Feedback Effects and Incentive Contracting

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Abstract

Previous literature has documented the presence of the feedback effect from the financial market to corporate investment strategies — managers use information revealed in the market to guide their investment decisions. We explore the implications of this feedback effect for managerial compensation both theoretically and empirically. Using a stylized model of optimal contracting in which firm value is endogenous to informed trading, we show that the existence of the feedback effect reduces optimal pay for performance in compensation. We empirically test our model results by using Reg-SHO Pilot program and Decimalization to instrument for exogenous shocks that lower the transaction cost and thus strengthen the feedback effect. Our empirical findings offer support for the predicted relationship. Overall, we show that accounting for feedback from market prices to managerial investment changes our understanding of managerial compensation.

JEL classification: G30, J33.

Keywords: Feedback effect, CEO compensation, Investment opportunities, Transaction costs, Reg-SHO PILOT program, Decimalization

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1 Introduction

Whether and how financial markets influence the real economy have received increased academic and regulatory attention, especially in light of the recent financial crisis. An important line of research has demonstrated the informational role of prices both theoretically and empirically, that is, the feedback effect from market prices to real economic activities.[1] The idea is that the market aggregates the information of many speculators, who may obtain and possess incremental information that is useful to the firm. As managers may not be perfectly informed about every decision-relevant factor, especially external information such as the state of the economy, they can learn new information from market prices and use this information to guide their real decisions such as investment and acquisition.

While executives are found to use information from market prices to guide their investment decisions (Baker, Stein and Wurgler (2003), Luo (2005), Chen, Goldstein and Jiang (2007), Bakke and Whited (2010), and Bond, Edmans, and Goldstein (2012)), the academic literature that studies how to align incentives of managers with those of shareholders largely ignores this trait. Meanwhile, existing studies of the feedback effect do not consider the possibility that compensation contracts can and should adjust for the feedback effect. In this paper, we specifically examine the contracting implication of the feedback effect, both theoretically and empirically. We show that incorporating the feedback effect into a contracting model can explain various properties of managerial compensation that otherwise seem puzzling.

The thesis of our paper is built upon the premise that empire-building managers learn from market prices and use the information to guide their investment decisions. We develop a stylized contracting model in which firm value is endogenous to trading, due to the feedback effect from market prices to investment decisions. A

[1] Please see the survey in Bond, Edmans, and Goldstein (2012).

key insight of our model is that the existence of the feedback effect reduces optimal pay-performance sensitivities in managerial compensation. Traditional contracting analysis suggests that when managers derive private benefits from having capital under control, high incentives are required to deter managers from making suboptimal high investment. Financial-market speculators, however, can collect and possess various sources of information that are not part of managers' information sets yet can be useful for corporate decision-making. High incentives in compensation reduce financial-market speculators' incentive to produce information, because trading profits are reduced when compensation implements a stringent investment policy. As informed trading provides additional information crucial for investment decisions and thus contributes to firm value, it is now optimal to lower pay-performance sensitivities so as to induce informed trading. Less monetary incentives are consequently required to align managerial incentives with shareholders' interest.

This model result highlights a contrast with the conventional wisdom on the relation between pay for performance and price informativeness. It has been argued that if stock prices are more informative about firm value, managers should be granted greater incentives to align incentives.[2] That is, financial markets may have real effects by affecting managerial incentives to take real actions. However, other than the incentive channel, price informativeness has an additional effect on pay-performance sensitivity due to the transmission of information, that is, the feedback effect. Information in stock prices can help managers make correct decisions. In other words, such feedback effects may be a substitute for incentive pay to align managers' incentives with shareholders'. From shareholders' perspective, the choice of pay-for-performance represents a trade-off between aligning incentives internally through compensation and inducing information provision externally in the financial market (i.e., the feedback effect).

[2]See, for example, Holmstrom (1979), Grossman and Hart (1983), Kim (1995), Kang and Liu (2008) and Kang and Liu (2010).

Our model also provides implications for a non-monotonic association between investment opportunities and pay-performance sensitivities in compensation. When managers derive private benefits from having capital under control, greater pay for performance is required in response to increased investment opportunities, in order to mitigate empire-building incentives. In firms where the feedback effect is likely to be pronounced, however, the value-enhancing effects of informed trading may dominate the benefits of implementing a stringent investment policy using compensation contracts, causing a lower pay for performance when investment opportunities increase. That is, the positive association between firms' investment opportunities and optimal pay-performance sensitivity is weakened by the feedback effect.

Using changes in traders' transaction cost to indicate changes in the relative importance of the feedback effect, our model produces three main empirical implications. First, all else equal, a reduced transaction cost increases speculators' trading profits and strengthens their incentives to collect and trade upon information, which, in turn, results in a lower pay for performance necessary in compensation.[3] Second, greater managerial tendencies for empire-building, enabled by lower financial constraints, would enhance the effects of changes in the transaction cost on incentive pay. Lastly, a reduced transaction cost enourages informed trading and hence weakens the positive association between firms' investment opportunities and optimal pay-performance sensitivity.

To test our model implications, we empirically examine properties of CEOs' pay for performance. To alleviate the endogeneity concerns, we employ two regulatory changes in the U.S. equity market that effectively reduce the transaction cost: Regulation SHO Pilot program (Reg SHO hereafter) and Decimalization. Reg SHO lifted the short-sale restrictions for around $1,000$ randomly selected pilot firms in 2005-2007.

[3] Literature has shown that some factors, such as brokerage commission, would affect the cost of both stock trading and information production (Brennan and Hughes (1999, JF) and Vissing-Jorgensen (2004)).

Reg SHO has been found to effectively lower the transaction cost.[4] Another exogenous shock to the transaction cost, Decimalization, occurred in January 2001 when the NYSE and Amex stock exchanges started to quote and trade listed shares in decimal prices instead of fraction (1/16).[5] Furfine (2003) find that bid-ask spread declines over 35% for actively traded stock. Bessembinder (2003) also find that quoted bid-ask spreads declined substantially, particularly for heavily traded stocks. Decimalization can thus be viewed as another exogenous shock that reduces the transaction costs. There has been empirical evidence on strengthened stock liquidity and feedback effects after Decimalization (e.g., Fang, Noe, and Tice (2009)). As Reg-SHO program and Decimalization result in a reduction in the transaction cost, we use both events to test our model implications.

Consistent with our first model implication, we find that both Reg SHO and Decimalization lead to a significant decrease in pay for performance, measured by scaled wealth-performance sensitivity (WPS). This result suggests that a reduction in the transaction cost incentivizes informed trading, which, in turn, reveals information that is used to guide managers in their investment decision. As a result, the required pay for performance to be lower in efficient contracts.

To test the second model implication, we employ four proxies for managerial tendency for empire-building (MTEB): negative New KZ Index (Hadlock and Pierce (2010)), negative KZ Index (Kaplan and Zingales (1997)), negative HP Index (Hadlock and Pierce (2010)), negative leverage ratio. The first three indices measure whether firms face financial constraints and are higher for less financially constrained firms. Managers who are subject to less financial constraint would have more resources to engage in empire-building, which magnifies the effects of changes in the transaction cost on incentive pay. Similarly, managers at firms with a lower lever-

[4]Diether, Lee, and Werner (2009) find that relative bid depth and trade-to-trade returns' volatility increase significantly for NYSE PILOT stocks. Alexander and Peterson (2008) find that short-sellers-initiated trades' effective spreads decrease significantly for PILOT stocks.

[5]NASDAQ started using decimal price in April 2001.

age ratio have greater flexibility to undertake large-scale investments. By interacting MTEBs with Decimalization dummies and Reg SHO stocks' dummies, we find that reductions in the degree of pay for performance in response to Reg-SHO and Decimalization are indeed significantly stronger for firms with higher MTEBs, in line with our model prediction.

Last but not least, we use Tobin's Q to proxy for firms' investment opportunities, and show that both Reg SHO and Decimalization have significant and negative impact on the positive association between Tobin's Q and incentive pay, which provides supporting evidence for our third model implication.

Our paper hinges on the growing literature on the feedback effect from financial markets to real economic decisions. Empirical and theoretical studies have shown that the feedback effect is significant enough to affect many important corporate policies, including investment (Baker, Stein and Wurgler (2003), Chen, Goldstein and Jiang (2007), Bakke and Whited (2010), acquisition (Luo (2005)), insider trading (Fishman and Hagerty (1992), Khanna, Slezak, and Bradley (1994)), decisions to seek public financing (Subrahmanyam and Titman (1999)), capital structure (Fulghieri and Lukin (2001)), disclosure policy (Gao and Liang (2013), and corporate governance (Gorton, Huang, and Kang (2013)). Given the significance of the feedback effect in corporate settings, we argue that managerial pay contracts can — and should — adjust for the feedback effect.

Our paper is also related to the literature on the effects of financial markets on compensation and corporate governance. Hartzell and Starks (2003) and Almazan, Hartzell and Starks (2005) show a complementary relation between monitoring by institutional investors and the degree of pay for performance in the compensation structure. Kang and Liu (2008) and Kang and Liu (2010) provide evidence that managerial incentives are positively related to measures of price informativeness. Ferreira, Ferreira and Raposo (2011) posit that, as price informativeness increases managerial incentives, there is less need for other disciplinary mechanisms such as board monitoring, resulting in a negative relation between price informativeness and board independence. By singling out the feedback effect, our paper finds that informed trading can actually decrease incentive pay, because the feedback effect serves as a substitute for pay-performance sensitivities to induce desired actions. Empirical tests using regulatory changes as instruments for exogenous shocks to the transaction cost and hence relative importance of the feedback effect provide supporting evidence.

In addition, recent studies illustrate that an external governance mechanism exists when blockholders, by increasing price efficiency through trading or exit, help exert governance and improve firm value (e.g., Admati and Pfleiderer (2009), Edmans (2009), and Edmans and Manso (2011)). But how does such an external governance mechanism translate into changes in managerial compensation? The answer remains ambiguous. For example, Admati and Pfleiderer (2009) show that although the blockholder alleviates the agency problem of the manager taking a bad action (e.g., shirking), she can also make it more difficult to motivate the manager to take a good action (e.g., exerting effort). Furthermore, recent empirical studies show that such an external governance mechanism would actually work better in firms with higher incentive pay (Bharath, Jayaraman and Nagar (2012), Chang, Lin and Ma (2014), Edmans, Fang and Zur (2013)). Our analysis is instead centered around the feedback effect, which emphasizes the transmission of information, and derives clear implications for managerial compensation.

The rest of the paper is organized as follows. Section 2 describes the model. In Section 3, we solve the model and discuss the testable predictions. Section 4 presents empirical findings. Section 5 concludes.

Figure 1: Model Timeline

Contract is offered; observed by all agents	CEO learns p and informed traders produce information	Informed & liquidity traders submit their orders	Market maker sets stock price based on aggregate orders	CEO makes investment decision based on p and stock price	CEO is compensated based on firm value; informed traders collect profits

2 The Model

2.1 Environment

Consider an one-period economy with three within period dates 0, 1/2, and 1. There is a firm whose stock is traded in the financial market. The firm's manager, who derives private benefits from having capital under his control, needs to make a decision as to whether to undertake a new investment or continue with the status-quo state with no new investment. The state of nature, which can be either good or bad, determines the final payoffs from the investment. The manager is privately informed about the distribution of the state realization. In addition, a speculator who knows the state of nature with certainty may be trading in the financial market. The investment decision is made by the manager after observing the stock price and may be affected by information revealed in the financial market. Having in mind managerial incentives and speculator's trading decision, shareholders select the compensation contract that maximizes the expected firm value minus expected pay. All agents are risk-neutral, and the risk-free rate and reservation wage are normalized to 0.

The key ingredient in our contracting model under managerial empire-building incentives is the feedback from stock prices to corporate investment. That is, the speculator may have insights into the state realization that were missed by the manager. The manager subsequently observes the share price and uses this information to update his belief about the state and consequently about the NPV of the investment opportunities. The manager then invests to maximize his own utility, which positively depends on both the compensation and amount of capital under his control. Note that the feedback effect is taken into account by the representative shareholder when designing the contract, by the speculator when acquiring information, and by the market maker when setting the price.

The time line of Figure 1 chronicles the sequence of events in the model. At date 0, the contract is offered, and the manager is privately informed that the state will be good with probability p. In addition, a speculator may be present in the financial market. If present, the speculator is informed about the state of nature that determines whether the firm should undertake new investment or continue with the status-quo. In addition to the speculator, two other types of agents participate in the financial market: a liquidity trader whose trades are unrelated to the realization of the state, and a market maker. The latter collects the orders from the speculator and liquidity trader, and sets a price equal to the expected firm value conditional on the aggregate order flows. Trading in the financial market occurs at date 1/2. The manager subsequently makes the investment decision, which may be affected by information revealed in the financial market. At date 1, all uncertainty is resolved and payoffs are realized. We now describe the firm's investment problem and the trading process in more detail.

Representative shareholder There is a representative risk-neutral shareholder with preferences over date 1 consumption c, which is realized firm value net of managerial pay. The shareholder has access to two mutually exclusive investment opportunities $I \in \{I_H, I_L\}$, where I_H and I_L represent high investment and low investment respectively. Low investment can be thought of as the firm's "status quo" state, and risky expansion can be implemented by making high investment. The shareholder faces uncertainty over the realization of value under each possible action. In particular, there are two possible states: $S \in \{g, b\}$ ("good" and "bad"). The payoffs from high investment and low investment at date 1 will be $I_i(1+s)$ if the state is good at date 1 and $I_i(1-s)$ if the state is bad, $\forall i \in \{H, L\}$, where $I_H > I_L$. In other words, the net payoff to firm value from investment I_i is $I_i s$ in the good state and $-I_i s$ in the bad state. We assume that the initial firm value at date 0 is V_0 and hence the firm value at date 1 will be $V_0 + I_i s$ in the good state and $V_0 - I_i s$ in the bad state, $\forall i \in \{H, L\}$.

The shareholder hires a manager to choose one of the two investment strategies, because the manager has private information about the state realization. The good state realizes with probability p, which is privately known by the manager due to his expertise. All other agents only know that p is uniformly distributed on the interval $[0, 1]$. Therefore, the value of the firm realized at date 1 depends on both the state of nature $S \in \{g, b\}$ and the manager's action $I_i, i \in \{H, L\}$. The shareholder designs the compensation contract to maximize his expected net payoff, which is the firm value realized at date 1 net of compensation payment. We restrict compensation contracts to be linear contracts, consisting of base salary and β shares of stocks. The recommended investment policy implemented by the compensation contract, represented by q, is that the manager takes high investment (I_H) if and only if $p \geq q$. We will show later that there is an one-to-one correspondence between β and q. As the compensation contract is observed by all agents, the investment policy q is known to all agents in the model.

We interpret $(I_H - I_L)$ as firm's strategic flexibility. The potential measures for the flexibility include Tobin's q, R&D expenditures, and capital expenditures. For example, Tobin's q measures a firm's future investment opportunities. All of these future projects will be implemented when the high-investment strategy is undertaken, while the low-investment strategy implies abandoning or postponing these future opportunities and only continuing the projects that have been previously undertaken.

Hence a high Tobin's q would correspond to a high level of $(I_H - I_L)$. Similarly, high R&D expenditures or capital expenditures represent more flexibilities to adjust investment downward, and therefore correspond to a high $(I_H - I_L)$.

Traders and market maker Trading occurs in the financial market at date 1/2. There is one speculator who can learn the state of nature at a cost. In particular, the speculator can choose to observe the state with probability θ at a cost $C(\theta) = \frac{1}{2}A\theta^2$. That is, with probability θ, the speculator perfectly observes the state of nature; and with probability $(1-\theta)$, the speculator's costly effort results in no information about the state realization. The speculator will optimally decide how much information to produce, i.e. the value of θ, to maximize his trading profits.

If the speculator incurs the cost to produce information and is consequently informed about the state realization, he will submit his order $z \in \{-1, 0, 1\}$ simultaneously with a liquidity trader to the market maker. Then the market maker will set a price that equals to the expected firm value conditional on the aggregate order flow. For simplicity, we assume that the liquidity trader submits either a buy order or a sell order of size 1 with equal probabilities: $n \in \{-1, 1\}$. If the speculator receives good news, i.e. the future state is good, he will submit a buy order of size 1; if the speculator receives bad news, i.e. the future state is bad, he will submit a sell order of size 1; if the speculator does not learn the state after costly information production, he will not trade. The orders are market orders and are not contingent on the price.

The market maker can only observe total order flow $X = z + n$, but not its individual components z and n. Possible order flows are $X \in \{-2, -1, 0, 1, 2\}$. The competitive market maker sets the price equal to expected firm value, conditional on both the information contained in the order flow and the firm's investment policy q. Thus the pricing function is $P(X, q) = E(v|X, q)$. In particular, the aggregate order flow may contain additional information on the future realization of the state if a speculator is present.

As is standard in the feedback literature, we assume that the speculator cannot communicate his information directly to the manager. It is clear that the speculator has neither incentive nor credibility to do so in our model since he has no initial stake in the firm; instead, he wishes to use his information to maximize her trading profits (as in the theories of governance through trading by Admati and Pfleiderer (2009), Edmans (2009), and Edmans and Manso (2011)).

Manager The manager is privately informed about the probability of a good state (p) and is thus hired to make investment decisions. The risk-neutral manager makes investment decision to maximize his own utility, which is increasing in the compensation payment he receives. In addition, the manager derives private benefits from running a project in the amount of bI if he has an amount of capital I under their control. Private benefits are not in terms of the consumption good and cannot be seized. Moreover, the manager has limited liability, i.e., his compensation cannot be negative.

In addition to the manager's private information regarding the state distribution (p), the manager may extract information about the nature of state from the financial market. As we will see later, there is an one-to-one correspondence between stock price and manager's action, so there is no difference between assuming that the manager observes the stock price and assuming that the manager observes the total order flow. If the stock price reveals the speculator's information on the state realization, the manager will update his belief about the state of nature and choose the corresponding optimal investment decision that maximizes his utility. If the stock price does not reveal the speculator's information, the manager will follow the recommended investment policy q given his private information p.

2.2 Equilibrium

The equilibrium concept we use is the Perfect Bayesian Nash Equilibrium. Here, it is defined as follows: (i) An information production strategy and a trading strategy by the speculator: $T : q \to \theta; S \to \{-1, 0, 1\}$ that maximize his expected trading profits, given the price setting rule, the strategy of the manager, and his information about the realization of state. (ii) An investment strategy by the manager: $M : \{\beta, p, X\} \to I$ that maximizes his expected utility, given the compensation contract, his private knowledge about future state, and the information revealed in the order flow. (iii) A compensation contract that includes a payment structure and a recommended investment strategy by the representative shareholder: $\xi : \{M, T, P\} \to \{\beta, q\}$, that maximizes expected firm value net of compensation, given the manager's strategy, the speculator's strategy, and the price setting rule. (iv) A price setting strategy by the market maker: $\zeta : \{X, q\} \to P$ that allows him to break even in expectation, given the information in the price and all other agents' strategies. Moreover, (v) the manager and the market maker use Bayes' rule to update their beliefs from the order they observe in the financial market, and (vi) beliefs on outcomes not observed on the equilibrium path satisfy the Cho and Kreps (1987) intuitive criterion. Finally, (vii) all agents have rational expectations in that each player's belief about the other players' strategies is correct in equilibrium.

3 Feedback effects and managerial pay

In this section, we characterize the pure-strategy equilibria in our model. We show that the equilibria are characterized by reduced incentives and enhanced firm value, due to feedback from market prices to managerial investment decisions.

3.1 Firm's investment policy

To illustrate the impact of informed trading and feedback effects on the recommended investment policy implemented by the optimal contract, we start by characterizing the investment policy in a baseline case absent of agency problems (i.e., managerial empire-building incentives) and informed trading. Recall that the recommended investment policy implemented by the compensation contract, represented by q, is that the manager takes high investment (I_H) if and only if $p \geq q$. For an investment policy q, the expected firm value is derived as follows.

$$\begin{aligned} V(q) &= V_0 + \int_0^q I_L[ps + (1-p)(-s)]dp + \int_q^1 I_H[ps + (1-p)(-s)]dp \\ &= V_0 + (I_H - I_L)s(q - q^2). \end{aligned}$$

It is straightforward to see that the first-best investment policy is $q = 1/2$. Recall that the NPV of investment I_i is $I_i s$ in good state and $-I_i s$ in bad state. The expected value of future state is $ps - (1-p)s = (2p-1)s \geq 0$ when $p \geq \frac{1}{2}$, thus it is optimal to take high investment and expand. Otherwise, it is value-maximizing to continue with the status-quo without new investment undertaken.

There are two factors that can cause the optimal investment to deviate from $q = 1/2$. First, the manager has empire-building incentives and derives private benefits from having an amount of capital under his control. The shareholders' objective is thus to maximize the firm value net of managerial compensation. For $q \leq 1/2$, although increasing q enhances the firm value, it also increases compensation necessary to implement the recommended investment policy (q) because the manager prefers to take high investment for personal benefits. The shareholder faces a trade-off in determining the recommended investment policy: increasing q increases the firm value, but it also increases managerial pay. As a result, the optimal recommended investment policy in the optimal contract can be less than 1/2.

Second, informed trading can also contribute to firm value in the presence of feedback effects. In particular, the speculator causes prices to move, which in turn reveals information to the manager who then takes investment based on the information revealed in the price. A better-informed investment decision made by the manager improves the underlying firm value. Therefore, the expected firm value depend on the recommended investment policy q implied by the compensation contract and the amount of informed trading (i.e. firm value will be the sum of $V(q)$ and the value created by informed trading). For $q \leq \frac{1}{2}$, increasing q increases $V(q)$, but as shown later, it reduces the speculator's incentives to produce information (because a higher q reduces the likelihood of high investment and the associated variability of investment payoff contingent on the state realization) and thus decreases the value created by informed trading. Consequently, the recommended investment policy in the optimal contract can be lower than the first-best investment policy ($q = \frac{1}{2}$) for the purpose of attracting informed trading. We will show later that any investment policy $q > \frac{1}{2}$ is not implementable, and we focus on the case $q \leq 1/2$ throughout the rest of the paper.

3.2 Trading decisions and information production

In this subsection, we analyze the incentives of financial-market speculators to produce information when they are aware of the feedback effect. That is, their trading may reveal information in stock prices, which will be used to guide managerial investment decision.

The existence of the feedback from market prices to managerial investment has two conflicting effects on the speculator's trading decision. On the one hand, the manager is more likely to take high investment as the share price goes up, so the firm may become more valuable given a positive signal about the state realization. On the other hand, the speculator cause prices to move by trading upon his information, which in turn may perfectly reveal information to the market maker who takes into account the feedback effect in pricing. This feedback effect may render the initial trading less profitable, deterring it from occurring in the first place.

As we will show later, in our model the speculator collects trading profits only when his information about the state realization contaminates with the liquidity trader's need. In the case of unrevealing stock prices, the speculator benefits from trading due to his information advantage compared to the market maker. When the stock price perfectly reveals the speculator's information regarding the state realization, the speculator does not benefit from informed trading because in the equilibrium the feedback effect is correctly priced in. We analyze the trading process in detail below.

In our model of informed trading and feedback effects, there are five possible order flows observed by the market maker and manager on the equilibrium path as shown in Table 1: 1) two buy orders; 2) two sell orders; 3) one buy order and one sell order; 4) one buy order; 5) one sell order. If there are two buy orders in the market, the manager understands that the speculator has received information that the future state is good, and the manager will update his belief and take high investment. The market maker knows that the future state is good and the manager will take high investment, so the market maker sets the share price equal to $V_0 + I_H s$. If there are two sell orders in the market, the manager understands that the speculator has received information indicating a bad state realization, and therefore the manager will optimally take low investment and the market maker sets the share price equal to $V_0 - I_L s$. In all the other cases, the aggregate order flow does not reveal the speculator's information, and thus the manager will follow the recommended investment policy q (implied by the compensation contract) given his private information p. The stock price will be equal to $V(q)$ in these cases absent of feedback.

We characterize the expected firm value and the speculator's profits in each possible case on the equilibrium path in the table below.

News	Order Flow in the Market	Probability of Event	Stock Price	CEO's Action	Informed Trader's Profits
Good	2 Buys	$p\theta/2$	$I_H s + V_0$	Take high investment	0
Good	1 Buy 1 Sell	$p\theta/2$	$V(q)$	Follow his own information	$I_H s + V_0 - V(q)$ if $p \geq q$, $I_L s + V_0 - V(q)$ if $p < q$
Bad	2 Sells	$(1-p)\theta/2$	$-I_L s + V_0$	Take low investment	0
Bad	1 Buy 1 Sell	$(1-p)\theta/2$	$V(q)$	Follow his own information	$V(q) + I_H s - V_0$ if $p \geq q$, $V(q) + I_L s - V_0$ if $p < q$
None	1 Buy or 1 Sell	$1-\theta$	$V(q)$	Follow his own information	0

Table 1: Informed Trading in Stock Market.

From Table 1, we can see that the speculator can absorb trading profits, denoted by Π, only when the total order flow in the market does not reveal his information, as in the case of 1 buy and 1 sell (i.e. the second and fourth row). When the total order flow perfectly reveals the speculator's information, as in the case of 2 buy orders or 2 sell orders, the market maker sets the price conditional on both the information revealed by the speculator's order and the corresponding subsequent investment undertaken by the manager (who makes the investment decision based on the speculator's information revealed in the market). The speculator's expected trading profits can be calculated as follows:

$$\begin{aligned} E\Pi &= \int_0^q \left[\frac{p\theta}{2}(I_L s + V_0 - V(q)) + \frac{(1-p)\theta}{2}(V(q) + I_L s - V_0)\right] dp \\ &+ \int_0^q \left[\frac{p\theta}{2}(I_H s + V_0 - V(q)) + \frac{(1-p)\theta}{2}(V(q) + I_H s - V_0)\right] dp \\ &= \frac{\theta s}{2}(I_H(1-q) + I_L q). \end{aligned}$$

The speculator's problem is to maximize his trading profits net of the cost of information production, given the recommended investment policy implied by the compensation contract (q):

$$\max_{\theta} E\Pi - \frac{1}{2}A\theta^2 = \frac{\theta s}{2}(I_H(1-q) + I_L q) - \frac{1}{2}A\theta^2.$$

The solution to the speculator's problem represents the optimal information production θ, which is characterized in the following lemma (proved in Appendix).

Lemma 1. *Given the firm's investment policy q, the optimal information production by the speculator is represented by*

$$\theta = \frac{s}{2A}[I_H(1-q) + I_L q]. \tag{1}$$

The optimal information produced (θ) is decreasing in the recommended investment policy q and the cost of information production A.

Recall that a lower q implies that the manager is more likely to take high investment, which, in turn, leads to greater variability in firm value. Volatile firm value generates incentives for the speculator to acquire information and seek trading profits, increasing the amount of information production. Similarly, information production will increase when it is less costly for the speculator to gather information, i.e. a lower A.

A key ingredient of our model is that financial-market speculators can produce additional information instrumental for corporate investment decisions, and their information revealed in the financial market helps managers update their beliefs when taking investment. Note that the recommended investment policy q is endogenous in that the representative shareholder takes into account informed trading and feedback effects when designing the compensation contract, which is analyzed in the next subsection.

3.3 Optimal contracting and feedback effects

We now characterize the optimal compensation contract and show how feedback from stock prices to managerial investment can mitigate the agency problem arising from the empire-building incentives. In our model, the representative shareholder takes into account of managerial empire-building incentives and feedback effects when designing the compensation contract. We restrict compensation contracts to be linear contracts, consisting of base salary and β shares of stock. The manager has zero reservation utility and limited liability, which means that the base salary is nonnegative. Note that since base salary is fixed regardless of investment strategies, it must be set to 0 at the optimum due to the limited liability. The number of shares granted (β) is chosen to implement the recommended investment policy $\tilde{q}$; that is, the manager makes high investment if and only if $p \geq \tilde{q}$. The optimal contract thus includes the pay-performance sensitivity β and a recommended investment policy q, both of which together maximize the expected firm value net of managerial pay at date 1.

The objective of the manager is to maximize his utility by choosing a threshold-type of investment policy as explained above (q), subject to the contract he is offered. When the probability of a good state realization, p, is equal to or greater than q, the manager takes high investment, and otherwise makes no new investment and continues with the status-quo projects; unless the stock price perfectly reveals the state realization due to the presence of informed trading. The manager's utility is of the form $U_m(q, I) = \beta V + bI$, where V represents date-1 firm value and I represents the investment: $I \in \{I_H, I_L\}$. The first term represents incentives in the compensation contracts. The second term represents the manager's personal benefits from having capital under his control.

Without informed trading

As a prelude to studying the contracting implications of feedback effects, we first analyze the optimal compensation contract in the absence of informed trading. The representative shareholder maximizes the expected terminal wealth. More specifically, the principal chooses the number of shares $\hat{\beta}$ and recommended investment policy $\hat{q}$ that maximize the the net payoff of the investment minus managerial pay. Formally, the optimal contract solves

$$\max_{\hat{\beta},\hat{q}} E[\text{Firm Value} - \text{managerial pay}] = (1-\beta)[V_0 + (I_H - I_L)s(q - q^2)],$$

subject to

$$\hat{q} = \arg\max_{q} E[U_m(q, I)]. \qquad (IC_I)$$

$$E[U_m(q, I)] \geq 0. \qquad (PC)$$

The objective function is the shareholder's expected net payoff, which is expected firm value net of compensation. The first constraint (IC_I) is the incentive constraint on the investment policy — as the investment decision has been necessarily delegated to the manager, the recommended investment policy must be voluntarily followed by the manager. The second constraint (PC) is the participation constraint, which will be automatically satisfied given the zero reservation utility and non-negativity of compensation.

The manager has tendencies to choose high investment, which can be seen in the case of $\beta = 0$: the manager will always take high investment since he can gain private benefits without bearing the loss in bad state. To implement the recommended investment policy $\hat{q}$, i.e. high investment is taken if and only if $p \geq \tilde{q}$, (IC_I) implies that the manager is indifferent between high investment and low investment when $p = \hat{q}$, that is

$$\hat{\beta}[\hat{q}I_H s - (1-\hat{q})I_H s] + \hat{\beta}V_0 + bI_H = \hat{\beta}[\hat{q}I_L s - (1-\hat{q})I_L s] + \hat{\beta}V_0 + bI_L.$$

Therefore the optimal contract will set $\hat{\beta} = \dfrac{b}{(1-2\hat{q})s}$ to implement policy $\hat{q}$. Note that $0 \leq \hat{\beta} \leq 1$ implies that $\hat{q} \leq \dfrac{1}{2} - \dfrac{b}{2s} < 1/2$. Later we will show that the optimal recommended investment policy satisfies $\hat{q} < 1/2$.

Lemma 2. *For a given recommended investment policy $q < 1/2$, the number of shares granted in the compensation contract β is represented by $\beta = \dfrac{b}{(1-2q)s}$. The pay-performance sensitivity β is increasing in the firm's investment policy q.*

The optimal contract includes the shares granted ($\hat{\beta}$) and recommended investment policy ($\hat{q}$) that maximizes the representative shareholder's objective function $(1-\beta)V(q)$ subject to $\beta = \dfrac{b}{(1-2q)s}$, which are formally stated in Proposition 1 and proved in the Appendix.

Proposition 1. *In the optimal contract without informed trading, the recommended investment policy $\hat{q} < 1/2$ satisfies the following equation:*

$$1 - 2q - \frac{b}{s} - \frac{2b(q-q^2)}{s(1-2q)^2} - \frac{2bV_0}{s^2(I_H - I_L)(1-2q)^2} = 0.$$

The optimal policy $\hat{q}$ and the corresponding CEO incentives $\hat{\beta}$ are both increasing in $(I_H - I_L)$.

Recall that in the baseline case without agency problems as we discussed in Section 3.1, the optimal policy is $q = 1/2$. As a higher q increases both the expected firm value and expected compensation payment, this cause the recommended investment policy ($\hat{q}$) to be less than 1/2. Because high investment becomes more profitable in the good state relative to low investment when $(I_H - I_L)$ increases, the optimal recommended investment policy will consequently increase (toward 1/2). Correspondingly, $\hat{\beta}$ increases to implement a higher $\hat{q}$ for an increased level of $(I_H - I_L)$.

With informed trading

In the presence of informed trading, the manager will use information revealed in the financial market to guide his investment decision. In particular, we can see from Table 1 that with probability $\frac{p\theta}{2}$, the manager learns from the market that the future state is good and consequently takes high investment; and with probability $\frac{(1-p)\theta}{2}$, the manager learns from the market that the future state is bad and take low investment. The expected firm value, denoted by V_I, can be derived as follows.

$$
\begin{aligned}
V_I &= E\left[\frac{p\theta}{2}(V_0 + I_H s) + \frac{(1-p)\theta}{2}(V_0 - I_L s) + \left(1 - \frac{\theta}{2}\right)V(q)\right] \\
&= \frac{\theta}{4}(V_0 + I_H s) + \frac{\theta}{4}(V_0 - I_L s) + \left(1 - \frac{\theta}{2}\right)\left[V_0 + \Delta s(q - q^2)\right] \\
&= \Delta s(q - q^2) + \frac{\theta \Delta s}{2}\left(\frac{1}{2} - q + q^2\right) + V_0,
\end{aligned}
$$

where $\Delta = I_H - I_L$. Recall that the recommended investment policy affects the speculator's expected trading profits and thus affects his incentive to produce information. The speculator's information production (θ) given a recommended investment policy is characterized by Equation (1) and is plugged into the equation above, yielding the following expression for the expected firm value in the presence of feedback effects.

$$
V_I = \frac{\Delta s^2}{4A}\left[-\Delta q^3 + (2I_H - I_L - B)\,q^2 - \left(\frac{3}{2}I_H - \frac{1}{2}I_L - B\right)q + \frac{I_H}{2} + \frac{V_0 B}{\Delta s}\right], \quad (2)
$$

where $B = 4A/s$ and $\Delta = I_H - I_L$. Comparing the expected firm value with and without informed trading, we have $V_I > V(q)$, indicating that the informed trading is beneficial from the shareholder's viewpoint. That is, the firm value is higher when the speculator produces more information, which is formally stated below in Lemma 3.

Lemma 3. *Compared to the case without feedback effects, the firm value with the feedback effect (V_I) is higher and is strictly increasing in the amount of information produced by the speculator (θ).*

Proof: Please see Appendix.

Bearing in mind how informed trading affects firm value through the feedback effect, the shareholder chooses the number of shares β^* and recommended investment policy q^* that maximize the the net payoff of the investment minus managerial pay. Formally, the optimal contract solves

$$\max_{\beta^*, q^*} (1-\beta)V_I,$$

subject to

$$\beta^* = \frac{b}{(1-2q^*)s}. \qquad (IC_I^*)$$

$$E[U_m(q, I)] \geq 0. \qquad (PC^*)$$

The objective function is the shareholder's expected net payoff, which is expected firm value net of compensation. The first constraint (IC_I^*) is the incentive constraint on the investment policy, taken from the results in Lemma 2. The second constraint (PC^*) is the participation constraint, which will be automatically satisfied given the zero reservation utility and non-negativity of compensation. We summarize the contracting results in Proposition 2 below (proved in Appendix).

Proposition 2. *In the optimal contract in the presence of the feedback effect, the recommended investment policy satisfies $q^* < \hat{q}$, and thus the corresponding incentives in the contract β^* are given by $\beta^* = \dfrac{b}{(1-2q^*)s} < \hat{\beta}$. We obtain the following results.*

(1) q^* and β^* are both increasing in A.

(2) If $A > \dfrac{\Delta^2 s^2}{8V_0}\left(\dfrac{3s}{2b} - \dfrac{1}{2}\right)$, then q^* is increasing in I_H and decreasing in I_L, which implies that q^* and β^* are both increasing in the firm's flexibility $I_H - I_L$.

(3) If $A < \dfrac{\Delta^2 s^2}{8V_0}\dfrac{1}{2}\left(\dfrac{1}{2} - \dfrac{3}{2}\left(\dfrac{b}{s}\right)^{1/3}\right)\left(1 - \left(\dfrac{b}{s}\right)^{1/3}\right)$, then q^* is decreasing in I_H and increasing in I_L, which implies that q^* and β^* are both decreasing in the firm's

flexibility $I_H - I_L$.

Proposition 2 shows that compared to the case without the feedback effect, the recommended investment policy and the corresponding incentives in compensation are lower in the presence of the feedback effect. The reason is that when the manager uses information revealed in the financial market to guide his investment decision, the speculator's information production and subsequent trading enhance firm value. We have shown that a lower recommended investment policy q (i.e. high investment is more likely) leads to greater variability of firm value and induces stronger incentives for the speculator to produce information that reveals the state of nature. To attract informed trading, the recommended investment policy and the corresponding incentives in compensation are both lower in the presence of the feedback effect.

Note that with the feedback effect, an increment in firm value can come from two sources: the value created by the feedback effect and that created through directly implementing the desired investment policy. When information production becomes less costly for the speculator, i.e. A decreases, informed trading is a more efficient mechanism to increase firm value, and it is therefore optimal to implement a lower q^* and a correspondingly lower β^* in the optimal contract.

Parts 2 and 3 in Proposition 2 show that the existence of the feedback effect can alter the relationship between optimal pay-performance sensitivities and the firm's investment flexibility. In the absence of informed trading, optimal pay-performance sensitivity is always increasing the firm's investment flexibility $(I_H - I_L)$, because high investment becomes relatively more attractive to the manager due to increased private benefits, and it is optimal to grant the manager more incentives to mitigate empire-building incentives. However, in the presence of the feedback effect, informed trading increases firm value by providing the manager additional information useful for making investment decisions. How the recommended investment policy and corresponding pay-performance sensitivity change with the firm's investment flexibility thus depends on the relative strength of the two offsetting forces.

Specifically, let us consider an increase in investment flexibility, i.e. a higher $(I_H - I_L)$. On the one hand, it exacerbates empire-building incentives, and higher incentives are required to implement a more stringent investment policy (i.e. a higher q^*). On the other hand, note that the firm value created by informed trading through the feedback effect is also proportional to $(I_H - I_L)$. A more stringent investment policy reduces the speculator's incentives to produce information, and thus destroys the value created by informed trading. A lower q might be chosen to induce informed trading which helps enhance firm value. This effect is particularly valuable when the cost of producing information is small. Therefore, when the transaction is cost is sufficiently small, incentive pay and recommended investment policy can be both decreasing in investment flexibility.

3.4 Testable predictions

In this subsection we discuss our model implications that can be directly tested in the data. We discuss each empirical prediction in turn below.

First, reductions in the transaction cost lower the degree of pay for performance used in compensation contract. Because the equilibrium pay for performance is determined by a trade-off between implementing a stringent policy through compensation and inducing informed trading that guides managerial investment, when it becomes costly for the speculator to acquire information (i.e. a higher A), informed trading is a more efficient mechanism to enhance firm value. It is therefore optimal to use less incentive pay in contracts. We formally state the this implication from Proposition 2 below.

Hypothesis 1. *A reduced transaction cost results in lower optimal pay for perfor-*

mance.

Second, as the results of Proposition 2 are based on the premise that the managers have empire-building incentives, the higher the managers' tendency to empire building, the stronger the above effect. This leads to the model prediction formulated below.

Hypothesis 2. *Higher managerial empire-building tendencies enhance the effects of changes in the transaction cost on the degree of pay for performance.*

Third, the positive association between incentive pay and investment flexibility predicted in standard models is attenuated by the feedback effect. In response to increased investment flexibility, greater incentives in compensation implement a more stringent investment policy and mitigate the intensified empire-building concern, which, however, also reduce the speculator's incentives to produce information. This would destroy the value created by informed trading. As a reduction in the transaction cost strengthens the feedback effect, it weakens the response in incentive pay to investment opportunities, stated as follows.

Hypothesis 3. *A reduced transaction cost weakens the positive association between firms' investment opportunities and optimal pay for performance.*

Taken together, an important insight of our model is that the feedback effect reduces optimal pay-performance sensitivities in compensation contract. The reason is that in addition to the incentives provided in compensation, managers will optimally use information revealed in the financial market to guide their investment decisions. Less monetary incentives are thus required to mitigate empire-building incentives. In addition, our model suggests that the relationship between a firm's investment flexibility and the optimal pay-performance sensitivity should depend on the importance of informed trading. When it is relatively costly for financial-market speculators to generate superior information (compared to corporate managers) that is useful in corporate decisions, pay-performance sensitivities should be higher for firms with more investment opportunities and higher corresponding investment flexibilities. Otherwise, pay-performance sensitivities may not be positively associated with investment opportunities due to feedback effects. In the next section, we will test our three empirical implications using compensation data and exogenous shocks to transaction costs.

4 Empirical tests

4.1 Methodology and Data

In this section we test our model predictions for the degree of pay for performance using compensation data. To alleviate the endogeneity concerns, we utilize a regulatory change that removed the short-sale constraint as an exogenous shock that reduces the transaction cost for speculators. That is, the SEC approved of Reg SHO program, which randomly selected one third of the Russell 3000 Index stocks as the pilot group, and removed the restrictions on short uptick rules for these PILOT stocks from May, 2005 to August, 2007. Two years after the experiment, SEC removed this short-sale restriction for all stocks. Reg SHO program is designed to examine the how the lift of short-sale constraints would affect stock market liquidity, volatility, and price efficiency. Diether, Lee, and Werner (2009) find evidence that the relative bid depth increases significantly for NYSE pilot stocks. They also find that NYSE pilot stocks have significantly higher trade-to-trade return volatility relative to control stocks, which would enhance the feedback effect implied in the model. Alexander and Peterson (2008) find that the effective spreads of trades initiated by short sellers decrease significantly for pilot stocks relative to control stocks. Given the increased bid depth and the reduced effective bid-ask spread, Reg-SHO program provides us an exogenous shock on the transaction costs for the treated stocks during the 2005 to 2007.

In addition, we interpret Decimalization as another exogenous shock that lowers traders' transaction cost. In 2001, NYSE and Amex (and subsequently NASDAQ) started to quote and trade their listed shares in cents (decimal prices) instead of increments of a sixteenth of a dollar (fractional prices). Literature has shown that liquidity increases significantly after Decimalization. Furfine (2003) find that bid-ask spread declines over 35% for actively traded stock. Bessembinder (2003) also find that quoted bid-ask spreads declined substantially, particularly for for heavily traded stocks. Decimalization can thus be viewed as an exogenous shock that reduces the transaction cost. Fang, Noe, and Tice (2009) find that firm performance increases after Decimalization, and they argue this evidence is consistent with the notion that high stock liquidity reinforces the feedback effect by stimulating the information incorporation into stock price and then improves firm performances.[6]

Empirical studies of both regulatory changes in the U.S. equity market, including Reg SHO and Decimalization, suggest that they can instrument for exogenous shocks to speculators' transaction cost, which allows us to examine our model implications using a difference-in-difference framework.

Stock prices and returns data are from the Center for Research in Security Prices (CRSP). Accounting data are from COMPUSTAT. The institutional ownership ratio and institutional ownership concentration are from Thomas Reuters Institutional (13F) Holdings. Following Edmans, Gabaix, and Landier (2009), we use the scaled wealth-performance sensitivity (WPS) to measure pay-performance sensitivities. The

[6] In a related strand of literature, Bharath, Jayaraman, and Nagar (2013) find that Decimalization enhances the positive association between blockholders' ownership and firm value, and they interpret this evidence as indicating that Decimalization strengthens the governance role of block ownership via exit threats.

scaled wealth-performance sensitivity (WPS) is the dollar change in CEO wealth for a 100 percent point change in firm value, divided by annual flow of compensation, and is obtained from Alex Edmans' website.

4.2 Empirical Results

Our model has three implications. First, reductions in the transaction cost result in lower optimal pay for performance. Second, higher managerial empire-building tendencies enhance the effects of changes in the transaction costs on optimal pay for performance. Third, a reduced transaction cost weakens the positive association between firms' investment opportunities and optimal pay for performance. We examine each of them in turn below.

4.2.1 Optimal Pay for Performance

There are two possible vehicles available for shareholders to overcome overinvestment incentives and deliver optimal investment decisions: internal pay structure to align incentives and external informed trading that reveals useful information to managers (i.e. the feedback effect). All else equal, when the overall trading cost decreases, informed traders are more incentivized to trade upon information they collect, seeking trading profits. As the optimal pay-for-performance is determined by a trade-off between aligning incentives internally and inducing informed trading externally, we expect a lower optimal incentive pay when broadly-defined transaction costs decline.

As the prior literature has shown that Reg SHO and Decimalization can serve as exogenous shock to broadly-defined transaction costs, we employ these two events to examine whether lower trading costs lead to lower optimal pay for performance, as our model predicts. First, we focus on the Reg SHO and Russell 3000 Index firms to conduct the regression as follows:

$$WPS_{i,t} = a_i + a_t + a_1 \cdot PILOT \times During + a_2 \cdot X_{i,t-1} + \epsilon_{i,t}, \tag{3}$$

where a_i is a dummy for the firm fixed effect and a_t is a dummy for the year fixed effect. WPS is measure for wealth performance sensitivities, which is the dollar change in CEO wealth for a 100 percentage point change in firm value, divided by annual flow compensation (Edmans, Gabaix, and Landier (2009)). PILOT is a dummy, which equals one if firms are selected as Reg SHO treated stock, and zero for other firms in the Russell 3000 Index. In particular, we employ the list of Russell 3000 Index members on June, 2004. During is a time dummy that equals one from 2005 to 2007, and zero for time during 2001 to 2003. We exclude the year of 2004, as this year is when SEC announced the PILOT program. $X_{i,t-1}$ denotes a set of control variables, including: firm size, leverage ratio, dividend payout dummy, firm age, institutional ownership ratio, ratio of cash to asset, ratio of capital expenditure to asset, institutional ownership concentration ratio, and stock return volatility. We do not include PILOT and During variables, owing to a collinearity with year- and firm-fixed effects.

Column (1) of Table 1 presents the results of Equation (3). We find that the coefficient on $PILOT \times During$ is negative with a significance level of 1%, suggesting that those firms selected as PILOT stocks would experience a significant reduction in optimal pay for performance during the program. This result is consistent with our model implication that reduced total trading costs make it easier to induce informed trading and strengthen the feedback effect, causing the required pay for performance to be lower in managerial compensation.

Second, we consider Decimalization as an alternative exogenous shock to transaction costs. In particular, we carry out the following regression:

$$WPS_{i,t} = a_i + a_t + a_1 \cdot DECIMAL + a_2 \cdot X_{i,t-1} + \epsilon_{i,t} \tag{4}$$

where a_i, a_t, WPS, and $X_{i,t-1}$ are identically defined as those in Equation (3). DECIMAL is a dummy variable that equals 1 for the period after 2001.

Column (2) of Table 1 presents the results of Equation (4). We find that the coefficient on DECIMAL is negative and significant, which is consistent with our model implication that optimal compensation pay is decreasing in the transaction cost. Note that this set of results highlight a contrast between our findings and those in the literature. Kang and Liu (2008) and Kang and Liu (2010) document a positive association between managerial pay for performance and stock price informativeness, and they argue that this evidence is consistent with the notion that more informative stock price enhances the link between managerial pay and firm performance. Using regulatory changes to circumvent the endogeneity issue underlying proxies such as price informativeness, we show that the degree of pay for performance can actually be substituted out by information provision in the financial market. The feedback effect, which features the transmission of information, is important for understanding the design of compensation structure.

4.2.2 Optimal Pay for Performance and Managerial Empire-building Tendencies

In this section, we examine whether managerial empire-building tendencies affect how incentive pay responds to changes in the transaction cost (due to Reg SHO and Decimalization). As the studies of the feedback effect in corporate finance have been concentrated on how stock prices help correct managerial investment decisions (Baker, Stein and Wurgler (2003), Luo (2005), Chen, Goldstein and Jiang (2007), Bakke and Whited (2010), and Bond, Edmans, and Goldstein (2012)), our model features managerial empire-building incentives and predicts that the relationship between the transaction cost and pay structure is particularly pronounced in firms whose managers are more inclined to overinvest. In particular, we employ four proxies to measure managerial tendencies for empire-building (MTEB): negative New KZ Index ((Hadlock and Pierce (2010)), negative KZ Index (Kaplan and Zingales (1997)), negative HP Index ((Hadlock and Pierce (2010)), and negative firms' leverage ratio. The first three measures capture the degree of financial slackness firms face. Lower level financial constraints provide more resources for managers to engage in empire-building. Similarly, managers at firms with a lower leverage ratio have greater flexibilities in undertaking large-scale investments and are thus more likely to do so, all else equal.

First, we employ Reg SHO program to capture the exogenous shock to transaction costs, and conduct the regression as follows:

$$
\begin{aligned}
&WPS_{i,t} = a_i + a_t + a_1 \cdot MTEB_{i,t-1} \times PILOT \times During + a_2 \cdot PILOT \times During \\
&+a_3 \cdot MTEB_{i,t-1} \times PILOT + a_4 \cdot MTEB_{i,t-1} \times During + a_5 \cdot MTEB_{i,t-1} \\
&+a_6 \cdot X_{i,t-1} + \epsilon_{i,t},
\end{aligned} \tag{5}
$$

where a_i, a_t, WPS, PILOT, During, and $X_{i,t-1}$ are identically defined as those in Equation (3) . MTEB is vector that proxies for managerial tendencies for empire-building, including negative New KZ Index, negative KZ Index, negative HP Index, and negative firms' leverage ratio. The larger the value of MTEB, the stronger the managerial tendency for empire-building.

As we focus on the impact of MTEBs on the association between WPS and PILOT program, our main variable of interest is the coefficients on the interaction $MTEB \times PILOT \times During$. In columns (1), (2), and (4) of Table 2, we find that the coefficients on the interaction $MTEB \times PILOT \times During$ are all negative and significant, implying that the negative association between WPS and $PILOT \times During$ is strengthened when managers have stronger tendencies to acquire capital control (lower level of financial constraints and lower firm's leverage ratio). When we use negative HP index to proxy for MTEB (column (3)), the coefficient on the three-way interaction is also negative as predicted, although not significant.

Second, we employ Decimalization as an alternative exogenous shock to transaction costs, and conduct regression as follows:

$$\begin{aligned} WPS_{i,t} &= a_i + a_t + a_1 \cdot MTEB_{i,t-1} \times DECMAL + a_2 \cdot DECIMAL \\ &+ a_3 \cdot MTEB_{i,t-1} + a_4 \cdot X_{i,t-1} + \epsilon_{i,t}, \end{aligned} \tag{6}$$

where a_i, a_t, WPS, DECIMAL, and $X_{i,t-1}$ are identically defined as those in Equation (4). MTEB is a vector that proxies for managerial tendencies for empire-building, including negative New KZ Index, negative KZ Index, negative HP Index, and negative firms' leverage ratio.

Table 3 presents the results of Equation (6). The coefficients on $MTEB \times DECIMAL$ are all negative and significant. That is, the reduction in WPS in response to a lowered transaction cost (post-Decimalization) is stronger in firms whose managers have greater empire-building tendencies, proxied by lower financial constraints and lower leverage ratio. Both sets of results provide supportive evidence to our second model implication.

4.2.3 Optimal Pay for Performance and Tobin's Q

In this subsection, we investigate whether exogenous shocks to transaction costs would weaken the positive association between WPS and firms' investment opportunities, proxied by Tobin's Q. First, we focus on the effect of Reg SHO program. We conduct the regression as follows:

$$
\begin{aligned}
&WPS_{i,t} = a_i + a_t + a_1 \cdot Tobin's\ Q_{i,t-1} \times PILOT \times During \\
&+a_2 \cdot Tobin's\ Q_{i,t-1} \times PILOT + a_3 \cdot Tobin's\ Q_{i,t-1} \times During \\
&+a_4 \cdot PILOT \times During + a_5 \cdot Tobin's\ Q_{i,t-1} + a_6 \cdot X_{i,t-1} + \epsilon_{i,t},
\end{aligned}
\tag{7}
$$

where a_i, a_t, WPS, PILOT, During, and $X_{i,t-1}$ are identically defined as those in Equation (3) and Equation (5) . Tobin's Q is the ratio of the market value of assets to the book value of assets, where the market value of assets is defined as the book value of assets (data 6) plus the market value of common equity (data 25 times data 199) less the book value of common equity (data 60) and balance sheet deferred taxes (data 74).

Our main variable of interest is the coefficient on the three-way interaction term $Tobin's\ Q_{i,t-1} \times PILOT \times During$, which captures whether the reduction in the transaction cost affects the positive relation between Tobin's Q and WPS. Column (2) of Table 4 show that the coefficient, a_1, is negative and significant at 10% significance level. This result indicates that inclusion in the PILOT program reduces the positive association between Tobin's Q and WPS, as lower transaction costs incentivize informed trading and strengthen the feedback effect, which in turn lower the degree of pay for performance in compensation.

Second, we examine the effect of Decimalization on the association between investment opportunities and managerial incentive, and conduct the regression as follows:

$$
\begin{aligned}
&WPS_{i,t} = a_i + a_t + a_1 \cdot Tobin's\ Q_{i,t-1} \times DECIMAL + a_2 \cdot Tobin's\ Q_{i,t-1} + \\
&a_3 \cdot X_{i,t-1} + \epsilon_{i,t},
\end{aligned}
\tag{8}
$$

where a_i, a_t, WPS, Tobins Q, and $X_{i,t-1}$ are defined identical to those in Equation (7). DECIMAL is a dummy variable that equals 1 for the period after 2001.

Column (4) of Table 4 shows that the coefficient on the interaction between $Tobin's\ Q_{i,t-1} \times DECIMAL$ is negative and significant at 10% level. This result echoes the Reg SHO analysis that strengthened feedback effect, induced by lower transaction costs after Decimalization, would alleviate the positive association between firms' investment opportunities and managerial incentive (WPS). These findings are consistent with our third model implication.

Taken together, results of empirical tests broadly support our model predications on managerial incentive pay. In the presence of feedback from market prices to corporate investment decisions, the choice of pay-performance sensitivities in managerial compensation represents a trade-off between aligning incentives internally and inducing information provision externally in the financial market. We show that regulatory changes that lower traders' transaction costs lead to a less degree of pay for performance used in compensation, as all else equal, lowered transaction costs increase speculators' trading profits and information revealed in the financial market, strengthening the importance of the feedback effect.

5 Conclusion

Existing studies have analyzed the feedback effect and managerial compensation in isolation. As the feedback effect directly influences managerial behavior, compensation should and can optimally adjust for the feedback effect. To examine the contracting implications of the feedback effect, we study the design of compensation in an equilibrium model where firm value is endogenous to trading, due to feedback from stock prices to investment decisions. Informed trading reveals information to managers and improves their investment decisions, enhancing firm value. From shareholders' perspective, it can be efficient to lower pay-performance sensitivities in managerial compensation, as it induces informed trading, which subsequently corrects managerial decisions in investment. We utilize two regulatory changes in the U.S. equity market to test our model implications. The findings from these tests broadly support our model predictions.

The optimal pay for performance in our model is determined by a trade-off between aligning incentives internally and inducing information production externally. In particular, our model predicts that reduced transaction costs, although increase price informativeness, have a negative effect on the managerial incentives used in compensation due to the feedback effect. Such an effect is stronger for managers with higher empire-building tendencies. In addition, a reduction in transaction cost would also weaken the positive association between firms' investment opportunities and optimal pay for performance. The traditional view of the relation between pay-performance sensitivity and price informativeness is that higher levels of price informativeness raise the optimal pay-performance sensitivity. We show that incorporating the feedback from the financial market to real decisions can change our understanding of managerial pay structure.

Appendix

Proof of Proposition 1: Without informed trading, the shareholders' objective is to maximize

$$\left(1-\frac{b}{(1-2q)s}\right)V(q)=\left(1-\frac{b}{(1-2q)s}\right)[\Delta s(q-q^2)+V_0],$$

where $\Delta = I_H - I_L$. Taking the first-order derivative w.r.t q yields

$$1-2q-\frac{b}{s}-\frac{2b(q-q^2)}{s(1-2q)^2}-\frac{2bV_0}{s^2\Delta(1-2q)^2}=0.$$

Denote the left-hand side of the above equation by $f(q,\Delta)$. Since $f(q,\Delta)=0$, we obtain that $\frac{\partial f}{\partial \Delta}+\frac{\partial f}{\partial q}\frac{\partial q}{\partial \Delta}=0$. Since at the maximum we must have $\frac{\partial f}{\partial q}<0$, the sign of $\frac{\partial q}{\partial \Delta}$ is the same as the sign of $\frac{\partial f}{\partial \Delta}$. Note that $\frac{\partial f}{\partial \Delta}=\frac{2bV_0}{s^2\Delta^2(1-2q)^2}>0$, so the optimal policy $\hat{q}$ is increasing in Δ, and thus $\hat{\beta}=\frac{b}{(1-2\hat{q})s}$ is also increasing in Δ.□

Proof of Lemma 3: $V_I > V(q), \forall q$. And $\frac{\partial V_I}{\partial \theta}=\frac{\Delta s}{2}\left(\frac{1}{2}-q+q^2\right)>0$.□

Proof of Proposition 2

For simplicity, we define $b' = b/s$, then $\beta=\frac{b}{(1-2q)s}=\frac{b'}{1-2q}$. Also $0<\beta<1$ implies that $0<b'<1$. The shareholders' objctive is to maximize $(1-\beta)V_I$, where $0<\beta=\frac{b'}{1-2q}<1$. Note that

$$\frac{\partial}{\partial q}\left[\left(1-\frac{b'}{1-2q}\right)V(q)\right]=\Delta s\left[1-2q-b'-\frac{2b'(q-q^2)}{(1-2q)^2}-\frac{2b'V_0}{s\Delta(1-2q)^2}\right]$$

is decreasing in q for $q<\frac{1}{2}$. So for any $\frac{1}{2}>q\geq\hat{q}$, $\frac{\partial}{\partial q}\left[\left(1-\frac{b'}{1-2q}\right)V(q)\right]\leq 0$. Hence for any $\frac{1}{2}>q\geq\hat{q}$,

$$\frac{\partial}{\partial q}\left[\left(1-\frac{b'}{1-2q}\right)V_I\right]\leq\frac{\partial}{\partial q}\left[\left(1-\frac{b'}{1-2q}\right)\frac{\theta\Delta s}{2}\left(\frac{1}{2}-q+q^2\right)\right]<0.$$

So $q^* < \hat{q}$. Thus $\beta^* = \frac{b'}{(1-2q^*)s} < \hat{\beta}$.

Note that from (2), maximizing $\left(1 - \frac{b'}{1-2q}\right) V_I$ is equivalent to maximizing

$$F(q,x) = \left(1 - \frac{b'}{1-2q}\right) \left[-\Delta q^3 + (2I_H - I_L - B)\, q^2 - \left(\frac{3}{2} I_H - \frac{1}{2} I_L - B\right) q + \frac{I_H}{2} + \frac{V_0 B}{\Delta s}\right].$$

Denote $f(q,x) = \frac{\partial F}{\partial q}$, where x refers to the parameter I_H I_L, or A. Then we have $\frac{\partial f}{\partial x} + \frac{\partial f}{\partial q}\frac{\partial q}{\partial x} = 0$. Since at the maximum q^*, we must have $\frac{\partial f}{\partial q} < 0$, the sign of $\frac{\partial q}{\partial x}$ is the same as the sign of $\frac{\partial f}{\partial x}$. We first can compute that

$$\frac{\partial f}{\partial I_H} = \frac{1}{(1-2q)^2}\left[(1-2q)^2\left(-3q^2 + 4q - \frac{3}{2}\right) - b'\left(4q^3 - 7q^2 + 4q - \frac{1}{2}\right) + \frac{2b'V_0 B}{\Delta^2 s}\right]$$

So we obtain that

$$\frac{\partial}{\partial q}\left[(1-2q)^2 \frac{\partial f}{\partial I_H}\right] = (1-2q)\left[-4\left(-3q^2 + 4q - \frac{3}{2}\right) + (1-2q-b')\,(4-6q)\right] > 0.$$

So $(1-2q)^2 \frac{\partial f}{\partial I_H}$ is increasing in q for $0 < q < \frac{1}{2}$.

Similarly, we can compute that

$$\frac{\partial f}{\partial I_L} = \frac{1}{(1-2q)^2}\left[(1-2q)^2\left(3q^2 - 2q + \frac{1}{2}\right) + b'\left(4q^3 - 5q^2 + 2q - \frac{1}{2}\right) - \frac{2b'V_0 B}{\Delta^2 s}\right],$$

and

$$\frac{\partial}{\partial q}\left[(1-2q)^2 \frac{\partial f}{\partial I_L}\right] = -2(1-2q)\left[12q^2 - 3(3-b')q + 2 - b'\right] < 0.$$

So $(1-2q)^2 \frac{\partial f}{\partial I_L}$ is decreasing in q for $0 < q < \frac{1}{2}$.

Proof of Part (1)

$$\frac{\partial f}{\partial A} = \frac{4}{\Delta s^2}\frac{\partial}{\partial q}\left[\left(1 - \frac{b'}{1-2q}\right) V(q)\right].$$

Since $\frac{\partial}{\partial q}\left[\left(1-\frac{b'}{1-2q}\right)V(q)\right]|_{q=q^*}>0$, q^* and β^* are both increasing in A.

Proof of Part (2)

Since $(1-2q)^2\frac{\partial f}{\partial I_H}$ is increasing in q, if $(1-2q)^2\frac{\partial f}{\partial I_H}|_{q=0}>0$, then we must have $(1-2q)^2\frac{\partial f}{\partial I_H}|_{q=q^*}>0$, which implies that $\frac{\partial f}{\partial I_H}|_{q=q^*}>0$. From the above calculations, we can see that $(1-2q)^2\frac{\partial f}{\partial I_H}|_{q=0}>0$ is equivalent to

$$(1-2q)^2\left(-3q^2+4q-\frac{3}{2}\right)-b'\left(4q^3-7q^2+4q-\frac{1}{2}\right)+\frac{2b'V_0B}{\Delta^2 s}|_{q=0}>0,$$

which can be simplified to $\frac{1}{2}b'+\frac{2b'V_0B}{\Delta^2 s}>\frac{3}{2}$.

Similarly, since $(1-2q)^2\frac{\partial f}{\partial I_L}$ is decreasing in q, if $(1-2q)^2\frac{\partial f}{\partial I_L}|_{q=0}<0$, then we must have $(1-2q)^2\frac{\partial f}{\partial I_L}|_{q=q^*}<0$, which implies that $\frac{\partial f}{\partial I_L}|_{q=q^*}<0$. Also $(1-2q)^2\frac{\partial f}{\partial I_L}|_{q=0}<0$ is equivalent to

$$(1-2q)^2\left(3q^2-2q+\frac{1}{2}\right)+b'\left(4q^3-5q^2+2q-\frac{1}{2}\right)-\frac{2b'V_0B}{\Delta^2 s}|_{q=0}<0,$$

which can be simplied to $\frac{1}{2}b'+\frac{2b'V_0B}{\Delta^2 s}>\frac{1}{2}$. Therefore, as long as $\frac{1}{2}b'+\frac{2b'V_0B}{\Delta^2 s}>\frac{3}{2}$, i.e. $A>\frac{\Delta^2 s^2}{8V_0}\left(\frac{3s}{2b}-\frac{1}{2}\right)$, then q^* is increasing in I_H and decreasing in I_L, which implies that q^* and β^* are both increasing in the firm's flexibility I_H-I_L.

Proof of Part (3)

Similar argument applies here: when $A<\frac{\Delta^2 s^2}{8V_0}\frac{1}{2}\left(\frac{1}{2}-\frac{3}{2}\left(\frac{b}{s}\right)^{1/3}\right)\left(1-\left(\frac{b}{s}\right)^{1/3}\right)$, we can show that $(1-2q)^2\frac{\partial f}{\partial I_H}|_{q=q^*}<0$ and $(1-2q)^2\frac{\partial f}{\partial I_L}|_{q=q^*}>0$. Therefore, q^* is decreasing in I_H and increasing in I_L, which implies that q^* and β^* are both decreasing in the firm's flexibility I_H-I_L.

Table 1. The effects of Reg SHO and Decimalization on WPS

This table presents the effects of Reg SHO and Decimalization on WPS. In columns (1), we examine the impact of Reg SHO on WPS. The sample is from 2001 till the end of Reg SHO (2007). PILOT is a dummy variable indicating firms that are selected as Reg SHO treated stock, and zero for the rest firms in the Russell 3000 index. During is a time dummy that equals one from 2005 to 2007, and zero for time during 2001 to 2003. We exclude the year of 2004, as this year is when SEC announced the PILOT program. In column (2), we examine the impact of Decimalization on WPS. DECIMAL is a dummy variable that equals 1 for the period after 2001. WPS measures the wealth-performance-sensitivities, which is the dollar change in CEO wealth for a 100 percentage point change in firm value, divided by annual flow compensation (Edmans et al. (2009)). Tobin's Q is the ratio of the market value of assets to the book value of assets, where the market value of assets is defined as the book value of assets (data 6) plus the market value of common equity (data 25 times data 199) less the book value of common equity (data 60) and balance sheet deferred taxes (data 74). Size is the logarithm of total asset. Leverage is sum of short-term debt (data 34) and long-term debt (data 9) divided by the sum of short-term and long-term debt and stockholders equity (data 216). Dividend is a dummy variable which equals to one when firm distribute dividend in this year, and zero otherwise. Age is calculated based on the first time when firm's accounting information appeared in Compustat. IOR is the institutional investors' ownership ratio. Cash is the ratio of cash (data 126) divided by total asset (data 6). INV is the investment-to-capital ratio (INV), which is capital expenditure (data 128) divided by fixed assets (data 8). IOC is the measure for concentration of institutional ownership, which is the sum of the top five institutional investors share ownership. RetStd is proxied for risk, which is calculated as the standard deviation of monthly stock returns. All regressions are controlled for firm and year fixed effect. Standard errors are clustered at year level, and reported in the parenthesis. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	(1) PILOT	(2) DECIMAL
PILOT×During	-0.195***	
	(0.053)	
DECIMAL		-0.307***
		(0.047)
Size	0.095	0.164***
	(0.090)	(0.020)
Tobin's Q	0.046**	0.145***
	(0.016)	(0.021)
Leverage	-0.060	-0.075
	(0.119)	(0.085)
Dividend	-0.052	-0.126***
	(0.075)	(0.023)
Age	-0.089	-0.167***
	(0.103)	(0.037)
IOR	-0.009	-0.120*
	(0.090)	(0.059)
Cash	0.056	0.065
	(0.497)	(0.090)
INV	0.128	0.057
	(0.124)	(0.048)
IOC	-0.500	-0.344*
	(0.349)	(0.166)
RetStd	-0.115	0.169
	(0.617)	(0.139)
Year Dummies	Y	Y
Firm Dummies	Y	Y
No. of Obs	5687	25571
R-squared	0.7048	0.5971

Table 2. The impact of MTEB on the negative association between PILOT and WPS

This table examines the impact of Managerial Tendencies for Empire-Building (MTEB) on the negative association between Reg SHO and manageiral compensation (WPS). The sample is from 2001 till the end of the Reg SHO program (2007). PILOT is a dummy variable indicating firms that are selected as Reg SHO treated stock, and zero for the rest firms in the Russell 3000 index. During is a time dummy that equals one from 2005 to 2007, and zero for time during 2001 to 2003. We exclude the year of 2004, as this year is when SEC announced the PILOT program. In column (1), MTEB1 represents negative New KZ index (Hadlock and Pierce (2010)). In column (2), we use negative Kaplan-Zingales index (Kaplan and Zingales (1997)) to proxy for MTEB2. In column (3), MTEB3 represents negative HP index (Hadlock and Pierce (2010)). In column (4), we use negative firms' leverage ratio to proxy for MTEB4. WPS measures the wealth-performance-sensitivities, which is the dollar change in CEO wealth for a 100 percentage point change in firm value, divided by annual flow compensation (Edmans et al. (2009)). Tobin's Q is the ratio of the market value of assets to the book value of assets, where the market value of assets is defined as the book value of assets (data 6) plus the market value of common equity (data 25 times data 199) less the book value of common equity (data 60) and balance sheet deferred taxes (data 74). Size is the logarithm of total asset. Leverage is sum of short-term debt (data 34) and long-term debt (data 9) divided by the sum of short-term and long-term debt and stockholders equity (data 216). Dividend is a dummy variable which equals to one when firm distribute dividend in this year, and zero otherwise. Age is calculated based on the first time when firm's accounting information appeared in Compustat. IOR is the institutional investors' ownership ratio. Cash is the ratio of cash (data 126) divided by total asset (data 6). INV is the investment-to-capital ratio (INV), which is capital expenditure (data 128) divided by fixed assets (data 8). IOC is the measure for concentration of institutional ownership, which is the sum of the top five institutional investors share ownership. RetStd is proxied for risk, which is calculated as the standard deviation of monthly stock returns. All regressions are controlled for firm and year fixed effect. Standard errors are clustered at year level and reported in the parenthesis. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable: WPS			
	(1) MTEB1	(2) MTEB2	(3) MTEB3	(4) MTEB4
MTEB×PILOT×During	-0.026**	-0.224***	-0.028	-1.160**
	(0.007)	(0.052)	(0.022)	(0.332)
PILOT×During	-0.103*	-0.351***	0.028	-0.442**
	(0.046)	(0.041)	(0.212)	(0.114)
MTEB×PILOT	0.029*	0.100*	0.045	0.731**
	(0.014)	(0.039)	(0.029)	(0.257)
MTEB×During	0.004	-0.034	0.025	0.042
	(0.003)	(0.068)	(0.012)	(0.241)
Size	0.085	0.088	0.172	0.091
	(0.081)	(0.066)	(0.198)	(0.082)
Tobin's Q	0.047**	0.059**	0.046**	0.046**
	(0.018)	(0.022)	(0.017)	(0.016)
Leverage	-0.000	-0.079	-0.023	
	(0.186)	(0.118)	(0.159)	
Dividend	-0.054	-0.036	-0.048	-0.035
	(0.073)	(0.047)	(0.078)	(0.098)
Age	-0.065	-0.060	-0.020	-0.025
	(0.098)	(0.102)	(0.108)	(0.074)
IOR	-0.013	-0.070	0.045	0.069
	(0.070)	(0.082)	(0.053)	(0.344)
Cash	-0.059	-0.173	0.053	0.170
	(0.334)	(0.103)	(0.340)	(0.089)
INV	0.163	0.085	0.124	-0.512*
	(0.114)	(0.112)	(0.084)	(0.214)
IOC	-0.529	-0.272	-0.571	0.011
	(0.288)	(0.225)	(0.287)	(0.851)
RetStd	-0.014	-0.193	-0.146	-0.081
	(0.858)	(0.695)	(0.849)	(0.127)
MTEB	-0.004	0.002	-0.095	-0.056
	(0.004)	(0.076)	(0.120)	(0.078)
Year Dummies	Y	Y	Y	Y
Firm Dummies	Y	Y	Y	Y
No. of Obs	5747	5748	5687	5686
R-squared	0.7040	0.7387	0.7051	0.7055

Table 3. The impact of MTEBs on the negative association between Decimalization and WPS
This table examines the impact of Managerial Tendencies for Empire-Building (MTEB) on the negative association between Decimalization and managerial compensation (WPS). DECIMAL is a dummy variable that equals 1 for the period after 2001. In column (1), MTEB1 represents negative New KZ index (Hadlock and Pierce (2010)). In column (2), we use negative Kaplan-Zingales index (Kaplan and Zingales (1997)) to proxy for MTEB2. In column (3), MTEB3 represents negative HP index (Hadlock and Pierce (2010)). In column (4), we use negative firms' leverage ratio to proxy for MTEB4. WPS measures the wealth-performance-sensitivities, which is the dollar change in CEO wealth for a 100 percentage point change in firm value, divided by annual flow compensation (Edmans et al. (2009)). Tobin's Q is the ratio of the market value of assets to the book value of assets, where the market value of assets is defined as the book value of assets (data 6) plus the market value of common equity (data 25 times data 199) less the book value of common equity (data 60) and balance sheet deferred taxes (data 74). Size is the logarithm of total asset. Leverage is sum of short-term debt (data 34) and long-term debt (data 9) divided by the sum of short-term and long-term debt and stockholders equity (data 216). Dividend is a dummy variable which equals to one when firm distribute dividend in this year, and zero otherwise. Age is calculated based on the first time when firm's accounting information appeared in Compustat. IOR is the institutional investors' ownership ratio. Cash is the ratio of cash (data 126) divided by total asset (data 6). INV is the investment-to-capital ratio (INV), which is capital expenditure (data 128) divided by fixed assets (data 8). IOC is the measure for concentration of institutional ownership, which is the sum of the top five institutional investors share ownership. RetStd is proxied for risk, which is calculated as the standard deviation of monthly stock returns. All regressions are controlled for firm and year fixed effect. Standard errors are clustered at year level and reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable: WPS			
	(1) MTEB1	(2) MTEB2	(3) MTEB3	(4) MTEB4
MTEB×DECIMAL	-0.075**	-0.004*	-0.027***	-0.305**
	(0.029)	(0.002)	(0.008)	(0.121)
DECIMAL	-0.391***	-0.305***	-0.080	-0.383***
	(0.056)	(0.054)	(0.101)	(0.048)
Size	0.166***	0.168***	0.211***	0.164***
	(0.020)	(0.025)	(0.029)	(0.020)
Tobin's Q	0.144***	0.147***	0.147***	0.142***
	(0.022)	(0.023)	(0.021)	(0.021)
Leverage	-0.061	-0.078	0.044	
	(0.215)	(0.090)	(0.085)	
Dividend	-0.124***	-0.130***	-0.111***	-0.124***
	(0.024)	(0.026)	(0.021)	(0.024)
Age	-0.158***	-0.163***	-0.191***	-0.157***
	(0.038)	(0.038)	(0.044)	(0.035)
IOR	-0.119*	-0.133**	-0.159**	-0.122*
	(0.059)	(0.061)	(0.068)	(0.059)
Cash	0.067	-0.016	0.093	0.069
	(0.092)	(0.106)	(0.096)	(0.089)
INV	0.046	0.024	0.066	0.046
	(0.047)	(0.061)	(0.047)	(0.047)
IOC	-0.342*	-0.263**	-0.240	-0.345*
	(0.166)	(0.108)	(0.154)	(0.165)
RetStd	0.138	0.244	0.182	0.130
	(0.147)	(0.172)	(0.133)	(0.148)
MTEB	0.042	0.004*	-0.019	0.221**
	(0.060)	(0.002)	(0.023)	(0.103)
Year Dummies	Y	Y	Y	Y
Firm Dummies	Y	Y	Y	Y
No. of Obs	25569	25569	25571	25571
R-squared	0.5973	0.5933	0.5911	0.5974

Table 4. The mitigation effect of Reg SHO and Decimalization on the positive relation between Tobin's Q and WPS
This table presents the mitigation effect of Reg SHO and Decimalization on the positive relation between Tobin's Q and WPS. In columns (1) and (2), we examine the impact of Reg-SHO program on positive association between Tobin's Q and WPS. The sample is from 2001 till the end of the Reg SHO program (2007). PILOT is a dummy variable indicating firms that are selected as Reg SHO treated stock, and zero for the rest firms in the Russell 3000 index. During is a time dummy that equals one from 2005 to 2007, and zero for time during 2001 to 2003. We exclude the year of 2004, as this year is when SEC announced the PILOT program. DECIMAL is a dummy variable that equals 1 for the period after 2001. WPS measures the wealth-performance-sensitivities, which is the dollar change in CEO wealth for a 100 percentage point change in firm value, divided by annual flow compensation (Edmans et al. (2009)). Tobin's Q is the ratio of the market value of assets to the book value of assets, where the market value of assets is defined as the book value of assets (data 6) plus the market value of common equity (data 25 times data 199) less the book value of common equity (data 60) and balance sheet deferred taxes (data 74). Size is the logarithm of total asset. Leverage is sum of short-term debt (data 34) and long-term debt (data 9) divided by the sum of short-term and long-term debt and stockholders equity (data 216). Dividend is a dummy variable which equals to one when firm distribute dividend in this year, and zero otherwise. Age is calculated based on the first time when firm's accounting information appeared in Compustat. IOR is the institutional investors' ownership ratio. Cash is the ratio of cash (data 126) divided by total asset (data 6). INV is the investment-to-capital ratio (INV), which is capital expenditure (data 128) divided by fixed assets (data 8). IOC is the measure for concentration of institutional ownership, which is the sum of the top five institutional investors share ownership. RetStd is proxied for risk, which is calculated as the standard deviation of monthly stock returns. All regressions are controlled for firm and year fixed effect. Standard errors are clustered at year level, and reported in the parenthesis. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent Variable: WPS			
	(1) PILOT	(2) PILOT	(3) DECIMAL	(4) DECIMAL
Tobin's Q×PILOT×During		**-0.107***		
		(0.042)		
PILOT×During		0.047		
		(0.109)		
Tobin's Q×PILOT		0.095*		
		(0.038)		
Tobin's Q×During		-0.078**		
		(0.028)		
Tobin's Q×DECIMAL				**-0.054***
				(0.027)
DECIMAL				-0.239***
				(0.068)
Tobin's Q	0.050**	0.030	0.149***	0.156***
	(0.018)	(0.017)	(0.023)	(0.026)
Size	0.094	0.144	0.174***	0.178***
	(0.087)	(0.078)	(0.025)	(0.025)
Leverage	0.039	0.091	-0.091	-0.084
	(0.163)	(0.141)	(0.090)	(0.091)
Dividend	-0.057	-0.048	-0.122***	-0.119***
	(0.077)	(0.079)	(0.024)	(0.024)
Age	-0.049	0.013	-0.170***	-0.159***
	(0.116)	(0.127)	(0.041)	(0.040)
IOR	0.005	-0.094	-0.136**	-0.147**
	(0.075)	(0.084)	(0.061)	(0.060)
Cash	0.049	0.097	0.052	0.079
	(0.354)	(0.340)	(0.095)	(0.095)
INV	0.164*	0.169	0.057	0.057
	(0.076)	(0.095)	(0.049)	(0.050)
IOC	-0.506*	-0.434	-0.254**	-0.282**
	(0.238)	(0.241)	(0.106)	(0.102)
RetStd	-0.035	-0.060	0.267	0.209
	(0.859)	(0.867)	(0.176)	(0.193)
Year Dummies	Y	Y	Y	Y
Firm Dummies	Y	Y	Y	Y
No. of Obs	5686	5686	25571	25571
R-squared	0.7044	0.7082	0.6480	0.6489

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