at the focus of this study (Peng et al., 2009; Qian et al., 2017).

corporate governance (Moshirian, Tian, Zhang & Zhang, 2020), which then results, together with a higher participation in the marketplace, in a more precise and unbiased valuation of firms' assets. Third, more efficient capital allocation systems and better access to capital allow firms to engage more strongly in innovation activities (Kumar et al., 1999; Xin, Zhang & Zheng, 2017), while whenever access to credit is restricted, large, incumbent firms are in a favorable position as compared to small entrants which are often unable to acquire the required capital for investing in R&D (Davis & Henrekson, 1999). This leads to a decrease in the total innovation output as larger firms, absent a competitive environment, do not have an incentive in investing in R&D (Arrow, 1962; Reinganum, 1983).

Legal institutions also affect the evaluation of innovative assets. First, in regions where IPR protection is only marginally enforced, there is a greater risk that innovative firms might not be able to appropriate the economic rents of their innovation activities (Qian et al., 2017). Considering the direct link between appropriation of economic rents and innovative assets' value, it is straightforward that a less efficient IPR protection system can lead to a lower market valuation of innovative asset (Chadha & Oriani, 2010; Teece, 1986). Second, more enforced property rights facilitate markets for innovation (Spulber, 2013), while a low degree of investor protection facilitates information asymmetries and when paired with a weak level of contract enforcement results again in a higher risk of rent misappropriation and lower market value of innovation (Himmelberg, Hubbard & Love, 2004). Third, more developed patent laws have been shown to increase innovation activities in a wide variety of sectors (Moser, 2005) and are critical for firms' ability to protect the economic rents derived by their innovation efforts (Levin et al., 1987; Cohen, Nelson & Walsh, 2000). Patent system have the further benefit for external investors that they publish detailed information about the protected patents so that outsiders can form an opinion

about the profitability and strategic value of a firm's inventions.

In summary, strong IPR laws and enforcement as well as strong protection of general property rights and well-developed financial institutions facilitate the market valuation of innovative assets.

> **Hypothesis (H1)**. *The market valuation of innovative assets is lower for firms located in a weak institutional environment compared to firm located in a strong institutional environment.*

A closer look at innovative assets

Innovative assets exist is various forms. We focus on R&D investment and patent applications as the two most common types. R&D investment reflects mainly the salary of highly skilled employees and the expenses for specialized equipment so that it proxies innovative assets (Edworthy & Wallis, 2009). Patent applications certify inventions with market potential and are tradable on the market for ideas (Arora et al., 2001a; Arora & Gambardella, 2010). While uncertainty is highest for R&D investment as it constitutes an investment in uncertain projects about which the public is not informed (Arrow, 1963), patents mark a successful invention with market potential and therewith reduce information asymmetries between the patenting firm and outside investors (Long, 2002).

Long (2002) distinguishes between patents as a tool for IP protection in exchange for disclosure of the patented invention and patents as a vehicle for credibly conveying information about the underlying invention. The latter view of patents portraits them as a signal for the quality of the R&D activities of the firm. Patents qualify as signals according to Spence (1973) because, first, they are costly to obtain. The largest share of the costs of patenting are associated with the R&D investment that led to the invention supplemented by administrative fees such as application costs and renewal fees (De Rassenfosse & Jaffe, 2018) and potentially infringement costs (Somaya,

2012). Second, as patent documents are publicly available and detailed enough for a person skilled in the art to understand the protected technology, patents can be easily verified by outsiders (Myers & Majluf, 1984). In addition, there are penalties for intentionally misrepresenting information in patent applications which further increases their credibility (Long, 2002). We argue that the signaling value of patents is limited when the institutional context is weak and where property rights and information disclosure laws are poorly defined and enforced. This is why we expect that also patent applications in weak environments receive a lower market valuation than patent applications in well-developed institutional contexts.

Insider trading, Institutional Development, and the Market Valuation of Innovative Assets

When insiders purchase shares of their own firms, they typically aim at increasing their private wealth (e.g. De La Brunière, Haye & Mazza, 2020). At the same time, they also convey private information about positive future expectation regarding the firm to outsiders and, therewith, reduce information asymmetries between the firm and outside investors (Carlton & Fischel, 1982; Glosten, 1989; John & Mishra, 1990; Leland, 1992).

Insider trading qualifies as a signaling devise in the sense of Spence (1973). First, insider trading is costly. Insiders put their personal wealth at risk when purchasing shares of their own firms, while patent applications barely affect the personal wealth of the affected insiders. Second, insider purchases can be verified by outsiders. Legal insider trading, which accounts for the vast majority of insider trades (see Mazza & Wang, 2021, for China), respects the country-specific regulations and is reported to the market authorities (see Mazza & Wang, 2021; and Huang, 2020, for a discussion of the insider trading regulations in China).

We argue, that, especially for firms located in a weak institutional environment characterized by strong information asymmetries, outside investors can interpret insider purchases as a signal that

they can profit by increasing their shareholdings. The reason is that the greater the expected information gap between insiders and external investors, the greater the expected gap between the fundamental value of the stock and the price of the stock so that a gain for external investors based on insider signals is larger. A small information advantage, in contrast, limits potential profits (Brunnermeier, 2005). Innovative assets add an additional layer of information asymmetry next to the environment and it has been shown that investors rely on the managerial foresight of firm insiders purchasing shares of their own firm especially (Ahuja, Coff & Lee, 2005; Coff & Lee, 2003).

We hence argue, that in a weak institutional environment characterized by information asymmetries insider trading can provide timely information about the value of innovative assets.

> **Hypothesis (H2)**. *In a weak environment, the market valuation of innovative asset is higher as insiders increase their shareholdings.*

DATA AND METHODOLOGY

Empirical context: China

Our empirical analysis focuses on China which offers unique features for testing our hypotheses. Since the start of the "reform and opening-up" process in the early 1980s which marked the shift from a centrally planned economy to a market system (Prasad & Rajan, 2006), China has recognized the importance of technology as the driver for turning the economy from a production-oriented state into a knowledge-based economy (Liang & Xue, 2010). The aim was to move to a market economy based on "innovation" rather than on "imitation" (Dang & Motohashi, 2015). The increase in foreign direct investment (FDI) has, further, put pressure on China to adapt to international standards (Hu & Jefferson, 2009). The adoption of international standards and the rapid economic growth led to a fast modernization of the institutional environment. What makes

China especially interesting for our empirical setting is that the laws and regulations covering accounting standards, investors protection, and transfer of information, and especially their enforcement are enacted and enforced locally, at the provincial, regional, and/or city level (Krug & Hendrischke, 2003). Therefore, China represents a highly variegate and fragmented institutional environment that varies from province to province (Fan & Wang, 2006; Wang, Wong & Xia, 2008). By exploiting the significant variation in the level of institutional development of the 31 provinces, cities, and independent regions of China, we are able to study the market valuation of innovation assets of publicly listed, non-government-owned Chinese firms in regions of different institutional development and the impact of insider trading.

Regarding insider trading, like most jurisdictions China allows legal insider trading (Bhattacharya, 2014). Illegal insider trading was prohibited in China by the Company Law of 1994, the Criminal Law of 1997 and the Securities Law of 1998 (Mazza & Wang, 2021). The Chinese Securities Law of 2006 and the implementation of stricter regulation let Mazza and Wang (2021) conclude that the incentives to engage in illegal insider trading in China is low. Strict insider trading laws and enforcement are an important prerequisite for our empirical test because in case of unregulated insider trading, stock market prices would show no reaction to events as Bhattacharya, Daouk, Jorgenson & Kehr (2000) demonstrates for the case of Mexico. In a recent comparative study, Huang (2020) concludes that based on the type, magnitude, and frequency of sanctions, the intensity of insider trading enforcement in China is at a comparable level to overseas jurisdictions such as the U.S., the U.K., Australia, Singapore, and Hong Kong. Also, Miller, Li, Eden & Hitt (2008) consider the period from 2001 onwards as a period of strong insider trading regulations for China (see also Mazza & Wang, 2021).

Data sources

Yearly data for publicly traded Chinese firms is gathered from the China Stock Market and Accounting Research (CSMAR) database and includes R&D expenditure, book value of total assets, number of patents applications, number of outstanding shares, including information on the number of state-owned shares, legal insider trading activity (purchases, sales and trading volumes), and firms' headquarter location.[5] The dataset is supplemented with the provincial-level National Economic Research Institute (NERI) Index of Marketization (Fan & Wang, 2006), which captures the development of marketization in all 31 Chinese provinces, municipalities, and autonomous regions, and provides a measure of institutional development (e.g. Qian et al., 2017).

Our sample consists of those Chinese firms that (1) are publicly listed on the Shanghai Stock Exchange (SSE) or the Shenzhen Stock Exchange (SZSE), (2) have positive R&D expenditure as we are interested in innovative assets, (3) belong to the manufacturing sector because innovation differs substantially in service industries where firms spend less on R&D and apply for fewer patents (Hipp & Grupp, 2005), and (4) have no state-ownership. We exclude firms with state participation because these firms have been shown to differ systematically from other publicly listed firms (see for example Phi, Taghizadeh-Hesary, Tu, Yoshino & Kim, 2021; Ruan, Cullen, Ma & Xiang, 2014; Shleifer & Vishny, 1994; Tong, Junarsin & Li, 2015). Our initial dataset covers an unbalanced sample between 2008 and 2016[6] and includes 4311 firm-year observations on 1262 firms.

[5] For a few firms, information on the location of the firms' headquarters is missing for individual years. We assume that the location of firms did not change if the information is missing in a particular year or several consecutive years, but it is the same for the previous and the first next year in which the information is not missing.

[6] These years have been chosen due to data availability. The first is dictated by the fact that information on R&D is only available as of 2008, while the latest year, 2016, is determined by the availability of the NERI index of marketization.

Dependent variable

Our empirical model is based on the market value model developed by Griliches (1981), and our dependent variable is the natural logarithm of Tobin's Q. We define Tobin's Q as the ratio of the firm's market value, i.e. the total number of shares outstanding multiplied by the price per share, to the book value of the firm's tangible assets (Dowell, Hart & Yeung, 2000; Morck & Yeung, 1991).

Independent variables

Innovative assets

The set of independent variables follows the market value model by Griliches (1981) and contains R&D investment and the patent application stock which define two distinctive types of innovative assets.

To measure R&D investment we use the amount of yearly R&D expenditure divided by the book value of the assets of the firm in the same year (Hall et al., 2005; Hillier, Pindado, De Queiroz & De La Torre, 2011; Pindado et al., 2010).

We calculate the firms' patent application stock as follows:

$$application\ stock_{it} = number\ of\ applications_{it} + (1-\delta) application\ stock_{it-1} \quad (1)$$

where δ is the depreciation rate that is set to 15% as is standard in previous studies (e.g. Hall & Mairesse, 1995; Hall, 2007; Nadiri & Prucha, 1996). We divide the patent application stock by the amount of yearly R&D expenditure.

Degree of institutional development

To test our first hypothesis, we make use of the NERI index of marketization. The NERI index is an assessment of the marketization progress of the 31 provinces, cities, and autonomous regions

in China. It uses a comparative method based on data gathered from the China annual statistics yearbook and enterprise and household surveys (Wang, Fan & Zhu, 2007). The index is divided into five broad fields (government and market relations, development of the nonstate enterprise sectors, development of the commodity market, credit market development, and development of legal environment) composed of a total of 23 basic indicators. In line with our hypothesis 1 and following Qian et al. (2017), we employ two of the basic indicators: credit market development and development of legal institutions. These two sub-indices reflect and measure the degree of development of the institutions that are more closely related to innovation and technological development. More specifically, the credit market development index measures the degree of competition in the financial markets (ratio of deposits taken by non-state-owned financial institutions to that of all financial institutions), the presence (in terms of market share) of non-state-owned financial institutions, and the efficiency of capital allocation (ratio of financial resources allocated to state-owned enterprises (SOEs) to that of all enterprises). The legal environment development index, instead, measures the conditions of service of market intermediaries such as lawyers and accountants and the extent to which industry associations help businesses.[7] Also, it measures the legal environment faced by businesses through an assessment of the level of law enforcement and the efficiency of local judicial and administrative law enforcement agencies (data gathered through a sample survey of enterprises). The final ingredient is a measure of IPR enforcement.

The index and sub-indices come in the form of a score and a ranking: a province that is ranked first (according to its score) has the highest level of institutional development. Our measure of provincial year-level institutional development is the mean of the ranking of the province for credit

[7] This data is gathered through corporate surveys asking questions such as: "How are the conditions of market services such as local lawyers, accountants, etc." and "The extent to which local industry associations help the enterprises".

market development and legal environment development. We chose the ranking over the score because the scores increase over time with the development of the regions.[8]

Insider trading

Testing our second hypothesis requires a measure of insider trading. Our dataset includes yearly data on the number of shares owned by insiders (members of the board of directors, board of supervisors, and executives) of publicly listed firms. Our measure of insider trading considers insiders' purchases as we expect that insiders buy shares of their own company if they anticipate major positive events. According to prior studies, insider purchases are perceived by outsiders as informative as opposed to insider sales (Cohen, Malloy & Pomorski, 2012; Marin & Olivier, 2008; Scott & Xu, 2004).[9] We calculate our insider trading measure as the total value of shares purchased multiplied by the shares closing price on the exact day, and use the logarithm to account for the skewness of the yearly insider trading volume:

$$insider\ trading_{it} = log\left(1 + total\ insider\ purchase\ value_{it}\right) \quad (2)$$

Lastly, we employ a set of industry, time, and firm level dummies. Table 1 provides a summary of all variables.

"INSERT TABLE 1 HERE"

Matched sample

For our empirical analysis, we face the problem that firms have more incentives to invest in R&D

[8] Very similar results are obtained when using the average of the scores.

[9] Friederich, Gregory, Matatko & Tonks (2002) and Fidrmuc, Goergen & Renneboog (2006) show significantly smaller absolute price reaction to insider sales than to insider purchases. According to Lakonishok & Lee (2001), "insiders have many reasons to sell shares but the main reason to buy shares is to make money", therefore only insider purchases can be interpreted as signals for the presence of information asymmetries and the existence of positive, not-yet-disclosed information. Thus, the consensus of the existing literature when interpreting these results is that "insider selling that is motivated by private information is dominated by portfolio rebalancing for diversification purposes" (Lakonishok & Lee, 2001).

when they are located in a well-developed institutional environment. A better information environment and more developed accounting standards (Brown & Martinsson, 2019; Zhong, 2018), a more liberalized banking system (Amore, Schneider & Žaldokas, 2013), a higher degree of competitiveness (Li, Wu & Lu, 2019), and more strictly enforced property right (Fang, Lerner & Wu, 2017), lead to an increase in R&D investment (Alam et al., 2019; Choi et al., 2014; Seitz & Watzinger, 2017). This poses a problem for our empirical analysis because firms in developed institutional environments may have systematically more innovative assets.

We use a matched sample to address the possible endogeneity issue that firms in weak institutional environments invest less in R&D compared to firms in strong institutional contexts. For each firm in a weak environment, we choose the most similar firm in a well-developed institutional context in terms of R&D investment adjusted by firm size (total assets).

As our measure of institutional development, i.e. the NERI index, changes yearly so that firms change their ranks over time, we exclude the middle range ranks values and only keep firm-year observations in the first and third quartile of the NERI index distribution. Using a coarsened exact matching, we link each firm-year observation in the weak environment group with a firm-year observation in the strong environment group according to the following matching criteria: R&D/assets (5 equally sized classes), year and industry dummies. This yields a final unbalanced sample of 1736 observations for 774 publicly listed firms equally divided between the two groups. T-tests show that both groups of firms do not differ in terms of their R&D/assets after (*p-value* = 0.1752). Further t-tests show that the matched sample is also balanced in terms of the granted patent stock although this was not a matching criterion.

RESULTS

Descriptive statistics for the matched sample

Table 2 shows the descriptive statistics and t-tests for our matched sample divided in weak and strong institutional environments. Table 3 shows a correlation matrix.

"INSERT TABLE 2 HERE"

"INSERT TABLE 3 HERE"

As expected, after the matching, the means of R&D over total assets, patent application stock, and patent grant stock are similar between the two groups. This ensures a balance in the innovation efforts and efficiency between treated (weak environment) and control (strong environment) group. R&D intensity (calculated as R&D spending over total assets) is on average slightly over 1.8%, in line with previous studies (Qian et al., 2017). The correlation matrices show low correlations between the variables.

Empirical results

Table 4 presents the results of our regression analysis with the logarithm of Tobin's Q as the dependent variable and measures of innovative assets, institutional development, insider trading, and their interactions as independent variables. We present different specifications starting with a lean specification which only includes our measures for innovative assets (Model 1). We then add subsequently further variables such as the insider trading variable and the variable for the degree of institutional development in Model 2. Model 3 adds the interaction terms between the innovative assets' variables and the degree of institutional development for testing Hypothesis 1. Model 4 shows a robustness check for the smaller firms in our sample with an asset size below the sample mean. We include this subsample analysis because the level of transparency increases with firm size so that we expect to find stronger effects for smaller firms about which less information is

available. Models 5 and 6 include an interaction term between the innovative assets' variables and insider trading for the full matched sample and the subsample of smaller firms. These models show whether insider trading is informative in all institutional contexts or only when the degree of institutional development is weak as we hypothesize with our second hypothesis. The last two models include a full set of interaction terms to test Hypothesis 2. Model 8 presents again a robustness check for smaller firms. All the models presented below include firm-level clustered standard errors and firm, industry, and time fixed effects.

"INSERT TABLE 4 HERE"

The results from Model 1 show that the coefficients for R&D investment and patent application stock are both significant ($p < 0.01$) and positive, with the former having a larger magnitude than the latter. This is due to the cascading structure of our model where the patent variable presents a premium that is paid for patents on top of the firms' R&D investment (Hall et al., 2005). The positive and strongly significant effects for our innovative assets variables are found in all our specifications.[10] Regarding the marginal effects, our results indicate that if R&D over assets increases by one standard deviation (0.01), the market value of the firm increases by 12.02 (=12.02*0.01*100) percentage points. The marginal effect for the patent application variable is 0.90. If the patent application stock over R&D increases by one standard deviation (0.21), the market value of the firm increases by 18.90 (=0.90*0.21*100) percentage points. These values for innovative assets of Chinese firms seem large as compared to previous estimates for developed countries, but they are in line with prior findings for developing countries reflecting an overall underinvestment in innovative assets in these countries (Chadha & Oriani, 2010; Kanwar & Hall,

[10] Note that we also added the stock of granted patents over the patent application stock as an additional measure for innovative assets, but did not find any significant result.

2015).[11]

In Model 2, we add our measure of institutional development which is insignificant, also for most of the following specifications. This indicates that the degree of institutional development does not affect the market value of the firm per se. The insider trading variable which we also add in Model 2 is positive and significant ($p < 0.01$), indicating that a higher level of insider trading is associated with higher market valuation of the firm. This suggests that, on average, outside investors interpret insider trading as a positive signal.

In Model 3, the coefficients of the interaction terms between R&D investment and institutional development and patent application stock and institutional development are both negative and significant ($p < 0.05$). This result provides support for Hypothesis 1 as a lower level of institutional development is associated with a lower market valuation of both R&D investment and patent applications.

Model 4 shows that the reduction of the market value of R&D investment over assets is larger for smaller firms. There is no significant difference regarding the estimated coefficient of the patent application stock variable when we compare Model 3 and Model 4.

Models 5 and 6 include interaction terms of insider trading and our measures of innovative assets. The coefficients are both are insignificant suggesting that insider trading does not act as a signal for the value of innovative assets for the average institutional development.

Model 7 and 8 include a full set of interaction terms presenting results for both our hypotheses. Let us first acknowledge that the full specification again supports Hypothesis 1 by showing negative and significant ($p < 0.01$) coefficients of the interaction terms between R&D investment

[11] Kanwar and Hall (2015) estimate an effect of 8.6 percentage points for India (based on their Model 3 of Table 4; the standard deviation is taken from their Table 1).

and institutional development and patent application stock and institutional development for the matched sample (Model 7) and the subsample of smaller firms (Model 8).[12]

Figure 1 shows the marginal effects based on Models 7 and 8 (column 1 and 2, respectively). Both the matched sample (left) and the subsample of smaller firms (right) show similar results, therefore we discuss only the marginal effects of the full matched model here. The top panels indicate the marginal effects of R&D investment for different levels of institutional development. In the highest-ranking regions, the marginal effect of R&D investment is 19.94 while in the lowest-ranking regions, it is -0.32 which reflects a drop of 101.60%. The middle panels indicate the marginal effects of patents. In the highest-ranking regions, the marginal effect of patents is 1.29 while in the lowest-ranking regions, it is 0.21 which reflects a drop of 83.72%. The reduction in the market value of R&D and patent applications with a decreasing level of institutional development supports Hypothesis 1.

"INSERT FIGURE 1 HERE"

Turning to Hypothesis 2, as tested in Models 7 and 8 of Table 4, the triple interaction term of R&D investment, the degree of institutional development, and insider trading is positive and significant ($p < 0.01$ and $p < 0.05$ in Models 7 and 8, respectively) indicating that in weak institutional environments a higher level of insider trading is associated with a lower downwards shift of the market valuation R&D. The result holds for the matched sample (Model 7) and the subsample of smaller firms (Model 8). Hypothesis 2 is only partially supported as we do not find the same effect of insider trading on the valuation of the patent application stock (Models 7 and 8).

Regarding the marginal effects as presented in Figure 1, the bottom panels provide the marginal

[12] In an unreported table, we show that insider trading before it actually happens has no effect on our dependent variable. This result confirms that insider trading in year t drives the results and acts as a signal for the value of innovative assets.

effects of R&D investment over different levels of institutional development and for three levels of insider purchases. The levels of insider purchases are distinguished by different lines, i.e. solid lines for no insider trading, dash-dotted line for a medium level of insider purchases, and a dotted line for a high level of insiders' purchases. It appears that as the level of insider trading increases, the lines becomes more parallel to the x-axis. This means that where we observe the highest level of insider trading, there is virtually no difference of the marginal effect of R&D investment for different levels of institutional development. This shows that insider purchases mitigate the negative effect of a decrease in the degree of institutional development on the market valuation of R&D, partially supporting Hypothesis 2.

Robustness checks

A more fine-grained matching

We detailed in the subsection "matched sample" that R&D investment is a factor that is likely affected by the institutional environment in which the firm operates. Similar arguments can be made for insider trading which may be more frequent in weak institutional environments where insiders can benefit from a higher degree of asymmetric information. In order to account for this, we use a second matched sample where we, in addition to R&D over assets and industry and year dummies, include the volume of insider trading (divided into 6 classes of equal length) and a dummy for insider trading in our list of matching criteria. The dummy for insider trading is included because a high share of firms in well-developed institutional settings show no insider trading in most of the years.

The second matched sample is composed of 1294 firm-year observations. T-tests show that both groups of firms do not differ in terms of their R&D/assets (*p-value* = 0.4317), patent application stock over R&D (*p-value* = 0.4332) and insider trading (*p-value* = 0.9678). Table 5 below shows

the results of the same set of specifications as presented in Table 4. It appears that, for the new matched sample, the interaction term of R&D and institutional development becomes insignificant (Model 3) or weakly significant at $p < 0.1$ (Model 7) while Hypothesis 1 still receives strong support for the smaller firms.

When matching on the level of insider trading, the support for Hypothesis 2 becomes stronger: the triple interaction terms of R&D investment, institutional development, and insider trading increase in magnitude in Models 7 and 8, specially for the smaller firms sample in which the significance level also increases to 1%.

"INSERT TABLE 5 HERE"

Figure 2 shows the marginal effects for the robustness check. For the matched sample (left), the marginal effects of R&D investment in the highest and lowest regions are 17.17 and 5.67, respectively, corresponding to a 66.97% drop. The marginal effect of patents instead drops by 145.77% for the same interval. The drop in the marginal effects for the subsample of smaller firms (right) is larger and corresponds to 111.69% and 152.77% for R&D investment and patents, respectively. In addition, as shown in the bottom panels, higher levels of insider purchase not only correct the negative effect that a lower level of institutional development has on R&D valuation, but they invert the trend. We find, in fact, that as the level of insider trading increases, the marginal effect slope does not tend to 0 (parallel to the x-axis) but becomes positive (dotted line).

"INSERT FIGURE 2 HERE"

A placebo test for the development indicator

One might also wonder whether the legal and financial institutional development, which are depicted by two sub-indices of the NERI index which we chose, are the ones leading our result. One might wonder whether alternative measures that capture different aspects of institutional

development would lead to similar findings. For this reason, we re-run our regressions using the sub-index of the NERI index which depicts the "development of the commodity market". In line with our arguments which state that the financial and legal environment should matter for the valuation of innovative assets, the regressions using the degree of the development of the commodity market instead do not show an association with the market valuation of innovative assets. This gives us confidence that legal and financial institutional development is leading the results. The results are available upon request.[13]

DISCUSSION

General discussion of the results

Within the RBV framework, an often-overlooked assumption in the process of generating or sustaining a competitive advantage is that the market needs to acknowledge the value of strategic assets and their expected economic rents. A positive market valuation of a firm's innovative assets is essential for the next steps in which they are turned into profit. It increases the firm's reputation as an innovator and facilitates the financing of future R&D (Hottenrott, Hall & Czarnitzki, 2016; Lev, Sarath & Sougiannis, 2005).

Our study shows that, when institutions are weak, the market valuation of innovative assets is lower than for comparable firms in more developed institutional contexts. More specifically, R&D investment as well as patent applications experience a lower market evaluation in environments with weak institutions. This result is more pronounced for the smaller firms in our sample. Firm size is correlated with the amount and the quality of information which outsiders receive. The

[13] As one might be concerned that our results might be impacted by the unbalancedness of the sample, we conducted a further robustness check which shows that our results hold when using a sample of firms that are present in our dataset for at least three years (1008 observations on 238 firms). The results are available upon request.

smaller the firm, the less likely it is that it enters into contracts that are publicly visible or widely reported by the press and the less well known are its labor force, suppliers, and customers (Berger & Udell, 1998). This explains why the additional layer of uncertainty introduced by the weakness of the institutional environment affects the value of the innovative assets of smaller firms more strongly.

While uncertainty is highest for R&D investment as it constitutes an investment in uncertain projects about which the public is not informed (Arrow, 1963), patent applications certify an already successfully finished R&D project with market potential. As patent applications are costly and verifiable by external investors they qualify as signals in the sense of Spence (1973). With these characteristics, patents reduce asymmetric information between insiders and outsiders so that their value is more correctly reflected in their market evaluation. Our results suggest that patent applications cannot create full trust in the firms' innovation activities and their ability to create future profits in weak institutional environments because we still find that the market value of patents is lower than in stronger institutional contexts. Their signaling power is therefore limited. As a result, we turn to analyze the signaling effect of insider trading, which is a costlier signal. Our results illustrate that insider trading mitigates the downwards shift of the market valuation of R&D investment for firms in weak institutional environments. Like patents, insider trading fulfills the Spence (1973) criteria of being costly and verifiable by outsiders. As compared to patents, they are costlier for insiders because insider trading directly affects insiders' personal wealth. China has insider regulations and reporting requirements in place which are comparable to overseas jurisdictions such as the U.S. (Huang, 2020, Mazza & Wang, 2021). This renders insider trades in weak environments "good news" and incentivizes outside investors to purchase stocks because the regulations do not allow insiders to capture the entire rent (Bhattacharya et al., 2000; Miller et al.,

2008). Our results show that this signaling effect holds for the average firm in the sample as shown by the positive, significant coefficient for the insider trading variable. The results further show that the signaling effect is particularly strong for innovative assets of firms in institutionally weak environments, as measured by their R&D expenses, because R&D is surrounded by a high degree of asymmetric information (Arrow, 1963; Czarnitzki & Toole, 2011; Hussinger & Pacher, 2019; Nemlioglu & Mallick, 2020). It is worthwhile to emphasize that insider trading does not increase the market valuation of patent applications. This is likely due to the signaling effect that patent applications feature themselves. The result suggests that insider trading does not add information beyond what the public can learn from the detailed description available in patent documents.

Contributions to the literature

The existing literature combining institutions and innovation has mainly focused on the effect of financial and/or legal institutions on quantity and quality of R&D investments and patents (see He & Tian, 2020, for a recent review). Moreover, most of the empirical evidence on innovative assets value focuses on the U.S. or, in general, on developed economies (e.g. Bloom & Van Reenen, 2002; Griliches, 1981; Hall et al., 2005; Toivanen et al., 2002; see Czarnitzki et al., 2006, for a survey). Our findings elucidate the situation of innovative firms in emerging economies characterized by poor enforcement of property rights, investors' protection, and information disclosure laws. Our result that innovative firms located in weak institutional environments receive a lower market valuation for their innovation assets compared to firms located in stronger institutional contexts can lead to a vicious circle. Firms in weak institutional settings have less incentives to invest in R&D (Alam et al., 2019; Amore et al., 2013; Brown & Martinsson, 2019; Choi et al., 2014; Fang et al., 2017; Li et al., 2019; Seitz & Watzinger, 2017; Zhong, 2018) in a first step. In a second step, their innovative assets are valued less by the market which then leads

to a lack of recognition as innovators and to higher costs of capital for the firms limiting their ability to grow and to finance future innovation.

By emphasizing the effect of the low market valuation of innovative assets in weak institutional environments we add to the RBV by clarifying an important assumption, i.e. the importance of the recognition of the value of innovative assets by externals in order to generate a sustainable competitive advantage from those assets (Bowman & Ambrosini, 2001; Priem & Butler, 2001; Srivastava et al., 2001). With this evidence, we close the gap to prior literature that shows that firms in weak institutional settings experience innovation and performance shortfalls (Qian et al., 2017).

We further add to the literature at the intersection of institutions and innovation (see He & Tian, 2020 for a recent survey). This literature shows that the institutional framework impacts firms' strategic choices and success (Peng, 2002; Peng et al., 2009). Focusing on the example of insider trading (Carlton & Fischel, 1982; Dye, 1984; Glosten, 1989; Leland, 1992; Levin et al., 2017; Manne, 1966; Merton, 1987), we show that managerial actions can have a different effect in environments of different levels of institutional development. Outside investors in weak environments (with proper insider trading regulations) interpret insider purchases as a positive signal concerning firm's innovative assets.

This finding touches upon the classic debate of pros and cons of insider trading. Some scholars believe in the value-enhancing of insider trading thanks to the improved speed at which information reaches the market, therefore improving informativeness of prices and allocation of resources (Carlton & Fischel, 1983; Glosten, 1989; Leland, 1992), and by motivating insiders to innovate, so they can profit through insider trades (Dye, 1984; Manne, 1966). Others, instead, suggest that policies aimed at restricting insider trading increase the valuation of innovative assets

as they improve incentives for outside investors to acquire information on such assets (which are usually difficult to evaluate), lower the cost of capital, and therefore increase investments in innovative assets (Levin et al., 2017; Merton, 1987). Our results are in line with John and Mishra (1990) who argue that in environments in which information asymmetries are present (therefore in a weak institutional context), corporate insiders have information superior to the market about the future prospects of the firm, and their trading activity is one of the most direct signals to communicate their private information to the market. In this sense, insider trading rebalances the information asymmetries generated by the poor enforcement of rules and regulations, especially on information disclosure, leading to a more efficient market.

Implications for practitioners

Our results have implications for practitioners. They suggest that outside investors in weak institutional environments with insider regulations use insider purchases as a positive signal concerning firm's innovative assets (in line with what Coff & Lee, 2003, found but without focusing on the institutional environment in which firms operate). This finding has important implications for managers of firms in emerging economies as it implies that, in weak institutional environments, managers can communicate their innovation activity credibly by risking their own wealth and therewith supporting the generation of a competitive sustainable advantage through innovation.

Limitations and future research

We believe that our study invites future research at the intersection between the institutional context and innovation (He & Tian, 2020). This literature documents that the institutional framework impacts firms' strategic choices and success (Peng, 2002; Peng et al., 2009), and believes that there is more room to investigate the implications for the innovative process and for

searching for measures that firms in weak institutional contexts can take.

As any, our study is not free of limitations. As we focus on the market value of innovative assets, we are restricted to publicly listed firms. We would expect that the innovative assets of privately held firms are more seriously affected, but this needs to be shown by future research. Furthermore, we focus on China and it would be interesting to replicate our results for other developing countries.

CONCLUSION

By exploiting inter-provincial institutional development differences in China, we show that innovation assets of firms located in weak institutional environments, characterized by poor enforcement of property rights, investors' protection, and information disclosure laws, receive a significantly lower market valuation compared to firms located in stronger institutional contexts. At the same time, this negative effect can be counterbalanced by managerial actions. In weak institutional environments, we find that higher levels of insider purchases are associated with higher market valuation of innovation assets. These findings have important practical implications for managers in emerging economies characterized by weak institutional contexts.

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TABLES

Table 1: Definitions of main variables

Variable	Abbreviation	Definition
Logarithm of Tobin's Q	Log. Tobin's Q	Total number of shares outstanding multiplied by the price per share and divided by the book value of the firm's tangible assets. It measures the value of a firm's intangible assets
R&D investment	R&D/Total Assets	Yearly R&D expenditure divided by the book value of firm's assets
Patent application stock	Application stock/R&D	Sum of the number of patents applied by a firm in the current year and number of patents applied in the previous years depreciated by $\delta = 15\%$ ($application\ stock_{it} = number\ of\ applications_{it} + (1-\delta) application\ stock_{it-1}$), and then discounted by the total amount of R&D expenditure in the current year
Institutional Development Ranking	Institutional Dev. Rank	Mean of province ranking in terms of financial and legal environment development
Insider Trading	Insider Trading	Logarithm of 1 plus value of shares purchased by the insiders in the current year (share price at the exact day of purchase times the amount of shares purchased)

Table 2: Pre- and Post-Matching Descriptive Statistics

	Pre-Matching					Post-Matching				
	Weak Environment		Strong Environment		T-test (p-value)	Weak Environment		Strong Environment		T-test (p-value)
	Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.	
Tobin's Q	1.744	1.594	1.728	1.545	0.805	1.748	1.596	1.682	1.518	0.3835
Total Assets	75,338	130,900	46,012	106,314	2.341e-08	74,544	130,352	47,876	116,020	7.176e-06
R&D investment	1,227	2,737	962	2,336	0.017	1,220	2,740	775	2,146	0.0001709
Application Stock	150	383	162	812	0.615	150	383	153	1,013	0.9341
Institutional Dev. Ranking	19	4.173	2.178	1.002		18.9	4.155	2.191	1.009	
Insider Trading	4.352	6.436	5.827	6.979	2.158e-07	4.380	6.449	5.809	7.030	1.072e-05
Log Tobin's Q	0.213	0.838	0.243	0.784	0.390	0.215	0.839	0.204	0.797	0.7956
R&D/Total Assets	0.017	0.014	0.022	0.013	5.904e-15	0.017	0.014	0.018	0.013	0.1752
Application Stock/R&D	0.191	0.193	0.193	0.188	0.8944	0.199	0.207	0.217	0.211	0.06781

Table 3: Correlation Matrix

		1	2	3	4	5	6	7	8
		Weak Institutional Environment							
1.	Tobin's Q								
2.	Total Assets	-0.21****							
3.	R&D Investment	-0.16****	0.72****						
4.	Application Stock	-0.12***	0.61****	0.68****					
5.	Institutional Dev. Rank	0.13****	0.06	0.02	-0.03				
6.	Insider Trading	0.10**	0.02	0.06	0.07	-0.03			
7.	Log Tobin's Q	0.88****	-0.34****	-0.22****	-0.14****	0.15****	0.11***		
8.	R&D/Total Assets	0.05	-0.06	0.35****	0.20****	-0.08*	0.04	0.09*	
9.	Application Stock/R&D	0.05	-0.08*	-0.16****	0.12***	0.01	-0.02	0.10**	-0.28****
		Strong Institutional Environment							
1.	Tobin's Q								
2.	Total Assets	-0.12***							
3.	R&D Investment	-0.01	0.56****						
4.	Application Stock	-0.03	0.53****	0.88****					
5.	Institutional Dev. Rank	0.21****	0.07*	0.06	0.06				
6.	Insider Trading	0.11***	0.04	0.03	-0.01	0.01			
7.	Log Tobin's Q	0.87****	-0.18****	-0.04	-0.04	0.17****	0.14****		
8.	R&D/Total Assets	0.19****	-0.08*	0.29****	0.09**	0.03	0.04	0.18****	
9.	Application Stock/R&D	0.15****	0.04	-0.03	0.13***	0.00	-0.02	0.15****	-0.27****

$N = 1736$. **** = p < .0001; *** = p < .001; ** = p < .01; * = p < .05

Table 4: Market value regression with institutional development and insider trading on matched sample
(Coarsened exact matching on R&D/total assets, year, and industry)

Dependent Variable:	Log Tobin' s Q							
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample:	full	full	full	small	full	small	full	small
Variables								
R&D/Total Assets	12.02***	11.65***	18.95***	17.89***	12.79***	9.027***	23.99***	21.22***
	(2.908)	(2.895)	(5.037)	(5.577)	(3.007)	(3.197)	(5.032)	(5.171)
Application Stock/R&D	0.8955***	0.8941***	1.285***	1.151***	0.9522***	0.8130***	1.396***	1.234***
	(0.1345)	(0.1353)	(0.1932)	(0.1962)	(0.1458)	(0.1489)	(0.2100)	(0.2144)
Institutional Dev. Rank		0.0065	0.0223	0.0318*			0.0269*	0.0369**
		(0.0127)	(0.0144)	(0.0173)			(0.0143)	(0.0168)
Insider Trading		0.0088***			0.0142***	0.0054	0.0205***	0.0115
		(0.0023)			(0.0050)	(0.0057)	(0.0070)	(0.0082)
R&D/Total Assets × Institutional Dev. Rank			-0.5687**	-0.7831**			-0.8768***	-1.025***
			(0.2894)	(0.3041)			(0.2943)	(0.2964)
Application Stock/R&D × Institutional Dev. Rank			-0.0330**	-0.0308**			-0.0380***	-0.0409***
			(0.0130)	(0.0145)			(0.0146)	(0.0157)
R&D/Total Assets × Insider Trading					-0.1633	-0.0683	-0.6606***	-0.5109*
					(0.1622)	(0.1786)	(0.2168)	(0.2615)
Application Stock/R&D × Insider Trading					-0.0114	0.0002	-0.0124	-0.0079
					(0.0103)	(0.0114)	(0.0135)	(0.0147)
Institutional Dev. Rank × Insider Trading							-0.0005	-0.0005
							(0.0005)	(0.0006)
R&D/Total Assets × Institutional Dev. Rank × Insider Trading							0.0395***	0.0344**
							(0.0152)	(0.0164)
Application Stock/R&D × Institutional Dev. Rank × Insider Trading							0.0004	0.0011
							(0.0010)	(0.0011)
Fixed-effects								
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
Observations	1,736	1,736	1,736	1,387	1,736	1,387	1,736	1,387
R^2	0.85221	0.85461	0.85392	0.85915	0.85484	0.85707	0.85778	0.86091
Within R^2	0.06863	0.08375	0.07942	0.07487	0.08523	0.06119	0.10371	0.08641

One-way (Firm) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: Ordinary Least Squares (OLS) regression with standard errors clustered at the firm level.
Small refers to firms with total assets below the sample mean.

Table 5: Robustness check
(Coarsened exact matching on insider trading volume and dummy, R&D/total assets, industry, and year)

Dependent Variable:	Log Tobin' s Q							
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample:	full	full	full	small	full	small	full	small
Variables								
R&D/ Total Assets	14.88***	15.20***	16.90***	25.02***	15.82***	18.38***	20.91***	28.33***
	(3.934)	(3.935)	(5.801)	(5.327)	(4.484)	(4.993)	(6.347)	(5.776)
Application Stock/R&D	0.8529***	0.9103***	1.490***	1.476***	0.9524***	0.9822***	1.625***	1.574***
	(0.2395)	(0.2476)	(0.3088)	(0.3120)	(0.2476)	(0.2581)	(0.3064)	(0.3090)
Institutional Dev. Rank		0.0027	0.0180	0.0167			0.0243	0.0211
		(0.0155)	(0.0182)	(0.0196)			(0.0182)	(0.0197)
Insider Trading		0.0113***			0.0187***	0.0151*	0.0300***	0.0204*
		(0.0030)			(0.0067)	(0.0077)	(0.0096)	(0.0113)
R&D/ Total Assets × Institutional Dev. Rank			-0.3196	-0.8704**			-0.7012*	-1.202***
			(0.3651)	(0.3688)			(0.3907)	(0.3919)
Application Stock/R&D × Institutional Dev. Rank			-0.0676***	-0.0688***			-0.0754***	-0.0761***
			(0.0215)	(0.0249)			(0.0218)	(0.0247)
R&D/ Total Assets × Insider Trading					-0.1579	-0.2515	-0.8575***	-0.8985***
					(0.2323)	(0.2457)	(0.3101)	(0.3220)
Application Stock/R&D × Insider Trading					-0.0229	-0.0128	-0.0348	-0.0150
					(0.0146)	(0.0150)	(0.0237)	(0.0239)
Institutional Dev. Rank × Insider Trading							-0.0014*	-0.0008
							(0.0008)	(0.0009)
R&D/ Total Assets × Institutional Dev. Rank × Insider Trading							0.0812***	0.0800***
							(0.0273)	(0.0304)
Application Stock/R&D × Institutional Dev. Rank × Insider Trading							0.0016	0.0006
							(0.0016)	(0.0019)
Fixed-effects								
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
Observations	1,294	1,294	1,294	1,034	1,294	1,034	1,294	1,034
R^2	0.87272	0.87565	0.87567	0.88378	0.87611	0.88182	0.88079	0.88794
Within R^2	0.06107	0.08271	0.08281	0.10808	0.08612	0.09308	0.12060	0.14000

One-way (Firm) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: Ordinary Least Squares (OLS) regression with standard errors clustered at the firm level.
Small refers to firms with total assets below the sample mean.

FIGURES

Figure 1: Marginal effects of main regression results

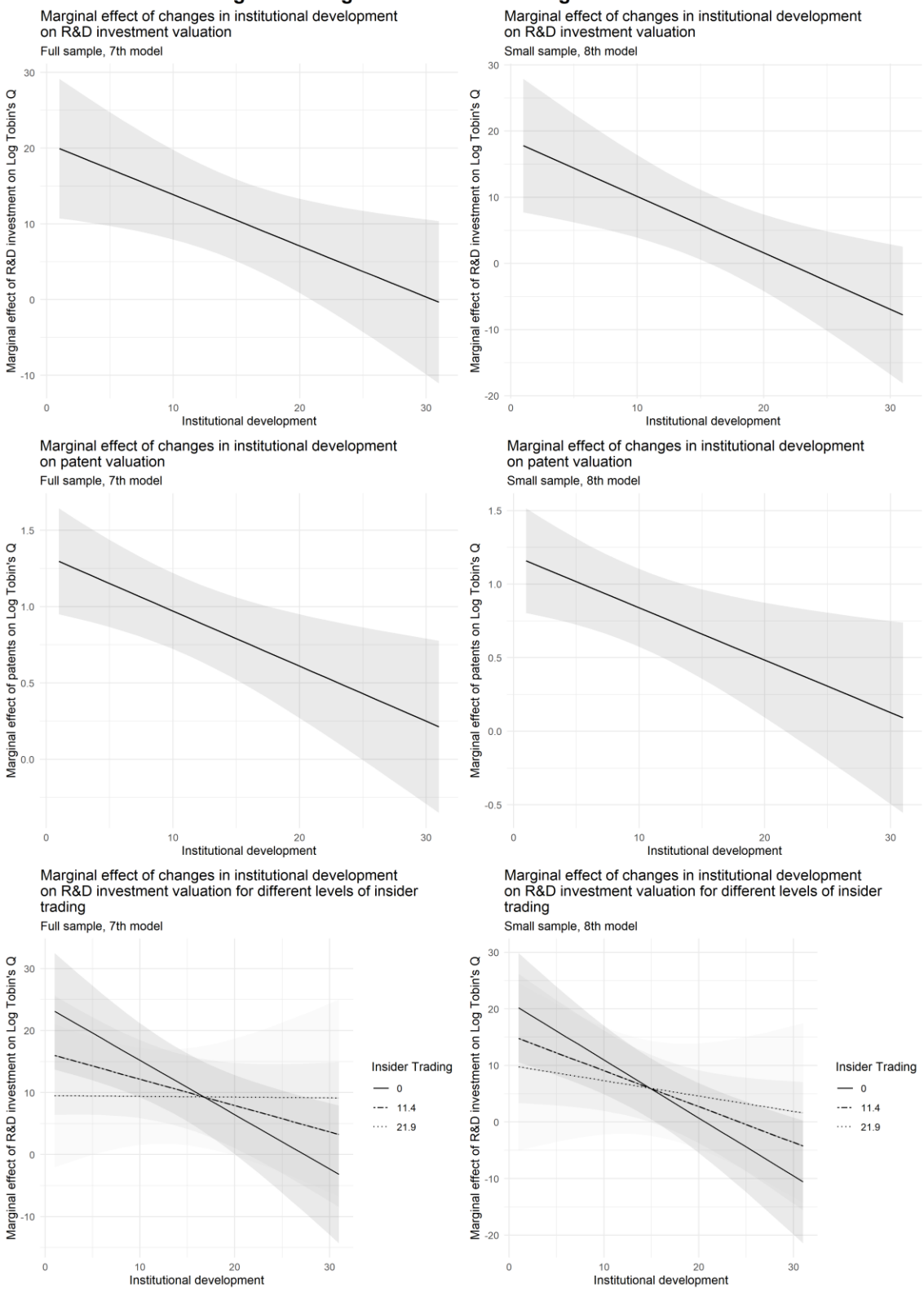

Figure 2: Marginal effects of robustness check regression results