Feedback effects and rational mispricing in markets

Lawrence Choo, Todd R. Kaplan, Ro'i Zultan

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Monaster Center for
Economic Research
Ben-Gurion University of the Negev
P.O. Box 653
Beer Sheva, Israel

Fax: 972-8-6472941
Tel: 972-8-6472286

Feedback effects and rational mispricing in markets*

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Abstract

Market prices should reflect expected asset values given the existing information in the market. A trader who can invest effort to increase the asset value may lead to rational mispricing: traders evaluate the asset correctly, yet the value exceeds the market price. One such situation arises when firm managers hold stock in the firm. Discretionary holdings generate feedback effects that can explain why stocks of firms with high CEO ownership are consistently traded below value and yield excess returns to stockholders. Mandatory disclosure policies, though designed to enhance transparency, might inadvertently prompt myopic trading behaviors influenced by fluctuations in the manager's holdings. We test these implications of managerial ownership in a controlled experiment. We find that the prices converge towards the equilibrium price predicted by a model allowing for feedback effects. The value of the stock to shareholders may be higher than the price, implying excess returns, depending on the environment. Furthermore, a mandatory disclosure-of-ownership policy has two effects. On the one hand, it allows the managers to extract funds from shareholders due to myopic trading. On the other hand, it also facilitates price convergence and increases efficiency, leading to gains for both managers and shareholders.

Keywords: managerial ownership, moral hazard, excess returns, efficient markets, experiment
JEL codes: C92, D53, D8, G14

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†Choo: Department of Economics, University of Macau. E-Mail: lawrence.cy.choo@gmail.com, Tel:+853 88224440 Kaplan: University of Exeter, Exeter, EX4 4PU, UK, and University of Haifa, Mount Carmel, Haifa 31905, Israel. E-mail: toddrkaplan@gmail.com, Tel: +44-4392-263237. Zultan: Ben-Gurion University of the Negev, P.O.B. 653, Beer-Sheva 84105, Israel. E-mail: zultan@bgu.ac.il, Tel:+972(0)86472306.

1. Introduction

Market prices should reflect the expected asset values given the existing information in the market. We study an environment where there is *rational mispricing*: the asset's value may exceed its market price, although the traders hold rational expectations, and their subjective valuation matches the asset's actual expected value. This anomaly may arise when there is a trader who can invest effort to increase the asset's redemption value. This trader chooses her portfolio and effort according to the market price. The market price, in turn, reflects the anticipated effort. Paradoxically, the resulting feedback loop uncouples the market price from the asset's redemption value.

The leading example of such an environment is managerial holdings. Many managers hold stocks in the companies they oversee, a practice intended to align their interests with those of shareholders (Edmans, Gabaix, and Jenter, 2017). Blonski and von Lilienfeld-Toal (2019, 2023) argued that the interplay of decisions and ownership may lead to mispricing of the firm stock. Following the reasoning outlined above, the manager's holdings incentivize her to exert costly effort in order to increase the firm's value. If stock prices reflect this high value, the manager is better off selling her holdings, allowing her to extract the stock value without exerting effort. Hence, the equilibrium price must be equal to the value for the manager from holding shares, taking into account effort costs—which is below the stock value for the shareholders. Von Lilienfeld-Toal and Ruenzi (2014) provide supporting evidence for this process. Their empirical analysis establishes that stocks of firms with substantial CEO holdings indeed yield excess risk-adjusted returns.

Moral hazard also implies that managerial ownership disclosure policies can have potential unintended consequences on market efficiency and wealth distribution. Such policies are widely prevalent. United States federal law, for example, requires all directors and officers of a firm to disclose any transactions of firm stock to the Securities and Exchange Commission (SEC) within two business days,[1] a policy primarily aimed at regulating inside trading.[2] Under moral hazard, however, such disclosure policies might interact with myopic trading to generate abnormal results. Assume that traders understand the manager's incentives to exert effort, yet they fail to account for how fluctuations in the stock price influence the manager's decision to buy or sell. This oversight on the part of traders may result in cyclical price dynamics. When traders observe the manager acquiring shares, they infer that the manager will take costly actions to boost the stock price. In anticipation, demand for the firm's stock increases, driving up the price. The manager then opts to sell at the inflated

[1] The United States Securities Exchange Act of 1934, Section 16(a).
[2] Public Utility Holding Company Act of 1935, Section 17(a).

price. Once traders notice the reduced managerial stake, they lower their expectations of effort, causing the price to drop back to levels at which the manager re-buys—and the cycle repeats itself. This cycle generates a *money pump* transferring wealth from the traders to the manager.

In this paper, we test the implications of managerial ownership and moral hazard. We show theoretically that strategic considerations fully determine the equilibrium price. In contrast to the efficient market hypothesis, this price does not necessarily reflect the stock value, which can be higher than the equilibrium price. We created experimental asset markets that include a manager-trader, whose post-market effort decision determines the redemption value of the asset. The manager holds one share, which she can trade on the market. After the trade closes, the manager can invest in increasing the asset's value. Thus, managerial holdings function as an incentivizing mechanism—The manager benefits personally from investing if and only if she holds a share at the time of decision. This design fully captures the proposed theoretical mechanism. Compared to field studies, this environment has the advantage of generating precise and testable predictions for equilibrium prices and allows us to manipulate the disclosure policy in a controlled manner.

An experimental setting may seem distant from the intricacies of an actual stock exchange. However, the unique features of the experimental market pose a strength rather than a limitation. The study of natural stock exchanges necessarily involves analyzing complex, noisy data. While invaluable, such data often reflect the combined influence of numerous overlapping factors—macroeconomic trends, institutional rules, and individual behaviors—obfuscating the role of the moral hazard and feedback effects at the heart of our study. Experiments allow us to strip away extraneous factors and focus on the core mechanisms under study, creating a clean environment for testing theoretical predictions directly and isolating the economic forces at play. The key advantage of this method compared to empirical studies of actual stock data is control. The experiment sets up a parsimonious market structure centering on the essential interest associated with managerial ownership. Trader preferences, unobservable in naturally occurring markets, are set as part of the experimental design. By manipulating disclosure policy and effort costs in a way not possible in natural markets, the experiment isolates the causal effect of disclosure and identifies the mechanisms driving market outcomes.

Our experimental results in the disclosure treatments are in line with the theoretical analysis. Disclosure provides traders real-time feedback, resulting in rapid convergence to the predicted equilibrium price. We generate different equilibrium prices across treatments by varying the manager's effort costs. The observed prices track the equilibrium price well in the different treatments, while final managerial holdings remain unaffected.

Without disclosure, prices in early periods are close to the high value, but converge to the predicted equilibrium price as the traders gain experience. The initial high prices lead the managers to sell in many markets, leading to low effort and therefore low economic efficiency during and even after the convergence process. Thus, we find that the disclosure policy facilitates convergence to the equilibrium.

Although we find convergence to the equilibrium in the disclosure treatments, the results provide clear evidence for myopic trading and money pumps. We observe repeated trading cycles, with the manager selling the share at an above-equilibrium price, later to reacquire the share after prices drop below the equilibrium price. The number of realized cycles is positively correlated with managerial earnings across markets.

In comparison, in the no-disclosure treatment, the number of cycles is significantly lower and the manager buys and sells at similar prices. Consequently, the number of cycles is not significantly correlated with managerial earnings. Thus, the disclosure policy leads shareholders to lose money to the manager. Nonetheless, as disclosure leads to higher managerial effort and, therefore, higher expected stock value, it primarily benefits the shareholders despite the effect of the money pump.

Taken together, our theoretical analysis and experimental results highlight the non-trivial consequences of managerial ownership. Under moral hazard, the dynamic relationship between managerial decisions and ownership positions leads to potential mispricing, as von Lilienfeld-Toal and Ruenzi (2014) document with stock-market data. Disclosure policies trigger a money pump that transfers money from the traders to the manager, while at the same time acting as a stabilizing mechanism. Policy makers overseeing managerial ownership regulations should take these dynamics into consideration.

Our results apply more broadly to environments where traders can costly influence the asset's value. Specifically, dedicated prediction markets increasingly serve to guide managerial and public policy (Arrow et al., 2008; Wolfers and Zitzewitz, 2004). Consider, for example, a firm that runs an internal prediction market to estimate the chances that the development of an innovative product will succeed. The firm naturally includes the development team, being best informed in the market. Market holdings incentivize developers to invest effort to increase the probability of the product succeeding, yielding feedback effects mirroring those emerging with managerial ownership.[3] Thus, our results may serve to guide the construction of inter-

[3]We note that the same incentive/information structure would exist in sports betting markets if athletes or managers were allowed to bet on their own team; however, this is explicitly forbidden. See, for example, MLB rule 21(d). Pete Rose was banned for life for a violation. The integrity of the game needs to ensure that there would be no moral hazard issues with athletes expected to always try their best to win. On the other side, improving the accuracy of betting markets appears to have no economic value. Interestingly, even though athletes are expected to try their best in all games, it is not taboo to have performance incentives built into their contracts and publicly disclosed.

nal prediction markets, including considerations of whom to include and the desired level of transparency in the market.

1.1. Background and literature review

The problem of providing incentives to CEOs that are in line with shareholders' interests is well established (Berle and Means, 1932; Jensen and Meckling, 1976). A common way to solve this agency problem is to provide CEOs with stock shares or options (Edmans, Gabaix, and Jenter, 2017; Hall and Liebman, 1998). This solution leads to several problems, such as increased risk-taking with stock options (see, e.g., Hall and Murphy, 2003). More recent research points to a new implication of managerial ownership of firm stocks. Von Lilienfeld-Toal and Ruenzi (2014) found that stocks of firms with high managerial ownership are often underpriced and yield excess risk-adjusted returns. Fahlenbrach (2009) reached similar conclusions based on founder-CEO firms.

Von Lilienfeld-Toal and Ruenzi (2014) put forward three potential explanations for this phenomenon. The first is that high ownership leads to mispricing as it incentivizes the CEO to invest in increasing the firm's value. The second explanation offers reverse causality; CEOs may exploit inside information regarding mispricing by increasing their holdings. Both these mechanisms lead to a positive correlation between high managerial ownership and firm value. Under rational expectations, however, market prices should adjust to reflect the high value. Thus, these explanations necessitate a departure from rationality, assuming that traders either fail to acknowledge the incentivizing effect of ownership, or else fail to incorporate the information revealed by the CEO's decision to own stocks.

The third explanation, which motivated this paper, argues that stocks are underpriced *in equilibrium* due to feedback effects resulting from moral hazard (Blonski and von Lilienfeld-Toal, 2013, 2019; Gorton, He, and Huang, 2014).[4] The reasoning is the following. The CEO can invest costly effort in order to increase the firm's value. If the stock is traded at a price that reflects this high value, the CEO is better off selling her shares and withholding effort. Thus, there is a critical equilibrium price, above which the CEO chooses low ownership and minimal effort, and below which the CEO prefers high ownership and high effort (Blonski and von Lilienfeld-Toal, 2019). Consequently, there does not exist an equilibrium in which the manager-owner exerts high effort and the market price reflects the stock's true value. However, equilibria exist, in which the value is higher than the equilibrium price, as shareholders maintain a low price to prevent the manager from selling. Holding shares at the market price, then, may lead to the excess returns documented in von Lilienfeld-Toal and

[4] See Bond, Edmans, and Goldstein (2012) for a survey of feedback effects in financial markets.

Ruenzi (2014).

This theoretical result stands in stark contrast to the efficient market hypothesis, which states that security prices fully reflect all the information in the market (Fama, 1970). If traders are Bayesian rational and form beliefs based on the observed market prices, in the resulting *Rational Expectation Equilibrium* (REE), market prices are the same as if all traders honestly and publicly reveal their private information (Radner, 1979). While there is ample evidence for "irrational" trading behavior or anomalies, markets remain nonetheless "amazingly successful devices for reflecting new information rapidly and, for the most part, accurately." (Malkiel, 2003, 2005). The existence of a fully revealing REE, however, results from the market acting as an independent unit that contains all the relevant information and incentives to trade on that information. When the market activity affects managerial decisions outside the market, the interplay of market forces and managerial decisions undermines the ability of the market to reveal information efficiently.

Our experiment relates to experimental studies of asset pricing where managerial decisions determine the asset's fundamental value endogenously. Jaworski and Kimbrough (2016) studied price bubbles in an asset market where the performance of a manager in an external market determines the fundamental value of the asset. They find the bubble and crash pattern typically found in experimental asset markets. Uncertainty regarding the managerial decision mitigated the moderating effect of experience on bubble creation. Pfeiffer and Shields (2015) studied an asset market where the fundamental value depends on risk and an endogenous managerial decision. The focus is on the extent to which the manager's choice of remuneration contract reveals private information and intentions. They find that market prices anticipate managerial decisions correctly and track the fundamental value well.

In these studies, there were no feedback effects, as market prices did not affect managerial decisions. Weber, Duffy, and Schram (2018) studied feedback effects between initial public offering (IPO) prices and subsequent market prices. The market is a dynamic bond market in which IPO prices affect the probability of default and, hence, the fundamental value of the bond. With experience, prices converge to the unique equilibrium price. Davis, Korenok, and Prescott (2014) and Davis and Prescott (2017) studied contingent capital with market-price triggers. In some of the experimental treatments, a regulator observes market prices and triggers conversions that affect the asset value. These feedback effects generated substantial mispricing. Similarly, Choo, Kaplan, and Zultan (2022) found that the traders who wish to misinform decision makers through price manipulation were able to generate some mispricing.

Closest to our experiment is the experiment by Bao et al. (2020), who explored the effects of allowing managers to trade an asset whose value depends on their de-

cisions. In their setting, however, the manager's compensation scheme created an incentive to purchase shares and exert high effort, as in our treatment without moral hazard, eliminating the feedback effects that are the focus of our study.

2. Theoretical analysis

Our model aims to account for both the competitive equilibrium in the market and the manager's strategic considerations.[5] On the market side, we define the competitive price given the manager's strategy at a level where no shareholder would want to trade. On the manager's side, we define the strategy that is the best response to the market price. In this section, we formalize these notions and characterize the resulting equilibria.[6]

We assume the following timeline following Blonski and von Lilienfeld-Toal (2019). First, the shareholders and manager trade in the firm's shares. We assume, as in Blonski and von Lilienfeld-Toal (2019), that the manager chooses a number of shares to hold $\omega \in [\underline{\omega}, \bar{\omega}]$ based on the market price. Next, the manager chooses her effort level $e \geq 0$. Higher effort increases the value of the firm's share $v(e) = \underline{v} + e\Delta v$, where $\Delta v > 0$ is the marginal effect of each unit of effort. The cost of effort is given by $c(e)$, where $c'(e) > 0, c''(e) > 0$, for all $e > 0, c'(0) < \underline{\omega}\Delta v$, and there exists an e such that $c'(e) > \bar{w}\Delta v$. Finally, the shares pay the dividend $v(e)$ that depends upon the effort.

Looking more explicitly at the manager's problem, given the market price p, the manager chooses ω and e to maximize the following objective function:

$$U(e, \omega, p) = \omega \cdot (\underline{v} + e\Delta v) + p \cdot (\alpha - \omega) - c(e), \tag{1}$$

where α is the manager's initial ownership. By our model's timing, in principle, the manager first chooses ω and then chooses an effort e based upon ω. However, we can think of these two being chosen simultaneously. We assume that the manager chooses a mixed strategy $\sigma_{\omega,e} \in \Delta(W \times E)$.

In our model, shareholders want to maximize trading profits given their beliefs v^* about the expectation of the value $v(e)$ given the strategy of the manager $\sigma_{\omega,e}$. While we still have not defined equilibrium, we say that shareholders also hold off-equilibrium

[5] Blonski and von Lilienfeld-Toal (2023) pose a specific trading mechanism and characterize the Nash equilibria in the resulting game.

[6] Our solution concept is similar in flavor to the Kyle model (Kyle, 1985), which is also a hybrid solution concept combining game-theoretical best-response analysis and competitive supply-demand equilibrium. In the Kyle model, the informed trader strategically maximizes profits, while the market maker sets prices by balancing supply and demand. Similar to our approach, this dual framework captures both the strategic interactions of market participants and the aggregate price-setting mechanism, bridging individual behavior with market outcomes.

beliefs v_b^*, v_s^* about the expected value of $v(e)$ contingent upon whether they buy or sell a share (where $v_b^* \leq v^* \leq v_s^*$).

We can now define an equilibrium where there is a price p^* such that the shareholders would not want to trade based on their beliefs about the manager's strategy, which is consistent with the manager's actual strategy. In addition, the manager's strategy must be optimal given the price p^*

Definition 1. *A* $(\sigma_{\omega,e}^*, p^*, v^*, v_b^*, v_s^*)$ *forms an* **equilibrium** *of the game iff:*

1. *All* ω^*, e^* *in the support of* $\sigma_{\omega,e}^*$ *maximize* $U(e, \omega, p^*)$.
2. *Given* $(\sigma_{\omega,e}^*, p^*, v^*, v_b^*, v_s^*)$*, no shareholder wishes to buy or sell.*
3. *Beliefs are consistent with* $\sigma_{\omega,e}^*$*, that is,* $v^* = E[v(e)|\sigma_{\omega,e}^*]$*, and* $\min_{e \in Supp(\sigma_{\omega,e}^*)} v(e) \leq v_b^* \leq v^* \leq v_s^* \leq \max_{e \in Supp(\sigma_{\omega,e}^*)} v(e)$.

2.1. Equilibrium analysis

We can now begin to characterize what an equilibrium would look like. Since the manager's strategy is optimal given the asset price p, we can start eliminating strategies that she would not use. In particular, the following Lemma shows the manager would choose a corner solution in share ownership (or mix over the two corner solutions).

Lemma 1. *The manager will choose either* $\omega = \underline{\omega}$ *or* $\omega = \bar{\omega}$.

Proof. The proof is by contradiction. Assume that the manager optimally chooses ownership level $\hat{\omega} \in (\underline{\omega}, \bar{\omega})$ and corresponding effort $\hat{e}$. Since U is linear in ω, the manager will only choose $\hat{\omega} \in (\underline{\omega}, \bar{\omega})$ if $p = \underline{v} + \hat{e}\Delta v$ so that the manager is indifferent between different levels of ω for effort level $\hat{e}$. In particular, $U(\hat{e}, \hat{\omega}, p) = U(\hat{e}, \bar{\omega}, p)$.

Take $\bar{e}$ as the optimal effort for $\bar{\omega}$. For $\bar{e}$ and $\hat{e}$, the FOCs imply $c'(\bar{e}) = \bar{\omega}\Delta v$ and $c'(\hat{e}) = \hat{\omega}\Delta v$. Since $c'' > 0$ and $\bar{\omega} > \hat{\omega}$, then $\bar{e} > \hat{e}$. Consider the following difference between two payoffs of the manager: $U(\bar{e}, \bar{\omega}, p) - U(\hat{e}, \bar{\omega}, p)$. Substituting as in Equation (1) and rearranging, we obtain $c'(\bar{e})(\bar{e} - \hat{e}) + c(\hat{e}) - c(\bar{e})$. This expression is strictly positive as $c'(e)$ is increasing in e, implying that $c'(\bar{e})$ is greater than the average slope between $\hat{e}$ and $\bar{e}$. Thus, $U(\bar{e}, \bar{\omega}, p) > U(\hat{e}, \bar{\omega}, p) = U(\hat{e}, \hat{\omega}, p)$ in contradiction to $\hat{e}$ and $\hat{\omega}$ being an optimal choice for the manager. □

This next Lemma shows that there is a unique price of shares that causes the manager to be indifferent between owning and not owning shares (the two corner solutions).

Lemma 2. *There is a unique critical price*

$$\tilde{p} = \underline{v} + \Delta v \frac{\bar{\omega}\bar{e} - \underline{\omega}\underline{e}}{\bar{\omega} - \underline{\omega}} - \frac{c(\bar{e}) - c(\underline{e})}{\bar{\omega} - \underline{\omega}}, \tag{2}$$

for which the manager is indifferent between ownership $\underline{\omega}$ with corresponding optimal effort $\underline{e}$ and ownership $\bar{\omega}$ with corresponding optimal effort $\bar{e}$. For prices strictly below $\tilde{p}$, the manager prefers owning $\bar{\omega}$. For prices strictly above $\tilde{p}$, the manager prefers owning $\underline{\omega}$.

Proof. The price $\tilde{p}$ is the price that is the solution of $U(\bar{e}, \bar{\omega}, p) = U(\underline{e}, \underline{\omega}, p)$. It exists (and is unique) since $U(\bar{e}, \bar{\omega}, 0) > U(\underline{e}, \underline{\omega}, 0)$ and for large enough price $\bar{p}$, we have $U(\bar{e}, \bar{\omega}, \bar{p}) < U(\underline{e}, \underline{\omega}, \bar{p})$. Finally, $\frac{\partial U(\underline{e},\underline{\omega},p) - U(\bar{e},\bar{\omega},p)}{\partial p} = \bar{\omega} - \underline{\omega}$, so the difference is continuously increasing by a constant amount. □

Our next Lemma shows that there is a unique probability of mixing by the manager that causes the expected value of the firm to equal the price $\tilde{p}$ where the manager is indifferent.

Lemma 3. *There exists a unique mixing probability of the manager $\tilde{q} \in (0,1)$ such that*

$$\tilde{p} = E[v(e)|\tilde{q}] = \tilde{q}v(\bar{e}) + (1 - \tilde{q})v(\underline{e})$$

where

$$\tilde{q} = \frac{\tilde{p} - \underline{v} - \underline{e}\Delta v}{(\bar{e} - \underline{e})\Delta v}.$$

Proof. First note that we have $v(\bar{e}) > \tilde{p}$ and $v(\underline{e}) < \tilde{p}$. This is shown as follows. From Lemma 2, for any price $p < \tilde{p}$, the manager chooses high ownership $\bar{\omega}$ and high effort $\bar{e}$. The share value at the high ownership $v(\bar{e}) = \underline{v} + \bar{e}\Delta v$ is strictly higher than the price $\tilde{p}$. We see this by rewriting (2) as

$$\begin{aligned}\tilde{p} &= \underline{v} + \Delta v\bar{e} + \Delta v \frac{\underline{\omega}\bar{e} - \underline{\omega}\underline{e}}{\bar{\omega} - \underline{\omega}} - \frac{c(\bar{e}) - c(\underline{e})}{\bar{\omega} - \underline{\omega}} \\ &= v(\bar{e}) + \frac{\Delta v\underline{\omega}\bar{e} - c(\bar{e}) - (\Delta v\underline{\omega}\underline{e} - c(\underline{e}))}{\bar{\omega} - \underline{\omega}}.\end{aligned}$$

However, since $\underline{e}$ is the optimal effort for $\underline{w}$, we have $\Delta v\underline{\omega}\bar{e} - c(\bar{e}) < \Delta v\underline{\omega}\underline{e} - c(\underline{e})$. Likewise, we can show $v(\underline{e}) < \tilde{p}$. Hence, there exists a unique $\tilde{q}$ such that $\tilde{p} = E[v(e)|\tilde{q}] = \tilde{q}v(\bar{e}) + (1 - \tilde{q})v(\underline{e})$.

We can derive $\tilde{q}$ in terms of $\tilde{p}$ using $\tilde{p} = \tilde{q}v(\bar{e}) + (1 - \tilde{q})v(\underline{e}) = \tilde{q}(\underline{v} + \bar{e}\Delta v) + (1 - \tilde{q})(\underline{v} + \underline{e}\Delta v)$ and solving for $\tilde{q}$. □

We now can use Lemmas 1, 2, and 3 to characterize the equilibrium.

Proposition 1. *In equilibrium, the price is $p^* = \tilde{p}$, the manager chooses $\bar{\omega}, \bar{e}$ with probability q^* where $1 > q^* \geq \tilde{q}$ and otherwise chooses $\underline{\omega}, \underline{e}$.*

Proof. First, we prove that $p^* = \tilde{p}$. If $p^* > \tilde{p}$, then the manager would want to sell if $\omega > \underline{\omega}$ (from Lemma 2). If $p^* > \tilde{p}$ and $\omega = \underline{\omega}$, then shareholders would want to sell since then $e = \underline{e}$ and $v(\underline{e}) < p^*$. If $p^* < \tilde{p}$, then the manager would want to buy if $\omega < \bar{\omega}$. If $p^* < \tilde{p}$ and $\omega = \bar{\omega}$, then shareholders would want to buy since then $e = \bar{e}$ and $v(\bar{e}) > p^*$.

Second, we prove that $1 > q^* \geq \tilde{q}$. We know that $p^* = \tilde{p}$ from the first part of the proof. If $q^* < \tilde{q}$, then we would have $v^* = E[v(e)|\sigma^*_{\omega,e}] < p^*$ and a shareholder would desire selling (note that even if a shareholder holds multiple shares, selling would not lower the value of the remaining shares). If $q^* = 1$, then a shareholder would wish to buy. The shareholder would believe that he/she would not be buying from the manager since the manager, in equilibrium, owns with certainty. Hence, the only possible values of q^* are $1 > q^* \geq \tilde{q}$.

Finally, $q^* = \tilde{q}$ is supported since the shareholders are indifferent to buying and selling shares (given their beliefs are that they are trading with other shareholders with $v^*_b = v^*_s = v^*$). Also, $1 > q^* > \tilde{q}$ is supported in equilibrium since (i) no shareholder would want to sell since $v^* = E[v(e)|\sigma^*_{\omega,e}] > p^*$, and (ii) no shareholder would want to buy if $v^*_b \leq p^*$. Since $(\underline{\omega}, \underline{e})$ is in the support of $\sigma^*_{\omega,e}$, then it is consistent with an off-equilibrium belief that $v^*_b = v(\underline{e})$. □

2.2. Equilibrium excess returns

We can refer to the equilibrium where $q^* = \tilde{q}$ as a *revealing equilibrium*, in which the market price matches the expected asset value according to the shareholders' beliefs. In contrast, whenever $q^* > \tilde{q}$, the price does not reflect the expected asset value. Accordingly, unconditional investments in the stock at the market price are profitable. We refer to this phenomenon as *ex-ante* excess returns. We also consider *ex-post* excess returns, referring to mispricing conditional on high ownership. Such *ex-post excess returns* occur even when $q^* = \tilde{q}$. In this case, the value of the stock is, on average, equal to its price. However, stocks of firms where the realization of the manager's strategy leads to high ownership are under-priced while the other stocks are over-priced. Recall that von Lilienfeld-Toal and Ruenzi (2014) found excess returns conditional on high ownership. However, the dynamic nature of the stock exchange makes it impossible to clearly separate the trading stage from the manager's decisions, which may have a lagged effect. Whether the excess returns observed in the field best map to ex-ante or ex-post excess returns in our theoretical and experimental settings is thus equivocal. In the following we, therefore, test and report both types of excess returns.

3. Experimental design and procedure

3.1. Parameters and treatments

We ran four experimental treatments varying in moral hazard, effort costs, and disclosure. We start by describing our core treatment, labeled DIS25, to reflect the disclosure policy and effort costs of 25, followed by the additional three treatments. Each of these treatments varies one aspect of the design with respect to DIS25. Table 1 summarizes the different treatments.[7]

DIS25. In equilibrium, the manager chooses either minimal or maximal ownership. We, therefore, implement a simple setting with binary effort and value. We set the parameters to be $\underline{v} = 20$, $e \in \{0,1\}$, $\Delta v = 80$, $c(0) = 0$, $c(1) = 25$. Let $\bar{v} = \underline{v} + \Delta v = 100$. We refer to effort levels of 0 and 1 as *high* and *low* effort, respectively. The managerial ownership is also binary, as the manager can only own one share ($\bar{\omega} = 1$) or no shares ($\underline{\omega} = 0$). Figure 1, adapted from Blonski and von Lilienfeld-Toal (2019), presents the share value as a function of the market price. At a price of $\tilde{p} = \bar{v} - c(1) = 75$, the manager is indifferent between owning a share and choosing high effort on the one hand and selling the share and choosing low effort on the other hand. At lower prices, the manager prefers high ownership and effort, leading to the high share value of 100. At higher prices, the manager prefers selling and choosing low effort, leading to the low share value of 20. The equilibrium region is at a price of 75 and share value in $[75, 100]$, marked by short dashes. To implement the disclosure policy, the trading screen indicates throughout the trading period whether the manager currently owns a share or not.

NMH25 (no moral hazard). To establish the role of moral hazard in setting prices, we ran a control treatment without moral hazard. In this treatment, the manager has one non-tradable share, and is thus always incentivized to exert effort, effectively eliminating the moral hazard problem. There is disclosure in the NMH25 treatment in the sense that shareholders always know that the manager owns one stock (or more), although they do not receive real-time information about managerial transactions as in the disclosure treatments. Without moral hazard, the manager always chooses high effort in equilibrium. Accordingly, the equilibrium price is 100. The manager is indifferent between owning or selling a share at the equilibrium price. Hence, the theory has no prediction with regard to the manager's strategy.

[7] The experimental design and analysis are preregistered on AsPredicted.org, pre-registration #34494. The DIS40 treatment is not part of the pre-registration, as we added it after observing the results from the other three treatments.

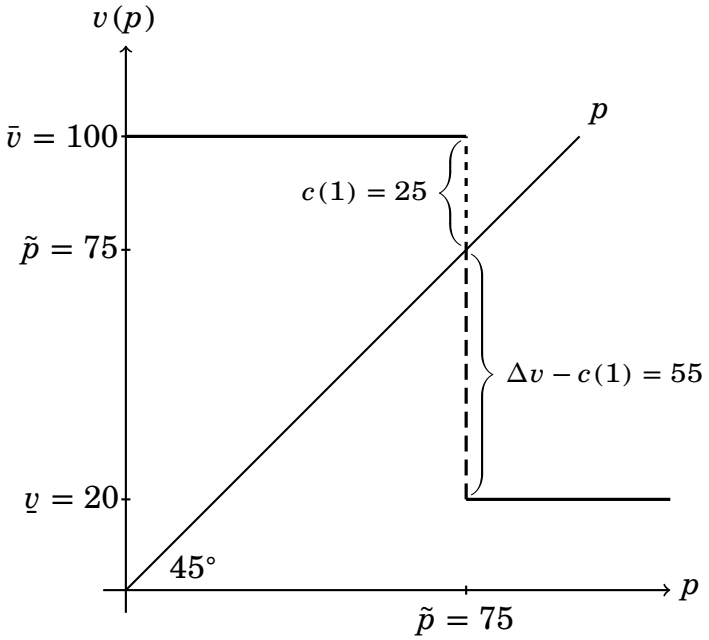


Figure 1: Share value and market price.

Notes: The figure shows the share value as a function of the market price. $v(p)$ denotes $v(e^*(\omega(p)))$, where $\omega(p)$ is the manager's optimal ownership given the price p.

NoDIS25 (no disclosure). The No-disclosure treatment is identical to DIS25 with the exception that shareholders are not informed in real time about the current managerial ownership.

DIS40. The DIS40 treatment is identical to DIS25 with the exception that the manager's effort costs are increased to 40. The equilibrium price $\tilde{p}$ is accordingly $100 - 40 = 60$, and the critical value for the manager's strategy is $\tilde{q} = .50$.

3.2. Experimental procedure

The experiment was conducted at the Southwestern University of Finance and Economics in China in May, June, and September 2021 and December 2023.[8] The student subjects were recruited from the laboratory's subject pool. The experiment was programmed with z-Tree Fischbacher (2007). At the end of each session, two periods were randomly chosen for payment. Payoffs were converted to cash at the rate of 100 ECU equals 5 Yuan and added to a show-up payment of 10 Yuan. The aver-

[8]We ran a pilot session for the DIS40 treatment in Israel in early 2020, which resulted in ex-ante excess returns. Due to the COVID-19 pandemic, we ran the main sessions for the DIS25, NODIS25, and NMH treatments in China during 2021. We changed the effort costs in the new sessions to avoid having the equilibrium price at exactly the midpoint of the high and low redemption values. We added sessions for the DIS40 treatment in 2023 to test whether lowering the equilibrium price compared to the DIS25 treatment leads to ex-ante excess returns, as in the pilot session.

Table 1: Experimental treatments.

Treatment	Effort costs	Disclosure	Managerial holding	Equilibrium price ($\tilde{p}$)	Equilibrium strategy ($\tilde{q}$)	Number of groups
DIS25	25	Yes	$\omega \in \{0,1\}$	75	0.69	20
NMH25	25	Yes	$\omega \in \{1,2\}$	100	–	8
NoDIS25	25	No	$\omega \in \{0,1\}$	75	0.69	20
DIS40	40	Yes	$\omega \in \{0,1\}$	60	0.50	20

Notes: Each group consisted of three shareholders and one manager. Disclosure indicates that shareholders know whether the manager holds one share or not during the market stage. The manager incurs the "Effort cost" for choosing the high effort.

age final payoff was 74.92 Yuan (approximately 11 USD) with a standard deviation of 9.82 Yuan.

Participants in each session were randomly allocated to groups of four and assigned the roles of manager and three shareholders. These roles remained fixed across 25 periods, each including a *market stage* followed by a *decision stage*.[9] The following describes the experimental procedures for the two stages. See the appendix for the experimental instructions and screenshots.

Market stage Each of the three shareholders is endowed with 400 ECU (Experimental Currency Units) and three shares. The manager is endowed with 100 ECU and one unit of the share and is restricted to owning no more than one share at any time. In the NMH25 treatment, the manager holds one additional non-tradable share. To equalize initial wealth across treatments and roles, the manager receives an additional sum of 500 ECU not available for trade (400 ECU and the non-tradable share in the NMH25 treatment). Trade takes place using the double-auction mechanism. Each trader can place or amend her ask and bid prices at any time during the trading period of 100 seconds, as well as accept any standing ask or bid. Once an offer is accepted, the transaction takes place. The transaction price is registered and announced on screen in a transaction list and in a graph displaying prices over time. In the Disclosure treatments only, the trading screen includes a real-time indication of whether the manager currently owns a share or not.

Decision stage In the decision stage, the manager makes a binary effort choice to determine the redemption value of the shares. If the manager chooses *normal* effort, each share is redeemed at 20 ECU. If the manager chooses *high* effort, each share is

[9]Due to a computer failure, one matching group in the DIS25 treatment proceeded with two shareholders and one manager.

redeemed at 100 ECU for the manager. The redemption value for the shareholders is randomly drawn from an iid uniform distribution over the integers in $[95, 105]$. This variation serves to induce trade without affecting the equilibrium price, which only depends on the manager's redemption value. At the same time, the shareholders are asked to guess the manager's decision on an 11-point scale and are paid according to a quadratic scoring rule.[10] After all participants have made their choices, the computer provides feedback on the final inventory and capital of the participant, the manager's effort choice, and the participant's payoffs from the market and from the guess (if shareholder).

3.3. Hypotheses

Our first three hypotheses reflect the equilibrium analysis with respect to market price and ex-ante and ex-post excess returns.

Hypothesis 1 (Market price)**.** *Market prices converge to the equilibrium prediction.*

Hypothesis 2 (Ex-ante excess returns)**.** *The average share value resulting from the managers' effort decisions is weakly higher than the price. Ex-ante excess returns exist if the share value is strictly higher than the observed price*

Hypothesis 3 (Ex-post excess returns)**.** *The average share value conditional on a manager holding a share in the treatments with moral hazard is strictly higher than the equilibrium price.*

In the REE, the shareholders rationally anticipate the probability that the manager owns a share at the decision stage. The analysis thus does not discriminate between the Disclosure and Non-Disclosure treatments.[11] In contrast, if we assume that traders update their beliefs dynamically and myopically based on the currently available information, price cycles should emerge, as discussed in the introduction (see, e.g., the dynamic myopic updating model in Choo, Kaplan, and Zultan, 2019).

[10] For example, a response of 10 (on a scale of 1–10) should be interpreted as a certainty that the manager exerts high effort and yields a bonus of 100 ECU if correct and 0 ECU otherwise, and vice versa for a response of 0. Assuming risk neutrality, a response of 7 should be interpreted as a belief that the manager chooses high effort with probability 70%, and yields a bonus of $100 - 7^2 = 51$ ECU if the manager chooses low effort, and $100 - (10 - 7)^2 = 91$ ECU if the manager chooses high effort.

[11] In the Disclosure treatments, the shareholders directly observe the managerial ownership, hence the price may also react to the ownership. Nonetheless, disclosure does not affect the equilibrium analysis, considering that the manager may accept an outstanding bid or ask in the last few seconds, leaving no time for further trade. Indeed, the managers in the disclosure treatments made transactions in the last five seconds of the round in 22.0% of the rounds (25.0% of rounds that included at least one transaction), significantly more than in the Non-Disclosure treatment ($\chi^2(1) = 5.47, p = .019$ based on a logistic regression that includes differential time trends by treatment and robust standard errors clustered on groups).

We test the existence of such dynamics in the following hypotheses, which compare the Disclosure and Non-Disclosure treatments.[12]

Hypothesis 4 (Price cycles)**.** *Managers sell and repurchase the share more times with disclosure.*

Hypothesis 5 (Managerial transactions)**.** *The difference between the manager's average buying and selling price is higher in the Disclosure treatments.*

One implication of Hypothesis 5 is that the trade cycles in the Disclosure treatments serve as a money pump, channeling funds from the shareholders to the managers, as stated in Hypothesis 6.

Hypothesis 6 (Money pump)**.** *Manager earnings are higher with compared to without Disclosure and are positively correlated with the number of trade cycles.*

4. Experimental results

This section is organized as follows. We start by testing convergence to equilibrium, first looking at market prices across treatments, followed by managerial ownership. The next subsection look at effort decisions. The fourth subsection puts together prices, ownership, and effort to study ex-ante and ex-post excess returns. We conclude with an analysis of price cycles and money pumps under disclosure, with the no-disclosure treatment as a benchmark. All of the regressions reported in this section are mixed-effects linear regressions with random effects for matching groups and robust standard errors clustered on matching groups. See the appendix for the full regression tables.

4.1. Market prices

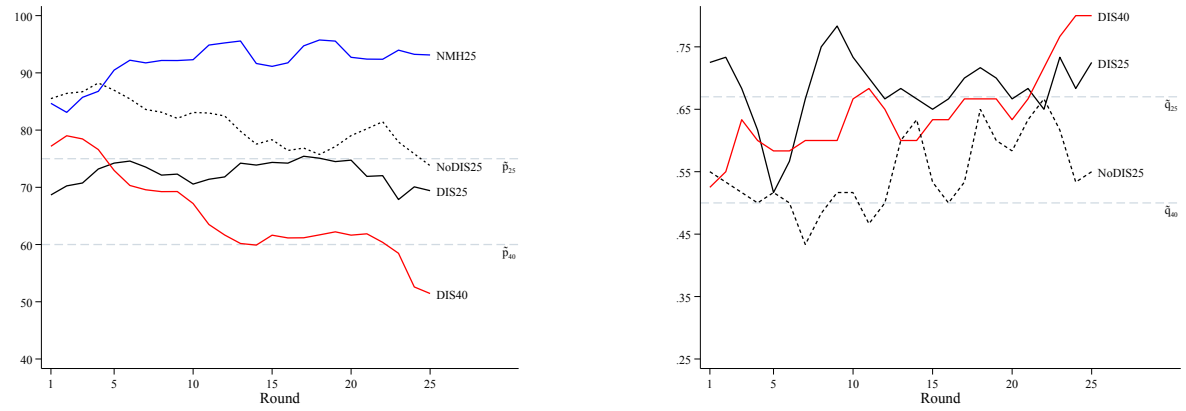
For each round and group, we define the *market price* as the mean transaction price.[13] Panel A of Figure 2 presents the three-round moving average of market prices for each treatment.[14] The horizontal lines indicate the corresponding equilibrium price ($p^* = \tilde{p}$). Table 2 presents results from a series of regression of prices on treatments by

[12] Our preregistered hypothesis predicted the existence of price cycles but also stated that the expectation was that price cycles reduce efficiency.

[13] The average number of transactions per round in the DIS25, DIS40, NoDIS25, and NMH treatments are 2.95, 2.75, 2.99, and 3.42, respectively. Using the median instead of the mean transaction price does not alter the results. The analysis excludes rounds without transactions, which account for 15%, 11%, 26%, and 3% of rounds in the NoDIS25, DIS25, DIS40, and NMH25 treatments, respectively.

[14] Each point in the plot represents the average of the market price for that round, the previous round (except for in period 1), and the subsequent round (except for in period 25).

A. Market price. *B. Managerial ownership.*



Notes: Market prices (Panel A) and share of managers owning a share at the end of trade (Panel B). Plots present running averages across three periods. The horizontal dashed lines in Panel A mark the equilibrium prices in the DIS25 and NoDIS25 treatments ($\tilde{p}_{25}$) and the DIS40 treatment ($\tilde{p}_{40}$). The horizontal dashed lines in Panel B mark the critical values in the DIS25 and NoDIS25 treatments ($\tilde{q}_{25}$) and the DIS40 treatment ($\tilde{q}_{40}$).

Figure 2: Market prices and managerial ownership.

blocks of 5 rounds and for all rounds. Several observations are immediately apparent. First, market prices in DIS25 are strikingly close to the predicted equilibrium price of 25 across the whole experiment. Prices in the NMH25 are significantly higher, despite remaining below the predicted price of 100, establishing the role of moral hazard in driving prices to the theoretical equilibrium levels. Without disclosure, prices are significantly higher than the equilibrium price in the first ten periods, but later converge to equilibrium levels in the last ten periods. Thus, we find that disclosure facilitates convergence to equilibrium. Market prices in DIS40 are not significantly different from those in DIS25 in the first ten rounds, but then converge towards the equilibrium price of 60. We summarize these observations in our first result.

Result 1. *Market prices converge to the equilibrium, in line with Hypothesis 1, especially with disclosure and as traders gain experience. Manipulating the effort costs has the predicted effect on market prices.*

4.2. Managerial ownership

A manager is said to have SKIN in the game if she holds at least one share at the end of market stage of the round. In such cases, it is optimal for the manager to choose high effort. We refer to such managers and rounds as SKIN managers and SKIN rounds, respectively. Panel B of Figure 2 presents the three-round moving average frequency of SKIN managers in the DIS25, DIS40, and NoDIS25 treatments, with dashed lines indicating the respective $\tilde{q}$ thresholds. The NMH25 treatment is omitted, as any level

Table 2: Within-and-between treatment comparison of market prices.

	Blocks of 5 Rounds					All
	1-5	6-10	11-15	16-20	20-25	Rounds
A. *Predicted margins*						
DIS25 ($\tilde{p} = 75$)	71.40 (3.28)	73.64 (4.11)	71.83 (3.63)	73.75 (2.62)	70.35 (3.14)	72.12 (3.04)
DIS40 ($\tilde{p} = 60$)	76.77*** (3.91)	69.93** (4.65)	57.48 (5.17)	62.08 (5.74)	56.25 (4.97)	66.28* (3.74)
NoDIS25 ($\tilde{p} = 75$)	87.10*** (3.19)	82.81** (3.43)	80.33 (3.29)	75.84 (3.48)	76.14 (3.62)	81.01** (3.04)
NMH25 ($\tilde{p} = 100$)	86.02*** (3.28)	92.17*** (2.88)	93.23** (3.38)	93.86** (2.81)	92.33** (3.31)	91.49*** (2.57)
B. *Between-treatment comparisons: χ^2 statistics*						
DIS25 vs. **DIS40**	1.01	0.36	5.15**	3.41*	5.48**	1.46
DIS25 vs. **NoDIS25**	10.47***	2.93*	3.00*	0.23	1.61	4.27**
DIS25 vs. **NMH25**	8.87***	13.65***	18.54***	27.25***	24.01***	23.59***
n	324	312	286	264	251	1,437

Notes: Statistics based on mixed-effects linear regressions of prices on treatment with random effects for matching groups and robust standard errors clustered on matching groups. Each column reports a separate regression for the given rounds. Panel A shows the predicted margins with robust standard errors in parentheses and significance stars for the comparison with the equilibrium price $\tilde{p}$. Panel B reports the χ^2 statistics for the between-treatment comparisons. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 3: Within-and-between treatment comparison of managerial ownership.

	Blocks of 5 Rounds					All
	1-5	6-10	11-15	16-20	20-25	Rounds
A. *Predicted margins*						
DIS25 ($\tilde{q} \approx .69$)	0.66 (0.05)	0.71 (0.05)	0.65 (0.05)	0.71 (0.07)	0.68 (0.04)	0.68 (0.04)
DIS40 ($\tilde{q} = .50$)	0.57 (0.05)	0.60 ** (0.04)	0.64 ** (0.05)	0.66 ** (0.07)	0.75 *** (0.04)	0.64 *** (0.03)
NoDIS25 ($\tilde{q} \approx .69$)	0.52 *** (0.05)	0.50 *** (0.05)	0.56 *** (0.05)	0.53 *** (0.05)	0.62 (0.05)	0.55 *** (0.03)
B. *Between-treatment comparisons: χ^2 statistics*						
DIS25 vs. **DIS40**	1.39	2.32	0.02	0.32	1.68	0.62
DIS25 vs. **NoDIS25**	3.75*	7.19***	1.62	6.39**	0.62	9.51***
n	300	300	300	300	300	1,500

Notes: Statistics based on mixed-effects linear regressions of SKIN on treatment with random effects for matching groups and robust standard errors clustered on matching groups. Each column reports a separate regression for the given rounds. Panel A shows the predicted margins with robust standard errors in parentheses and significance stars for the comparison with the equilibrium critical value $\tilde{q}$. Panel B reports the χ^2 statistics for the between-treatment comparisons. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

of ownership is consistent with equilibrium. Table 3 presents results from a series of regressions of SKIN on treatments by blocks of 5 rounds and for all rounds.

In DIS25, managerial ownership is close to the predicted lower bound $\tilde{q}$ throughout the experiment. The results for NoDIS25 show that, without disclosure, managers are less likely to own a share at the end of trade compared to the equilibrium prediction. Thus, as with market prices, disclosure facilitates convergence to equilibrium.

Taken together, the market prices and managerial ownership in DIS25 correspond to the equilibrium without excess returns. Thus, they support the equilibrium analysis, but are also consistent with the alternative hypothesis that prices necessarily reflect asset values. For a more stringent test of the theory, we introduced the DIS40 treatment. The reasoning behind the additional treatment is the following. The equilibrium analysis imposes a lower bound on managerial ownership without pinning down a point prediction. Assume that there is some market sentiment that determines an aspiration level for managerial ownership, possibly resulting from noisy trading behavior or from the manager's social preferences. Ownership reaches this aspiration level as long as it surpasses the lower bound $\tilde{q}$ and otherwise matches it. In this view, a price of $\tilde{p} = 75$ indicates that the aspiration level is below, and possibly close to $\tilde{q}_{25}$. Accordingly, higher effort costs of 40 necessarily reduce the equilibrium price $\tilde{p}$ but do not necessarily affect managerial ownership by reducing $\tilde{q}$. The results support this prediction. While Market prices in DIS40 are significantly lower than in DIS25 after an initial learning period, the share of SKIN managers remains similar across the two treatments in all rounds. We summarize in the next result.

Result 2. *Managerial ownership is in line with the revealing equilibrium in DIS25. Increasing the effort costs does not significantly affect managerial ownership, which corresponds to an excess-returns equilibrium in DIS40. Without disclosure, ownership levels reject the equilibrium prediction.*

4.3. Effort

Managers should optimally choose high effort if they have at least one share and low effort otherwise. Table 4 presents the shares of managers choosing high effort by treatment and SKIN. Managers who end up not owning a share almost always choose low effort, while SKIN managers predominantly choose high effort. We see, however, somewhat lower effort levels in NMH25 and DIS40. Without moral hazard, the incentives to choose high effort are weaker when owning one share compared to two shares. Effort levels by ownership suggest that managers erroneously believed that low effort is optimal with (relatively) low ownership, as managers who end up owning just one share chose high effort 81% of the time compared to 90.5% when owning two shares. In DIS40, the benefit from high effort when owning a share is only 40 com-

Table 4: Shares of managers choosing high effort.

	SKIN		
	No	Yes	Overall
DIS25	0.6% (n=159)	95.5% (n=341)	65.0% (n=500)
DIS40	0.6% (n=178)	83.2% (n=322)	53.8% (n=500)
NoDIS25	2.2% (n=227)	91.9% (n=273)	51.2% (n=500)
NMH25	–	85.5% (n=200)	85.5% (n=200)

Notes: A manager has *skin in the game* if she ends the market with at least one stock. Each cell reports the frequency of managers choosing *high* effort with the number of observations in parenthesis.

pared to 55 in DIS25, which may explain the relatively lower effort levels. See the Appendix for effort levels for the individual managers and an analysis of shareholders' beliefs regarding managerial effort.

Result 3. *Managers generally choose effort optimally given their ownership. Effort levels are somewhat lower without moral hazard and with high effort costs.*

4.4. Excess returns

As established in Results 1 and 2, market prices and manager ownership in the disclosure treatments DIS25 and DIS40 are consistent with equilibrium behavior. They, furthermore, correspond to equilibria with no excess returns in DIS25 and with excess returns in DIS40. We turn now to a direct analysis of *ex-ante* and *ex-post* excess returns in these treatments.

Ex-ante excess returns. To test Hypothesis 2, we calculated π as the realized stock value (20 or 100) minus the market price in each round.[15] A positive π indicates that the market price is below the realized value, whereas a negative π suggests that the market price exceeds the realized value. Panel A in Table 5 presents the estimated values of π based on a series of regressions with treatment as independent variable by blocks of 5 rounds and for all rounds. Consistent with Results 1 and 2, π is not significantly different from zero in DIS25. Somewhat surprisingly, it is also not significantly higher than zero in DIS40. Thus, although the share of SKIN managers exceeds $\tilde{q}$ in this treatment, the non-negligible share of SKIN managers who choose low effort means that the overall share of high-effort choices is not statistically distinguishable from $\tilde{q}$.

[15] π is undefined for rounds where no transaction occur.

Table 5: Excess returns.

	Blocks of 5 Rounds					All
	1-5	6-10	11-15	16-20	20-25	Rounds
A. *Ex-ante excess returns: π all rounds*						
DIS25	−1.76	−0.08	−4.70	−3.10	−4.42	−2.54
	(4.53)	(6.17)	(6.72)	(5.47)	(5.01)	(4.17)
DIS40	−18.11***	−10.49	−4.20	−9.29	0.18	−9.66*
	(6.66)	(6.81)	(8.24)	(7.97)	(5.81)	(4.89)
NoDIS25	−28.02***	−24.97***	−23.07***	−24.11***	−24.66***	−24.92***
	(5.10)	(5.50)	(5.13)	(4.30)	(6.90)	(2.83)
NMH25	−6.95	−4.17	−3.23	−3.43	−0.88	−3.65
	(7.42)	(3.70)	(4.30)	(2.93)	(1.21)	(2.53)
n	324	312	286	264	251	1,437
B. *Ex-post excess returns: π in SKIN managers rounds.*						
DIS25	25.92***	25.40***	25.45***	28.50***	30.70***	27.88***
	(4.53)	(5.44)	(5.03)	(3.21)	(3.88)	(3.56)
DIS40	15.97***	32.36***	32.11***	27.39***	23.79**	24.77***
	(5.62)	(4.69)	(8.17)	(7.77)	(9.09)	(4.53)
NoDIS25	10.16**	16.35***	18.15***	15.13**	13.43*	15.25***
	(3.65)	(2.85)	(3.57)	(5.10)	(5.87)	(2.58)
NMH25	−7.09	−4.17	−3.23	−3.55	−0.90	−3.66
	(7.49)	(3.72)	(4.32)	(2.97)	(1.20)	(2.52)
n	199	193	171	154	156	873

Notes: Statistics based on mixed-effects linear regressions of π on treatment with random effects for participants. Each column in Panels A and B reports a separate regression for the mentioned rounds. Each cell denotes the estimated π with robust standard errors in parentheses and significance stars for the comparison against 0. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Result 4. *Average prices match the mean asset value. With high effort costs, excess returns would emerge if effort choices were optimal given the market stage outcomes.*

Ex-post excess returns. Markets are typically successful in predicting future events. Do market prices in the experiment predict the realization of the manager's strategy? The lack of ex-ante excess returns in DIS25 and DIS40 is consistent with the hypothesis that prices correspond to the realized asset value ex post. If, on the other hand, prices are not correlated with ownership, they should be lower than the asset's value *conditional on high ownership*. In other words, there are ex-post excess returns as stated in Hypothesis 3.

Figure A5 in the appendix shows that market prices are not correlated with managerial ownership. Panel B in Table 5 replicates the results of Panel A for SKIN rounds only. The values of π are significantly higher than zero for all three moral-hazard treatments and all blocks, but not in the NMH25 treatment. These results indicate that, as predicted, strong ex-post excess returns emerge due to moral hazard.

Result 5. *Market prices are not predictive of managerial ownership, resulting in ex-post excess returns in the disclosure treatments with moral hazard.*

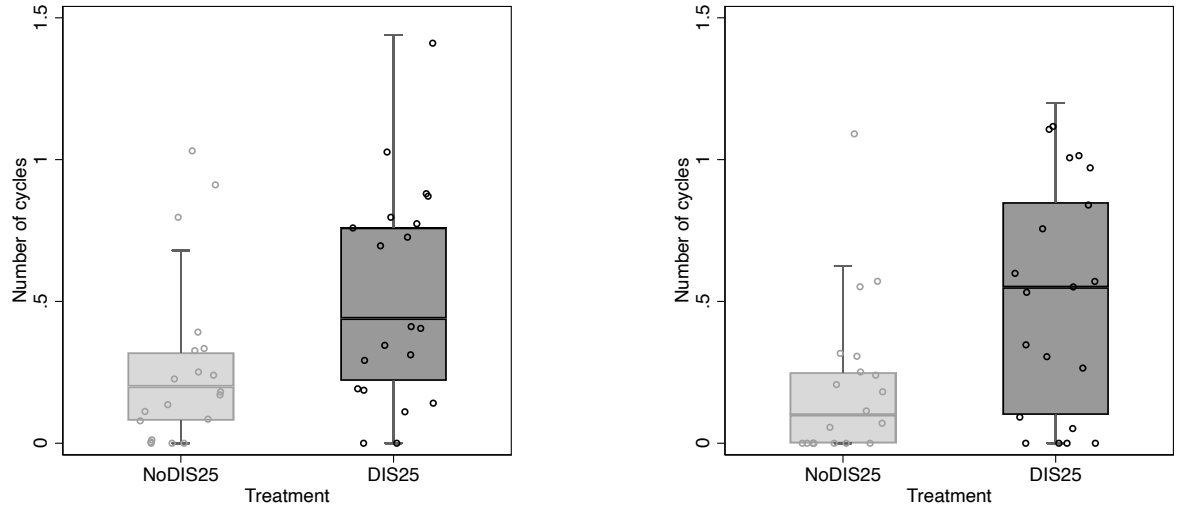
4.5. Price cycles and "money pumps"

We test Hypotheses 4 and 5 by comparing managerial transactions between the DIS25 and NoDIS25 treatments. With disclosure, we expect repeated cycles in which the manager sells above the equilibrium price and re-buys below it. Thus, the number of *price cycles* is defined as the number of times that a manager buys a share in the round. Price cycles result in a "money pump", transferring wealth from the shareholders to the manager. As a consequence, we expect that the manager's profits will be higher with disclosure, as well as more strongly correlated with the number of price cycles in comparison with the no-disclosure treatment.

Number of cycles. Figure 3 presents the distributions of the number of cycles in the NoDIS25 and DIS25 treatments. Although the overall number of cycles is low, cycles clearly occur more frequently with disclosure. The first column in Table 6 reports regressions of number of cycles on disclosure. The coefficient on disclosure is highly significant for all rounds (Panel A, $p = .015$) and for the last ten rounds (Panel B, $p < .001$), after prices in NoDIS25 converged towards the equilibrium.[16]

[16]These results are robust to considering the number of cycles normalized by the total number of transactions in the market.

A. All rounds. *B. Last ten rounds.*



Notes: Each observation is the average for the matching group across the 25 rounds. A cycle is registered whenever a manager sells and buys back his stock.

Figure 3: Average number of cycles.

Managerial transaction prices. Price cycles imply not only that the manager is active in the market, but more specifically that managers sell at prices above the equilibrium price and buy below it. Table 7 presents the share of managerial transactions in the predicted price range and mean prices depending on whether the manager buys or sells. With disclosure, the manager buys below and sells above $\tilde{p}$, on average and most of the time. In contrast, without disclosure, buying and selling prices are—on average and most of the time—above the equilibrium price.

Price cycles and profits. To test the relationship between price cycles and managerial profits, we regressed the managerial profits on disclosure. Figure 4 plots the predicted margins based on the number of cycles (across all rounds). The results indicate a positive and significant correlation between profits and cycles for managers in the DIS25 treatment ($p = .001$), but no significant correlation in the NoDIS25 treatment ($p = .846$). These results hold when restricting the model to the last ten rounds. See the appendix for details.

The second column in Table 6 confirms that disclosure increases the manager's profits. Unexpectedly, the regressions for *shareholder's* profits presented in Column (3) of the table show that they benefit even more than the manager from disclosure. The price cycles—while transferring wealth from the shareholders to the manager—are arguably the stabilizing mechanism that drives the prices to equilibrium, leading to higher effort and efficiency. While the manager is indifferent between receiving her profits as market price (with low effort) or share value (with high effort), the share-

Table 6: Price cycles and profits.

		Profit	
	No. of cycles	Managers	Shareholders
	(1)	(2)	(3)
Panel A. All rounds			
DIS25	0.25 ** (0.10)	10.36** (4.02)	31.24 *** (10.71)
Constant	0.26 *** (0.06)	675.75*** (2.23)	574.50*** (6.52)
n observations	1,000	1,000	2,975
Panel B. Last 10 rounds			
DIS25	0.29 *** (0.11)	16.27*** (4.67)	27.36 ** (13.86)
Constant	0.21 *** (0.07)	673.20*** (2.44)	577.12*** (9.81)
n observations	440	440	1,309

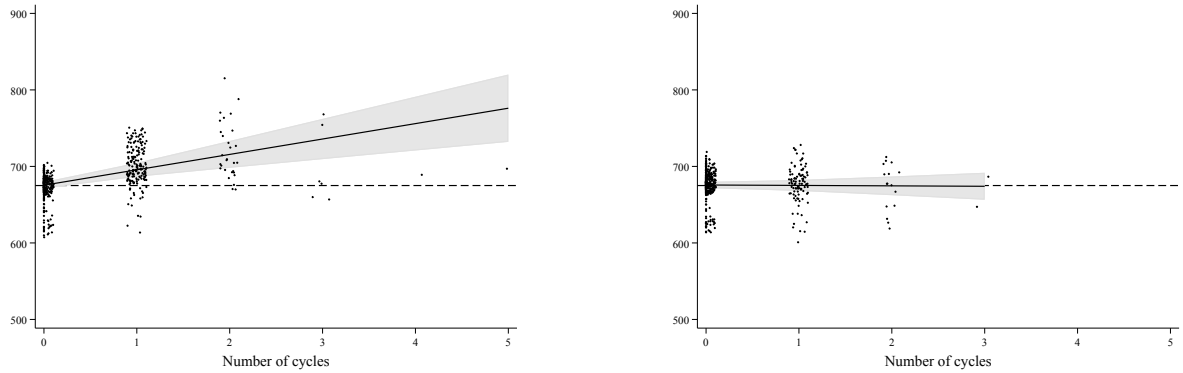
Notes: Mixed-effects linear regressions with random effects for matching groups and robust standard errors clustered on matching groups. Note that each round results in three observations fro shareholders' profits. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 7: Managerial transactions.

	Buying Price		Selling Price		Diff. in prices
	Mean (SD)	Percent $\leq \tilde{p}$	Mean (SD)	Percent $> \tilde{p}$	(p value)
DIS25	62.37 (21.74)	0.78	82.46 (18.61)	0.70	$p < .001$
n	261		420		
NoDIS25	85.20 (18.03)	0.28	83.28 (16.12)	0.77	$p = .899$
n	134		361		

Notes: Mean prices and share of transaction where the price was consistent with the money pump. The right-most column presents p-values for mixed-effects linear regressions of the difference between the manager's average selling and buying prices in a round on a constant with random effects for matching groups and robust standard errors clustered on matching groups. See the appendix for details.

A. DIS25. *B. NoDIS25.*



Notes: Each dot represents one market (matching group and round). Regression line and confidence interval based on mixed-effects linear regressions of manager's profit on number of cycles with random effects for matching groups and robust standard errors clustered on matching groups.

Figure 4: Manager's profits and number of cycles.

holders benefit substantially from the high effort exerted by the manager.

Result 6. *Disclosure of the manager's stock ownership results in more frequent price cycles, with the manager repeatedly buying below and selling above the equilibrium price, and a positive correlation between the number of cycles and the manager's profit. Price cycles lead to higher managerial profits but also to higher efficiency and higher profits for the shareholders.*

5. Conclusion

This study provides novel insights into the dynamics resulting from managerial ownership and the implications for market efficiency and shareholder value under conditions of moral hazard. Feedback effects arising from managerial stock holdings can theoretically anchor the market price, potentially leading to persistent mispricing and excess returns. Our experimental results show that, with full disclosure of managerial transactions, prices indeed converge to the levels predicted by theory. An increase in the manager's effort costs has the predicted effect on prices, whereas managerial ownership remains at similarly high levels.

The comparison to the no-disclosure treatment suggests that prices converge through a cyclic process resulting from myopic belief updating. Traders set supply and demand based on current managerial holding, apparently not fully anticipating future managerial transactions. As managers tend to buy at below-equilibrium prices and sell at above-equilibrium prices, supply and demand adjust to push prices toward the equilibrium. While this process transfers wealth from traders to managers, it in-

creases efficiency in the experiment by facilitating price convergence.[17] As a result, the disclosure policy primarily benefits the traders.

Does price convergence imply excess returns? Prices in the DIS25 and DIS40 are completely uninformative with regard to the realization of the manager's strategy, i.e., whether the manager ends up with skin in the game or not. We, therefore, observe strong ex-post excess returns even when the prices match the expected value. The picture is less clear when it comes to ex-ante excess returns. Prices and manager behavior in DIS25 treatment closely match the equilibrium with no excess returns. The theoretical analysis predicts a unique equilibrium price, but merely places a lower bound on the manager's ownership and effort.

Consistent with this insight, increasing the manager's costs in the DIS40 treatment pushes prices down without significantly affecting managerial ownership. This would generate ex-ante excess returns if not for the fact that skin managers in this treatment choose low effort too often, which we can only attribute to mistakes. The results are, therefore, equivocal with regard to the existence of ex-ante excess returns. Final judgment ultimately relies on whether we view the mistakes as a transitory phenomenon to be ignored or as an integral part of the analysis.

Our experimental design aimed to implement key features—managerial ownership, moral hazard, and disclosure policies—in a simplified environment. While this minimal setup allows us to identify the major behavioral patterns, it does come with some constraints. By separating managerial decisions from trade, the experiment ensures that the fundamentals drive the stock value, thereby minimizing the confounding effects of speculative trade and price bubbles. Stock resale value, however, is a major consideration in actual stock markets. Future research can extend our findings to a more dynamic decision-making scenario to investigate the implications of moral hazard in this more natural environment.

Our results contribute more broadly to the discussion of rationality in markets. An interesting observation in our experiment is that market prices converge to the rational expectations equilibrium despite the presence of myopic price cycles, which contradict rational expectations. This supports the view that individual-level rationality is not a necessary condition for market convergence (Gode and Sunder, 1993).

Returning to the prediction markets example discussed in the introduction, our results suggest that allowing insiders to participate in the market may undermine the ability of the market to make accurate predictions due to rational mispricing.[18] At the same time, insider participation may improve efficiency. Direct bonuses can substitute the incentivizing role of the market, but lose any predictive power that the market

[17]This increase in efficiency is due to the high prices and corresponding low effort levels due to lower ownership when there is no disclosure. Different environments may lead to different levels of efficiency, and therefore to different effects of disclosure on efficiency.

[18]See also Collin-Dufresne and Fos (2016) for effects of insiders on pricing.

may have. Establishing market transparency may improve the informativeness of the prices while at the same time promoting efficiency.

More broadly, our results shed light on the implications of disclosure policy regarding insider stock ownership and trades. Although the emergence of price cycles points against mandatory disclosure, the faster convergence to the equilibrium price is a notable benefit, even if it might lead to an underestimation of the true value. Considering insider information and a more dynamic investment of effort further supports the case for disclosure. Given that longer delays in disclosure may resemble our non-disclosure environment, our results suggest that minimizing the time until insider trades are disclosed is desirable.

The feedback effects studied in this paper rely on moral hazard. In principle, moral hazard can be contracted away, alleviating the problem. However, moral hazard is a real-world problem that is not easily solved due to information asymmetries, costly monitoring and enforcement, and incomplete or infeasible contracts, among others. A CEO may try to bargain for a compensation scheme that would provide incentives to put forth the high effort. However, the necessary amount (even if known) may be substantial, which may make it difficult for the shareholders to agree. For instance, Tesla had agreed to pay Elon Musk 55.8 billion over 10 years (on top of his significant initial ownership), but this was rejected by a court after complaints. In firm prediction markets, the firm might not have the information necessary to write the compensation schemes for the employees. This would require not only the knowledge of how each employee contributes to the success of the project but also the compensation necessary to induce effort.

By integrating theoretical and experimental approaches, this study advances our understanding of feedback effects in markets, and, specifically, how managerial ownership and moral hazard interact to affect market and economic efficiency in financial markets. It provides some support to the view that feedback effects may induce mispricing with rational expectations. At the same time, it highlights the importance of considering behavioral responses in the context of feedback effects when designing policies aimed at aligning managerial and shareholder interests.

References

Arrow, Kenneth J., Robert Forsythe, Michael Gorham, Robert Hahn, Robin Hanson, John O. Ledyard, Saul Levmore, Robert Litan, Paul Milgrom, Forrest D. Nelson, George R. Neumann, Marco Ottaviani, Thomas C. Schelling, Robert J. Shiller, Vernon L. Smith, Erik Snowberg, Cass R. Sunstein, Paul C. Tetlock, Philip E. Tetlock, Hal R. Varian, Justin Wolfers, and Eric Zitzewitz (2008). The promise of prediction markets. *Science* 320.(5878), pp. 877–878.

Bao, Te, Edward Halim, Charles N. Noussair, and Yohanes E. Riyanto (2020). Managerial incentives and stock price dynamics: an experimental approach. *Experimental Economics*, pp. 1–32.

Berle, Adolf A. and Gardner C. Means (1932). The modern corporation and private property. New York: MacMillan.

Blonski, Matthias and Ulf von Lilienfeld-Toal (2013). Moral hazard and excess returns. *mimeo*.

— (2019). Discontinuous feedback effects. *mimeo*.

— (2023). Moral hazard with excess returns. *Mathematics and Financial Economics* 17, pp. 537–572.

Bond, Philip, Alex Edmans, and Itay Goldstein (2012). The real effects of financial markets. *Annu. Rev. Financ. Econ.* 4.(1), pp. 339–360.

Choo, Lawrence, Todd R. Kaplan, and Ro'i Zultan (2019). Information aggregation in Arrow-Debreu markets: an experiment. *Experimental Economics* 22, pp. 625–652.

— (2022). Manipulation and (mis)trust in prediction markets. *Management Science*. In press.

Collin-Dufresne, Pierre and Vyacheslav Fos (2016). Insider trading, stochastic liquidity, and equilibrium prices. *Econometrica* 84.(4), pp. 1441–1475.

Davis, Douglas, Oleg Korenok, and Edward Simpson Prescott (2014). An experimental analysis of contingent capital with market-price triggers. *Journal of Money, Credit and Banking* 46.(5), pp. 999–1033.

Davis, Douglas and Edward Prescott (2017). Fixed prices and regulatory discretion as triggers for contingent capital conversion: an experimental examination. *International Journal of Central Banking* 13.(2), pp. 33–71.

Edmans, Alex, Xavier Gabaix, and Dirk Jenter (2017). Executive compensation: a survey of theory and evidence. *The handbook of the economics of corporate governance* 1, pp. 383–539.

Fahlenbrach, Rüdiger (2009). Founder-CEOs, investment decisions, and stock market performance. *Journal of Financial and Quantitative Analysis* 44, pp. 439–466.

Fama, Eugene F. (1970). Efficient capital markets: a review of theory and empirical work. *The journal of Finance* 25.(2), pp. 383–417.

Fischbacher, Urs (2007). Z-Tree: Zurich toolbox for teady-made economic experiments. *Experimental Economics* 10.(2), pp. 171–178.

Gode, Dhananjay K. and Shyam Sunder (1993). Allocative efficiency of markets with zero-intelligence traders: market as a partial substitute for individual rationality. *Journal of Political Economy* 101.(1), pp. 119–137.

Gorton, Gary B., Ping He, and Lixin Huang (2014). Agency-based asset pricing. *Journal of Economic Theory* 149, pp. 311–349.

Hall, Brian J. and Jeffrey B. Liebman (1998). Are CEOs really paid like bureaucrats? *The Quarterly Journal of Economics* 113.(3), pp. 653–691.

Hall, Brian J. and Kevin J. Murphy (2003). The trouble with stock options. *Journal of economic perspectives* 17.(3), pp. 49–70.

Jaworski, Taylor and Erik O. Kimbrough (2016). Bubbles, crashes, and endogenous uncertainty in linked asset and product markets. *International Economic Review* 57.(1), pp. 155–176.

Jensen, Michael C. and William H. Meckling (1976). Theory of the firm: managerial behavior, agency costs and ownership structure. *Journal of financial economics* 3.(4), pp. 305–360.

Kyle, Albert S. (1985). Continuous auctions and insider trading. *Econometrica: Journal of the Econometric Society*, pp. 1315–1335.

Malkiel, Burton G. (2003). The efficient market hypothesis and its critics. *Journal of economic perspectives* 17.(1), pp. 59–82.

— (2005). Reflections on the efficient market hypothesis: 30 years later. *Financial Review* 40.(1), pp. 1–9.

Pfeiffer, Glenn M. and Timothy W. Shields (2015). Performance-based compensation and firm value—experimental evidence. *Accounting Horizons* 29.(4), pp. 777–798.

Radner, Roy (1979). Rational expectations equilibrium: generic existence and the information revealed by prices. *Econometrica: Journal of the Econometric Society*, pp. 655–678.

Von Lilienfeld-Toal, Ulf and Stefan Ruenzi (2014). CEO ownership, stock market performance, and managerial discretion. *Journal of Finance* 69.(3), pp. 1013–1050.

Weber, Matthias, John Duffy, and Arthur Schram (2018). An experimental study of bond market pricing. *The Journal of Finance* 73.(4), pp. 1857–1892.

Wolfers, Justin and Eric Zitzewitz (2004). Prediction markets. *Journal of Economic Perspectives* 18.(2), pp. 107–126.

Appendix A. Supplementary Information

A.1. Market prices and SKIN frequency

Tables A1 and A2 present the full results for the regressions presented in Tables 2 and 3, respectively. Figures A1 to A4 report the market price in each group of the respective treatments, with SKIN ronds indicated by black circles. Figure A5 illustrates the average market prices across the DIS25, DIS40, and NoDIS25 treatments. Additionally, it presents the average prices separately for the SKIN and NoSKIN manager rounds when the analysis is restricted to these subsets.

Table A1: Regressions on market prices.

Dependent variable: Market price						
Rounds	1-5	6-10	11-15	16-20	20-25	1-25
Reference: *DIS25*						
NMH25	14.62***	18.53***	21.40***	20.11***	22.40***	19.38***
	(4.91)	(5.02)	(4.97)	(3.85)	(4.57)	(3.99)
NoDIS25	15.70***	9.17 *	8.50 *	2.09	6.10	8.89 **
	(4.85)	(5.36)	(4.91)	(4.37)	(4.80)	(4.31)
DIS40	5.38	-3.71	-14.35**	-11.67*	-13.79**	-5.84
	(5.36)	(6.21)	(6.33)	(6.32)	(5.89)	(4.83)
Constant	71.40***	73.64***	71.83***	73.75***	70.05***	72.12***
	(3.65)	(4.11)	(3.64)	(2.63)	(3.15)	(3.05)
R^2 Between	0.1576	0.1550	0.3199	0.2353	0.2883	0.2569
R^2 Overall	0.1129	0.1385	0.2393	0.2375	0.2859	0.1647
n	324	312	286	264	251	1,437
Groups	68	68	67	66	66	68

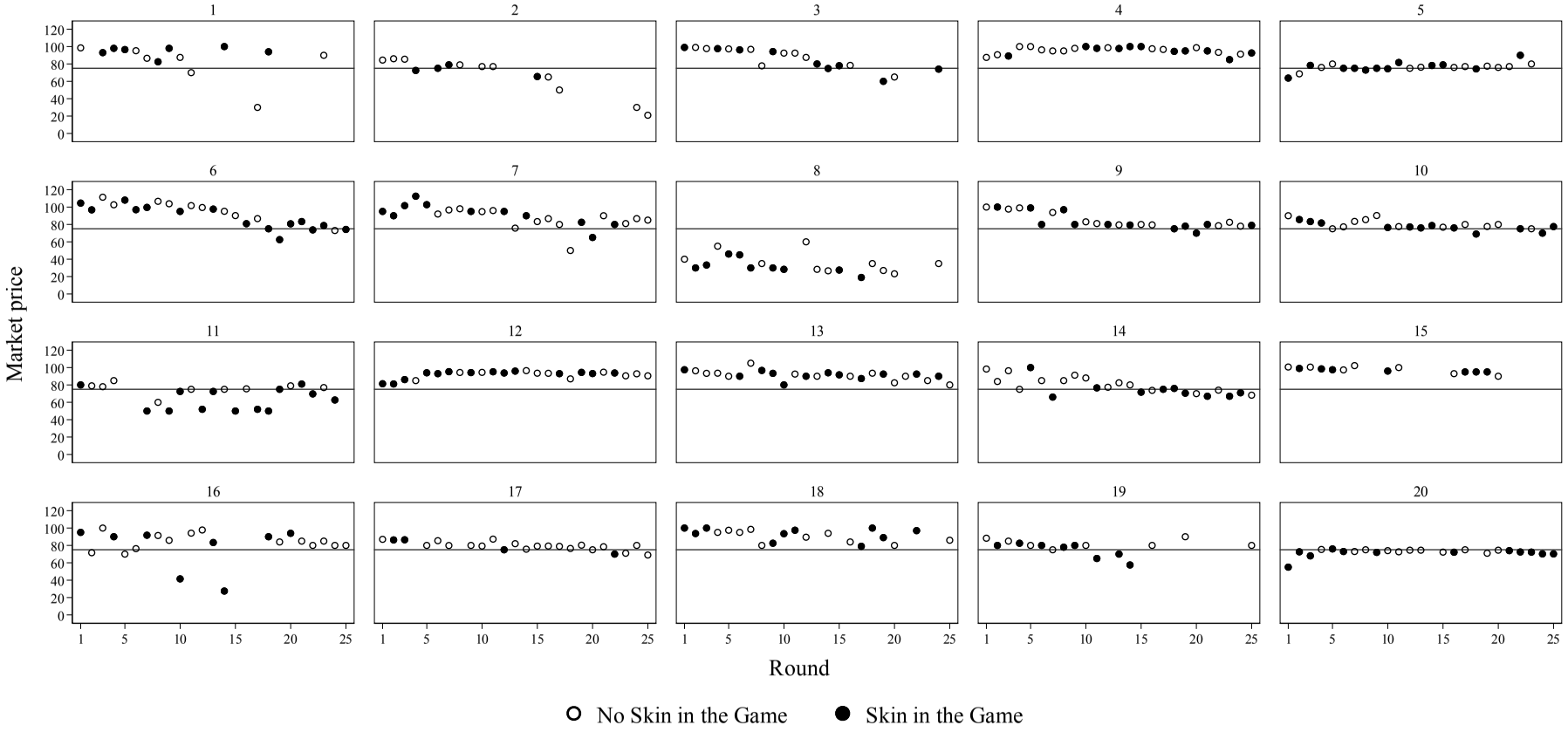
Notes: Mixed-effects linear regressions with random effects for matching groups and robust standard errors clustered on matching groups. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A2: Regressions on managerial ownership.

Dependent variable: SKIN managers						
Rounds	1-5	6-10	11-15	16-20	20-25	1-25
Reference: *DIS25*						
NoDIS25	-0.14 *	-0.21 ***	-0.09	-0.18 **	-0.06	-0.14 ***
	(0.072)	(0.078)	(0.071)	(0.071)	(0.076)	(0.044)
DIS40	-0.09	-0.11	-0.01	-0.05	0.07	-0.04
	(0.076)	(0.072)	(0.075)	(0.088)	(0.054)	(0.048)
Constant	0.66 ***	0.71 ***	0.65 ***	0.71 ***	0.68 ***	0.68 ***
	(0.054)	(0.058)	(0.051)	(0.054)	(0.039)	(0.036)
R^2 Between	0.0595	0.1240	0.0302	0.0827	0.0568	0.1444
R^2 Overall	0.0138	0.0307	0.0069	0.0248	0.0130	0.0140
n	300	300	300	300	300	1,500
Groups	60	60	60	60	60	60

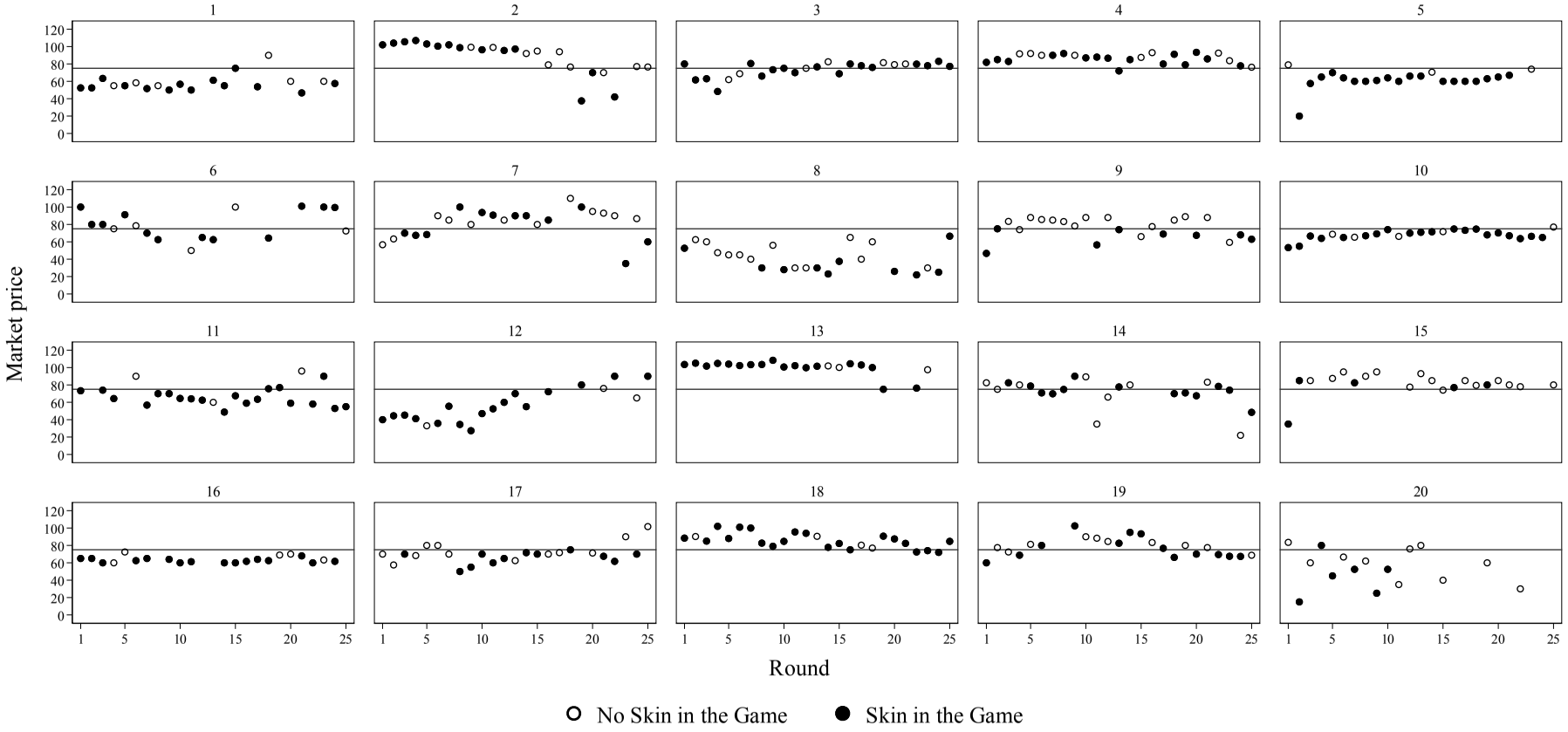
Notes: Mixed-effects linear regressions with random effects for matching groups and robust standard errors clustered on matching groups. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Figure A1: Market prices in the NoDIS25 treatment (by groups) depending on whether the manager ends the market with or without skin in the game.



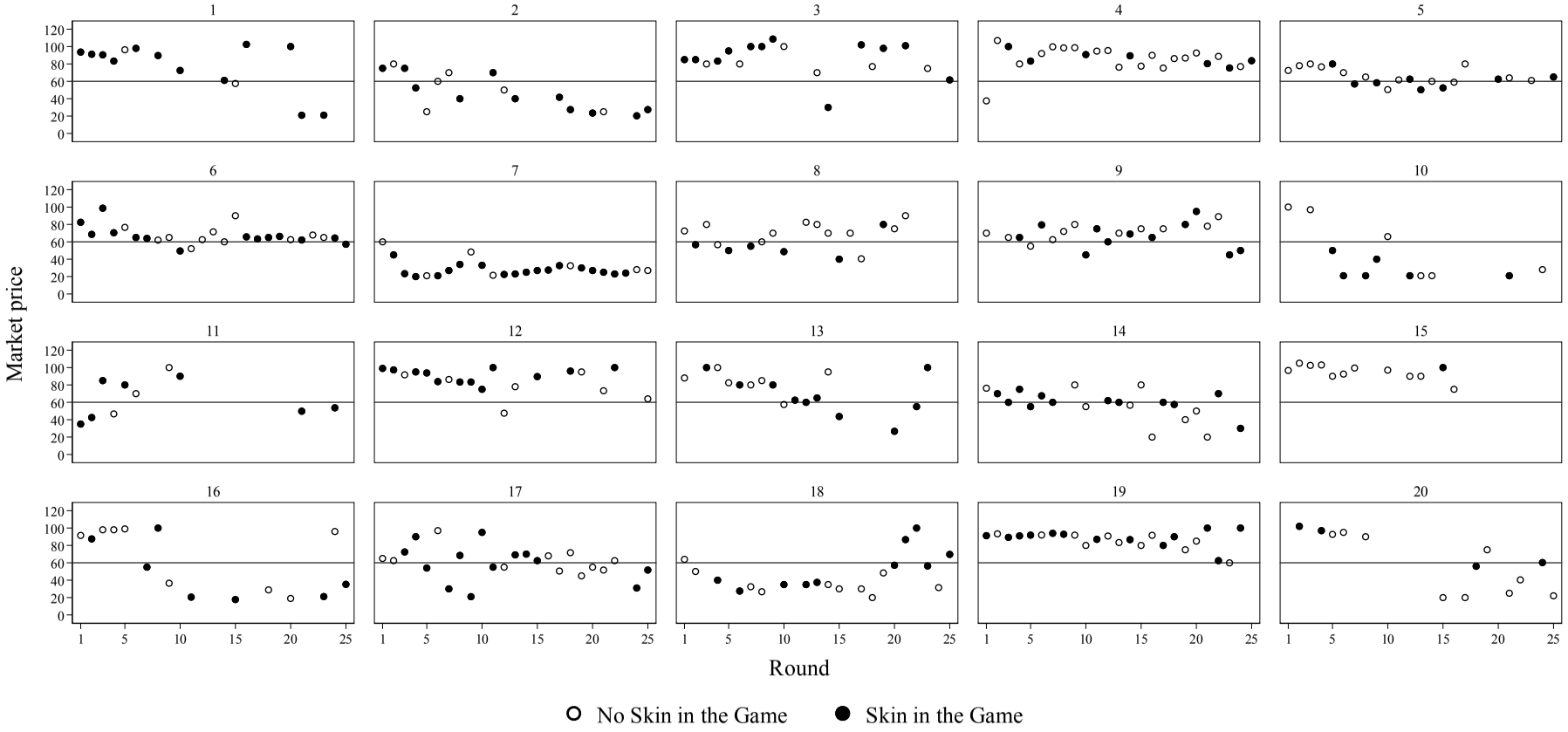
Notes: The header denotes the matching group and the horizontal line details the equilibrium price.

Figure A2: Market prices in the DIS25 treatment (by groups) depending on whether the manager ends the market with or without skin in the game.



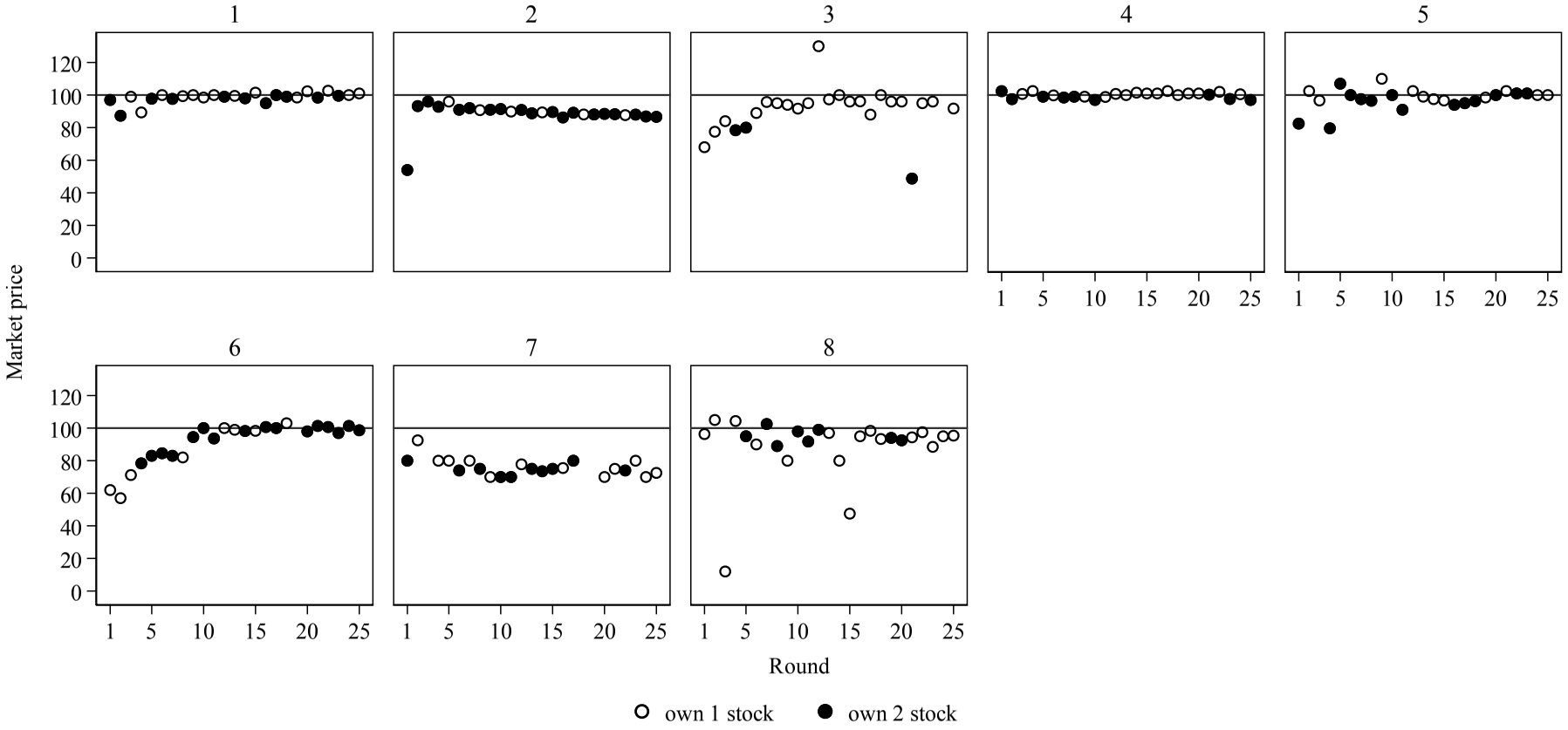
Notes: The header denotes the matching group, and the horizontal line details the equilibrium price.

Figure A3: Market prices in the DIS40 treatment (by groups) depending on whether the manager ends the market with or without skin in the game.



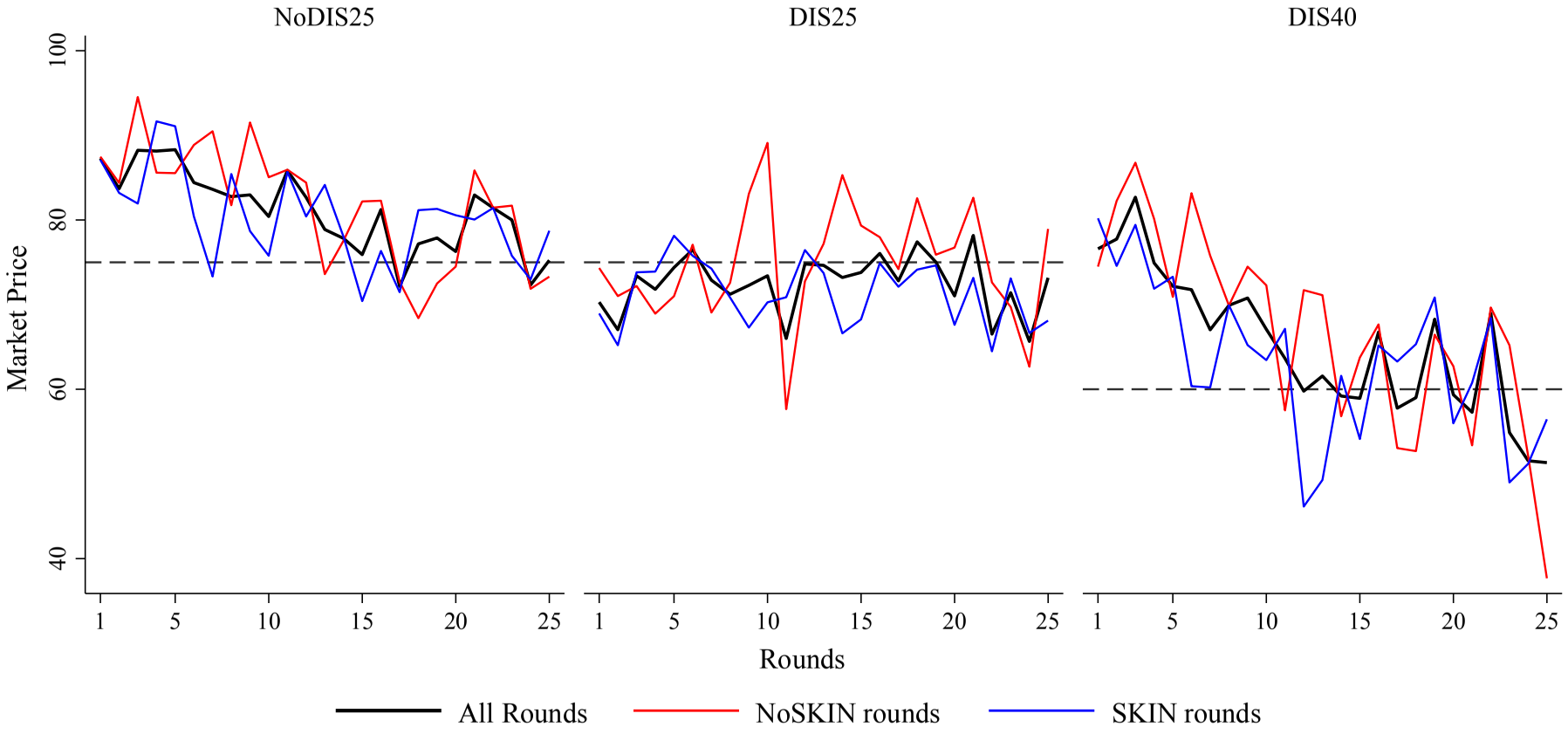
Notes: The header denotes the matching group, and the horizontal line details the equilibrium price.

Figure A4: Market prices in the NHM25 treatment (by groups) depending on whether the manager ends the market with 1 or 2 stocks.



Notes: The header denotes the matching group, and the horizontal line details the equilibrium price.

Figure A5: Average market prices in NoDIS25, DIS25 and DIS40 treatments



Notes: The horizontal line details the equilibrium price.

Table A3: Regressions on managerial transactions.

Dependent variable: Δ			
Treatment	NoDIS25	DIS25	DIS40
Constant	-0.36 (2.84)	-21.75*** (4.56)	-18.31*** (4.98)
n	114	213	147
Groups	18	18	19

Notes: Mixed-effects linear regressions with random effects for matching groups and robust standard errors clustered on matching groups. The dependent variable Δ is the difference between the manager's average selling and buying price in a round. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

A.2. Manager's behavior

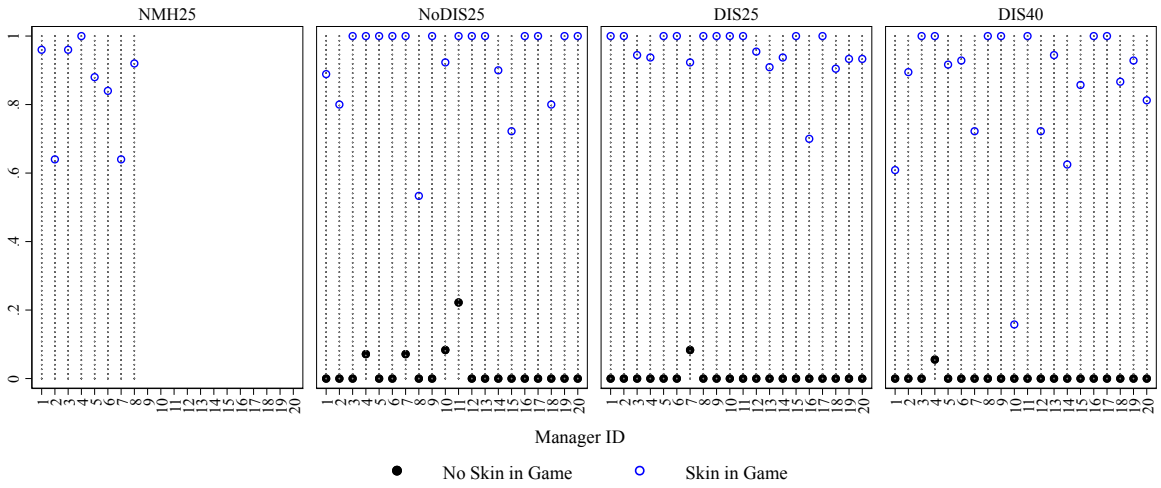
Figure A6 presents the frequency with which each manager chooses the *high* effort, distinguishing between situations where they have *SKIN* and those where they do not. We see that a minority of managers (e.g., ID=8 in NoDIS25, ID=10 in DIS40) sometimes choose the low effort even when they have skin in the game. It is unlikely that such subjects failed to understand the experimental design, given that all subjects had to correctly complete a detailed set of control questions. Instead, such behavior may be indicative of *other-regarding* preferences (e.g., they would like to "punish" the shareholders by choosing the low effort). For each manager and round, we compute the:

- Sale price: the average price that the manager sells her stocks at.
- Buy price: the average price that the manager buys her stocks at.
- Δ index: the manager's Sale price minus her Purchase price.[19] Here, $\Delta \geq 0$ indicates that the manager (on average) sells her stock at prices no less than what she had paid for.

Here Δ corresponds to the average differences between the manager's selling and buying prices. Figure A7 plots the average managers' sale and purchase prices by treatment. The average purchase prices tend to be below and the average sale prices above the equilibrium price in the DIS25 and DIS40 treatments. In the NoDIS25 treatment, both averages are mostly above the equilibrium prices and do not differ much from each other. We use the random-effects to regress Δ on a constant (see Table A3)—the p-value of the constant estimate correspond to the reported p-values on the final column of the Manuscript Table 7. The estimate results do not change if we only concentrate on the managers' buying and selling prices in the trade cycle.

[19] Only computed for instances where the manager is both a seller and buyer of stocks.

Figure A6: Managers' frequency of choosing the high effort.

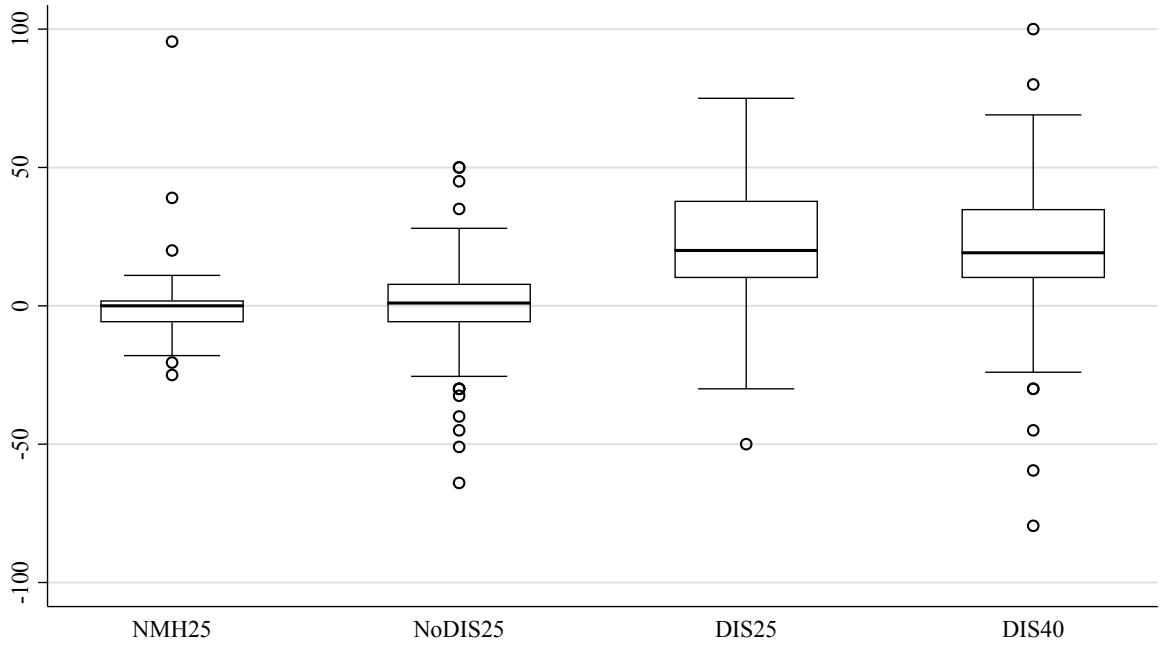


Notes: Each line corresponds to an individual manager's behavior over 25 rounds. The manager ID refers to the matching group.

Figure A7: Managers' purchase and sale prices (Treatment average).

Notes: The Sale and Buy prices are the average price that the manager sells and buys her stock at, respectively. The horizontal line details the equilibrium price.

Figure A8: Boxplot of managers' Δ.

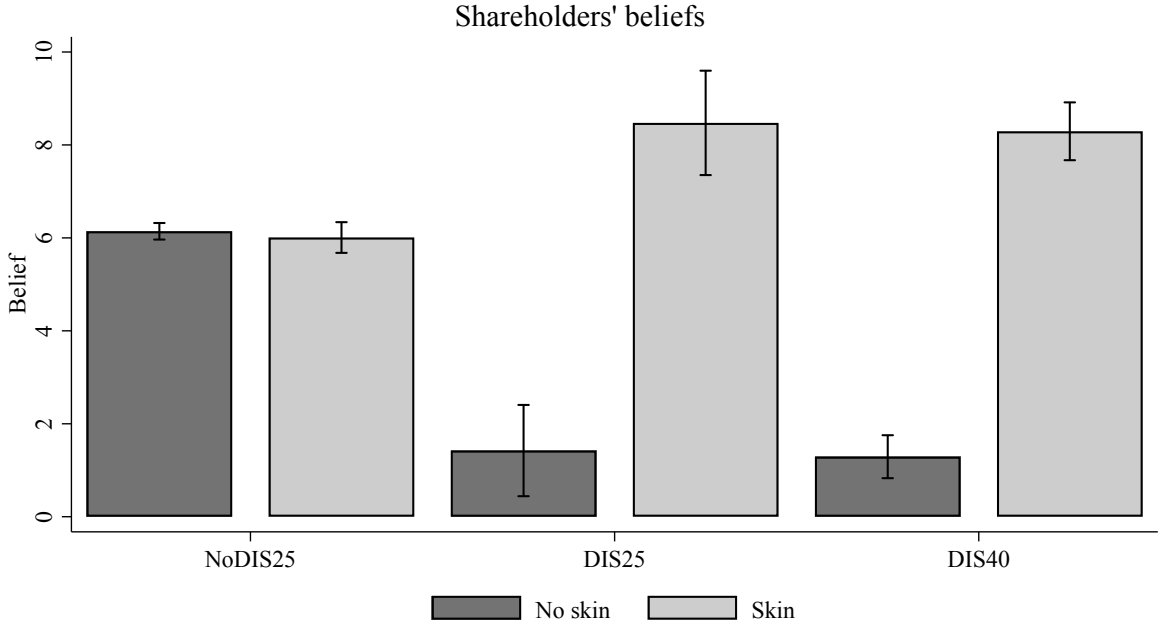


Notes: Δ is computed by the manager's average sale price minus her average purchase price. Outliers are denoted by hollow circles.

A.3. Shareholders' beliefs:

We elicited shareholders' beliefs about the manager's effort provision decision—each shareholder submits an integer between 0 and 10, where a higher number indicates a greater likelihood of the high effort. We use the random effects model to regress shareholders' beliefs on the treatment co-variate (NoDIS25, DIS25, and DIS40), on whether the manager ends the round with Skin in the Game (Yes or No), as well as the interaction between the aforementioned covariates. Figure A9 details the corresponding prediction margins of the regression estimates. The findings can be summarised as follows. Beliefs in the NoDIS25 treatment do not differ significantly ($p = .128$) depending on the managers' end-of-market stock ownership. In contrast, beliefs in the DIS25 and DIS40 treatments are significantly higher ($p < .001$) when the manager ends the round with skin in the game. Finally, beliefs in the DIS25 and DIS40 treatments do not differ significantly when the manager ends the market without ($p = .775$) and with ($p = .955$) Skin in the game.

Figure A9: Predicted margins (mean and 95% CI) about the likelihood of managers choosing the high effort.



Notes: Point predictions and confidence intervals based on mixed-effects linear regressions of shareholders' beliefs on treatment(NoDIS25, DIS25, and DIS40) interacted with SKIN with random effects for matching groups and robust standard errors clustered on matching groups. Shareholders' submitted beliefs are on a scale from 0 (the manager chooses low effort) to 10 (the manager chooses high effort).

A.4. Price cycles and profit

Figure A10 reports the average number of cycles in the NoDIS25 and DIS25 treatments at each round. Table A4 details the econometric estimates from Figure 4 of the manuscript.

Figure A10: Average number of cycles.

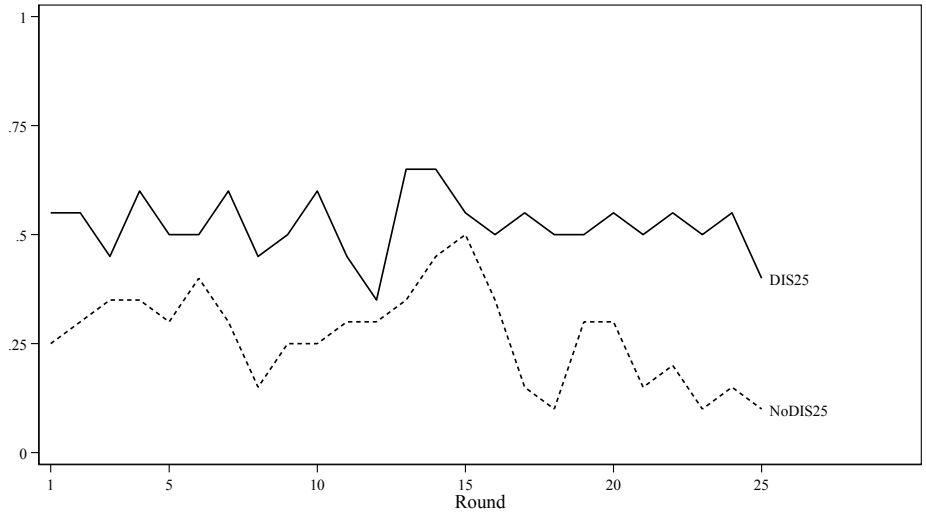


Table A4: Regressions of manager's profits on the number of cycles.

Dependent variable: Manager's payoff

	NoDIS25		DIS25	
Rounds	1-25	15-25	1-25	15-25
Number of cycles	-0.56	6.56 *	20.13***	31.02***
	(2.88)	(3.70)	(4.55)	(4.73)
Constant	675.73***	671.77***	675.44***	673.55***
	(2.09)	(2.39)	(2.14)	(2.45)
R^2 Between	0.0039	0.1067	0.2757	0.6258
R^2 Overall	0.0000	0.0455	0.2774	0.4889
n	500	220	500	220
Groups	20	20	20	20

Notes: mixed-effects linear regressions with random effects for matching groups and robust standard errors clustered on matching groups. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Appendix B. Experimental instructions

The following is the English translation of the experiment instructions (originally conducted in Chinese) for the NMH25, NoDIS25, and DIS25 treatments. Note that the DIS25 treatment is identical to DIS40 except for differences in the cost parameter.

Where applicable, we will highlight sections of the instructions that are specific to the Moral Hazard treatments (NoDIS25, DIS25, DIS40), the No Moral Hazard treatment (NMH25), as well as the Disclosure treatments (DIS25, DIS40).

Welcome to the experiment!

Please read the instructions carefully

During the experiment, please remain quiet. If you have any questions, raise your hand, and we will come to assist you. To avoid disturbing others, please set your mobile phone to silent mode and keep it in your bag. Additionally, please put away any items unrelated to the experiment, such as books, notebooks, or other electronic devices. Lastly, do not use any other functions on the computer, as this may cause it to crash or result in program errors.

In today's experiment, all your decisions will remain anonymous. You will not have access to any information about other participants, nor will others have access to any information about you. Furthermore, your payment will be issued individually at the end of the experiment, meaning no one else will know the decisions you made or the amount you earned.

Please carefully read the instructions for each part of the experiment, as your payment will depend on your understanding of the experiment. In today's experiment, we will use points as the unit of calculation for rewards instead of RMB. The experiment will consist of **25 rounds**. At the end of the experiment, the computer will randomly select the results of **two rounds**, and your payment will be the total profit from these two randomly selected rounds.

At the end of the experiment, the points you earn (the total profit from the two selected rounds) will be converted into RMB at the following exchange rate:

$$20 \text{ points} = 1\text{RMB}$$

Additionally, you will receive a 10 RMB participation fee. We will provide a detailed explanation of the tasks for each round of the experiment. Please read them carefully. At the end of the instructions is a set of questionnaire that you are to answer on the computer.

Information for Each Round

The participants in the experiment will be allocated to groups of four. These groups will remain fixed throughout the experiment. Each group will include one manager and three shareholders.

- One participant in each group will be randomly assigned by the computer to the manager role.
- The other three participants will be in the role of shareholders.

Throughout the experiment (25 rounds), you will maintain the same role (manager or shareholder).

Each round will include two stages, the trading stage, followed by a decision stage:

- **Trading stage:** All participants will trade asset certificates within their respective groups of four.
- **Decision stage:** The manager will decide their effort level, which can either be normal effort or high effort. The manager can choose Normal effort or high effort. The manager pays a cost depending on his or her choice. The manager will decide their effort level, which can either be normal effort or high effort.

In each round, the value of each certificate will depend on the manager's chosen effort level (normal or high) and the participants' roles (manager or shareholder)—see the table below.

Effort Level Chosen by the Manager	Normal Effort	High Effort
Value of Each Certificate for the Manager	20 points	100 points
Value of Each Certificate for Shareholders	20 points	A random value between 95 and 105 points

In the information presented in the table above, please note:

- If the manager chooses the normal effort level, the value of each certificate will be 20 points, regardless of your role.
- If the manager chooses a high effort level, the value of each certificate held by the manager will be 100 points. The value of each certificate held by shareholders will be a random value between 95-105 points. At the beginning of each round of experiments, the value of each shareholder's certificate is independently and randomly determined and informed by the computer, and each

shareholder only knows the value of his certificate. This means that the value of the asset certificates of the three shareholders is random, independent, and uncorrelated. On average, each shareholder has a certificate value of 100 points.

Example 1: If the manager selects the normal effort level during the decision stage, the value of each certificate will be 20 points.

Example 2: If the manager chooses a high level of effort during the decision stage, the value of each certificate held by the manager will be 100 points. The value of each certificate held by each shareholder will be between 95-105 points.

Now, we will describe in more detail the two stages of each round of the experiment: the trading stage and the decision stage.

Trading stage

During the trading stage, all four participants, including managers and shareholders, will be able to trade certificates and only within the group (four people).

- Each shareholder start the round with 400 points and 3 certificates.
- <ONLY IN THE MORAL HAZARD TREATMENTS.> The manager starts the round with 100 points and 1 certificate.
- <ONLY IN THE NO MORAL HAZARD TREATMENT.> The manager starts the round with 100 points and 2 certificates.

The manager and shareholders can buy and sell shares in the market for a duration of 100 seconds. At each moment of the trading stage

- <ONLY IN THE MORAL HAZARD TREATMENTS.> The manager can own up to 1 certificate.
- <ONLY IN THE NO MORAL HAZARD TREATMENTS.> The manager must have a minimum of 1 certificate and a maximum of 2 certificates. That is, the manager can own 1 or 2 certificates.
- Shareholders can have any number of certificates—there is no limit to the number of certificates that a shareholder can have.

<ONLY IN THE MORAL HAZARD TREATMENTS.>

Example 3: Suppose the manager has 1 certificate. This means that he/she can no longer buy additional certificates, but he/she can sell his/her certificate.

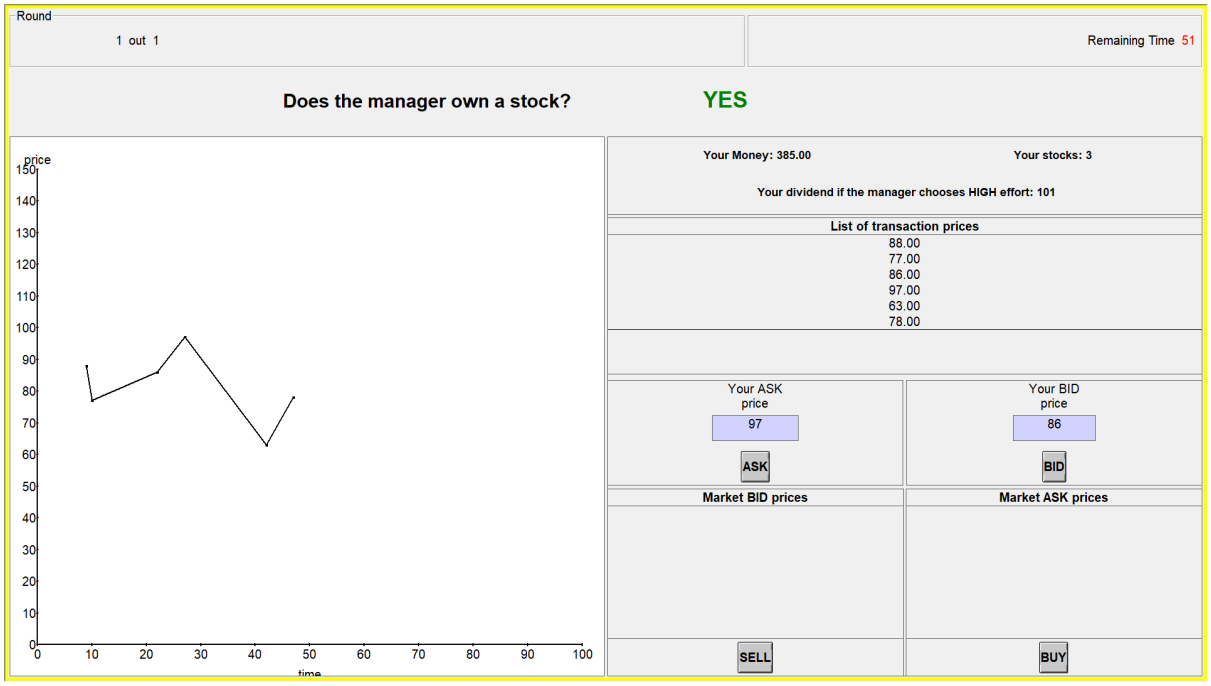
Example 4: Suppose the manager has 0 certificate. This means that he/she is able to buy a certificate if he/she wants to. <ONLY IN THE NO MORAL HAZARD TREATMENTS.>

Example 3': Suppose the manager has 2 certificates. This means that he/she can no longer buy additional certificates, but he/she can sell his/her certificate(s).

Example 4': Suppose the manager has 1 certificate. This means that he/she is able to buy an additional certificate if he/she wants to.

<ONLY IN THE NO DISCLOSURE TREATMENTS.> During the trading stage, you can only see the number of points and the number of certificates you own. This means that you will not be able to see the number of points and certificates that other participants have.
<ONLY IN THE DISCLOSURE TREATMENTS.> During the trading stage, you can see the number of points and the number of certificates you own. In addition, shareholders can also see the number of certificates owned by the manager in real time (0 or 1). However, neither shareholders nor managers can see the number of certificates owned by other shareholders.

The screen during trade may look like this: <THE INDICATION AT THE TOP APPEARS ONLY IN THE DISCLOSURE TREATMENT.>



Below we will go into more detail on how the trading works and how to buy and sell certificates on the trading interface.

- The number of points and certificates you have will be displayed at the top right of your computer screen and will be updated in real time as you buy or sell certificates.
- The historical transaction prices of the group (4 people) will be displayed in the form of charts and tables in the trading interface.

At any time, each participant can submit a BID and an ASK price:

- Your BID is the price you are willing to pay to buy a certificate.
- Your ASK is the price you are willing to accept to sell a certificate.

The transaction prices can be between 0 and 150 points. You can choose a BID or an ASK by typing in a number in the appropriate place (BID or ASK) and clicking the **BUY** or the **SELL** button. You can see all BIDs and ASKs of all the participants in the corresponding columns. You can buy or sell a share in the BID or ASK price of another participant thus:

- To buy a share: click on the price in the ASK column, and click the **BUY** button.
- **To sell a share**: click on the price in the BID column, and click the **SELL** button.

Your BIDs and ASKs will be marked in blue. You cannot buy from yourself or sell to yourself. You can buy a share only if you have enough points, and you can sell a certificate only if you own at least one certificate. Each time somebody buys or sells a certificate, the transaction price appears in the transaction prices column, and also in the graph on the left.

The decision stage

The manager

The manager chooses his or her effort at the decision stage. The manager can choose normal effort or high effort.

- The high effort carries a cost of 25 points.
- The low effort carries a cost of 0 points.

Please note that the cost of the manager's effort is borne only by the manager.

Profit for the round

At the end of each round, your profit for that round will be calculated. This will depend on: your role, the value of each certificate, the number of certificates you have, and the number of points you have at the end of the trading stage.

Again, as a reminder, the cost to the manager is 25 points when choosing a high effort level and 0 points when choosing a normal effort level. If the manager selects the normal effort level, the value of each certificate is 20 points. If the manager chooses a high effort level, each certificate is worth 100 points to the manager and 95-105 points to the shareholders.

Manager's Profit

<ONLY IN THE MORAL HAZARD TREATMENTS.>

The manager's profit	=	**500**	+	**Certificate owned by the manager** × **certificate value**	+	**Money remaining at the end of trade**	-	**Effort Cost**

Example 5: Assume that the manager has 80 points and one certificate at the end of the trading stage. The certificate value for the **manager** if he/she chooses **high** is exactly **100** points.

- The manager's profit with normal effort is:
  $500 + 80 + (1 \times 20) - 0 = \mathbf{600}$
- The manager's profit with high effort is:
  $500 + 80 + (1 \times 100) - 25 = \mathbf{655}$

Example 6: Assume that the manager has 80 points and no certificate at the end of trade.

- The manager's profit with normal effort is:
  $500 + 80 + (0 \times 20) - 0 = \mathbf{580}$
- The manager's profit with high effort is:
  $500 + 80 + (0 \times 100) - 25 = \mathbf{555}$

<ONLY IN THE NO MORAL HAZARD TREATMENTS.>

The manager's profit	=	400	+	Certificate(s) owned by the manager × certificate value	+	Money remaining at the end of trade	-	Effort Cost

Example 5': Assume that the manager has 80 points and one certificate at the end of the trading stage. The certificate value for the **manager** if he/she chooses **high** is exactly **100** points.

- The manager's profit with normal effort is:
  $500 + 80 + (1 \times 20) - 0 = \mathbf{600}$
- The manager's profit with high effort is:
  $500 + 80 + (1 \times 100) - 25 = \mathbf{655}$

Example 6': Assume that the manager has 80 points and 2 certificates at the end of trade.

- The manager's profit with normal effort is:
  $500 + 80 + (2 \times 20) - 0 = \mathbf{520}$
- The manager's profit with high effort is:
  $500 + 80 + (2 \times 100) - 25 = \mathbf{655}$

Shareholders Profit

Shareholder's profit in the round	=	Certificates owned by the shareholder × certificate value	+	Money remaining at the end of trade

Example 7: Assume that shareholder A has 420 points and two certificates at the end of trade, and assume that the certificate value for **this shareholder** if the manager chooses **high** effort is **105** points.

- Shareholder A's profit if the manager chooses normal effort:
  $420 + (2 \times 20) = \mathbf{460}$

- Shareholder A's profit if the manager chooses high effort:
  $420 + (2 \times 105) = \mathbf{630}$

Note that the shareholders' profits are always higher if the manager chooses **high** effort.

Guessing the Manager's decision (Shareholders Only)

While the manager chooses the effort level, the share holders will be asked to **guess** the effort level that the manager chose. For this guess you can receive a **bonus** as follows. The guess will be a number between 0 and 10, where **0** means a **low** probability and **10** means a **high** probability that the manager chose **high** effort. The bonus that a shareholder receives **depends on the guess and on the manager's decision**, according to this table:

The guess	**The manager chose normal effort**	**The manager chose high effort**
0	100 points	0 points
1	99 points	19 points
2	96 points	36 points
3	91 points	51 points
4	84 points	64 points
5	75 points	75 points
6	64 points	84 points
7	51 points	91 points
8	36 points	96 points
9	19 points	99 points
10	0 points	100 points

The payments in the table are chosen in such a way that you are always better off if you guess according to what you really believe about the manager's decision.

Example 8: The shareholder's guess is **2**, and the manager chose **normal** effort. The bonus to the shareholder is **96 points**.

Example 9: The shareholder's guess is **2**, and the manager chose **high** effort. The bonus to the shareholder is **19 points**.

At the end of the experiment, the computer will randomly choose **one round**. The shareholders will receive the **bonus** based on their guess and the manager's choice **in the chosen round**, in addition to the market payment from the two chosen rounds.

Other information

To ensure that all participants are fully aware of the experimental design, do the following: Please fill out the test questionnaire on the next page.

When everyone has completed the questionnaire, we will proceed with 2 practice rounds. The purpose of the practice rounds is to help you understand how to make decisions in this experiment. Your decisions in practice rounds will not affect the rest of the experiment or how much you earn in that experiment.

The experiment will begin after the completion of the 2 practice rounds. Again, the experiment will consist of 25 rounds, and you will interact with the same other participants in each round. And, you are in the same role (manager or shareholder) in all 25 rounds.

Control Questionnaire

1. Suppose the manager has 1 certificate. He is able to purchase additional certificates. (True/False)
2. Suppose the manager has 1 certificate. He is able to sell the certificate. (True/False)
3. Suppose a shareholder has 1 certificate. He is able to purchase additional certificates. (True/False)
4. Suppose a shareholder has 1 certificate. He is able to sell the certificate. (True/False)
5. During the trading stage, shareholders can observe the number of certificates owned by the manager at any time. (True/False)
6. How much does it cost the manager to choose a normal level of effort? (0, 25, 40, 75, 100, 125)
7. How much does it cost a manager to choose a high effort level? (0, 25, 40, 75, 100, 125)
8. If the manager chooses the normal effort level, what is the value of each certificate? (0, 20, 40,60,80, 100)
9. If the manager chooses a high effort level, how many points is each certificate worth to him? (0, 20, 40,60,80, 100)
10. If the manager chooses a high level of effort, how many points is each certificate worth to to each shareholder (on average)? (0, 20, 40,60,80,100)

11. When a manager chooses a high level of effort, the shareholder's income is higher. (True/False)

12. If the manager has a certificate, he earns more when he chooses a high level of effort. (True/False)

13. <ONLY IN THE MORAL HAZARD TREATMENTS.> If the manager does not have a certificate, he will earn more when he chooses a high level of effort. (True/False)

13'. <ONLY IN THE NO MORAL HAZARD TREATMENTS.> If the manager has two certificates, he will earn more when he chooses a high level of effort. (True/False)