CEO Incentives and Stock Price Dynamics: An Experimental Approach[1]

TE BAO, EDWARD HALIM, CHARLES N. NOUSSAIR, and YOHANES E. RIYANTO

ABSTRACT

We investigate experimentally how granting a CEO *stock ownership* and *the opportunity to trade* influence the CEO's effort and overall behavior in the market for the company's shares. In our design, CEO effort affects the fundamental value of the firm. Our findings suggest that stock ownership alone does not significantly increase the CEO's effort. However, CEOs tend to accumulate additional shares when they are given the opportunity to trade, and this leads to greater CEO effort and increased company value. In all of our treatments, prices tend to reflect underlying fundamentals and bubbles are rare. When CEOs receive stock ownership, prices deviate even less from the fundamental values than they do otherwise. When CEOs can trade shares, the asset exhibits somewhat greater mispricing.

Keywords: Executive Compensation, CEO Incentives, Experimental Finance, Asset Bubbles, Agency Problem.

JEL Code: C91, C92, D53, D86, M1

[1] We thank Eric Aldrich, Nobuyuki Hanaki, Rosemarie Nagel, Tibor Neugebauer, Luba Petersen, Yi Tang, Utz Weitzel and participants at the 2016 Experimental Finance Conference in Nijmegen, The Netherlands, the 2016 North American Meeting of the Economic Science Association at the University of Arizona, Tucson, USA, the 2017 Experimental Finance Conference in Nice, France, the 2018 Asian Meeting of the Econometric Society in Shanghai, China and the 2018 Society for Computational Economics Annual Meeting at Milan, Italy for helpful comments.

I. Introduction

The economic analysis of CEO compensation has become more important, as the world has witnessed a sharp increase in CEO renumeration over the last few decades. According to the Economic Policy Institute (Mishel and Sabadish, 2012), the average ratio between CEO compensation and median employee compensation in the same company has increased from roughly 20 in the 1960s to about 200 in the 2010s. This trend has stimulated discussion among researchers regarding whether such high payments to CEOs are justified. The empirical evidence is mixed. While Jensen and Murphy (1990b) find a positive relationship between CEO compensation and firm performance, Core et al. (1999) find that CEO pay is correlated with poor corporate governance, perhaps reflecting revenue extraction by insiders.

The structure of CEO compensation has also changed. Many firms now offer compensation in terms of stock shares and options. Theoretically, these incentives are an appropriate response to the agency problem between the CEO and shareholders (Jensen and Meckling, 1976; Jensen and Murphy, 1990a). Granting shares of stock to CEOs aligns their incentives with those of shareholders. Indeed, Mehran (1995) finds that firm performance is positively correlated with the percentage of CEO compensation that is equity-based. Moreover, equity ownership might induce a sense of proprietorship (Wasserman, 2006; Pierce et al., 2001), leading the CEO to behave more like a "steward" of the firm (Davis et al., 1997), who maximizes the objective function of the organization.[2]

In this paper, we use an experimental approach to study how the incentive structure that a CEO faces affects her effort and resulting stock prices.[3] The research questions that we address are the following. *First*, do CEOs invest greater effort to increase stock value when they receive shares or when they receive cash bonuses? *Second*, is the market able to price the CEO's effort correctly by incorporating effort information, which may include expectations of future effort, into share prices? *Third*, how does allowing the CEOs to trade the shares of their own firm matter for their effort? In other words, will she work harder when she can profit from trading shares? *Fourth*, how does permitting the CEO to trade affect asset prices?

In our experiment, there is a firm whose shares can be traded over a number of periods. Shares do not pay dividends. Rather, all profits are automatically reinvested and paid to shareholders at the end of the last period of trading. Transactions for shares are concluded in a continuous double auction market (Smith, 1962). The experimental design follows a 2x2 structure. The treatment dimensions are (1) whether the CEO receives a bonus in cash or in shares, and (2) whether or not the CEO is allowed to trade shares in the open

[2] For comprehensive surveys of executive compensation, see Frydman and Jenter (2010),Edmans and Gabaix (2016) and Edmans et al. (2017).

[3] There are, of course, also other rationales for providing stock-based incentives instead of cash bonuses to CEOs, e.g. forces related to taxation, control rights, signaling one's commitment to the firm, or other more behavioral reasons, like moral values, etc. We abstract away those factors to keep focus on the choice of effort, which is usually at the center of the application of agency theory to corporate finance.

market. If the CEOs invest greater effort in the stock ownership treatments, it would suggest that ownership motivates CEOs better than a cash bonus does. If permitting the CEOs to trade increases effort and market stability, it would lend support for the current practice of most regulatory authories to allow CEOs to trade stock of her own company, subject to some restrictions and disclosure requirements.[4]

Our results show that stock ownership does not significantly increase managerial effort, which might suggest that the effort-inducing effect of stock ownership is absent in our setup. The market, however, demonstrates more desirable qualities in the presence of stock ownership. Specifically, we find that price bubbles are smaller than under cash bonuses, with prices tracking fundamental values more closely under stock ownership.

CEOs tend to accumulate additional shares of stock when they are given the opportunity to trade, and greater shareholdings, in turn, lead to greater CEO effort. However, if CEOs have the opportunity to trade, the market tends to overreact to the CEO's effort decisions. Traders price the firm above its underlying value, perhaps due to anticipation of future growth of its value. Thus, we find that price discovery tends to be undermined when the CEO can participate in trading.

The gaps between market prices and the liquidation values in our experiment are generally quite small, suggesting that markets for assets with endogenously determined liquidation values display a high level of efficiency. In this regard, the behavior of our markets contrasts sharply with experiments studying long-lived assets with exogenous liquidation values (Smith et al., 1988; Palan, 2013, Akiyama et al., 2017), and are more in accord with experiments on portfolio choice and information revealation and market effeiciency, where asset prices converge to a predicted equilibrium (Copeland and Friedman, 1987, 1991, Bossaerts and Plott, 2002, 2004, Bossaerts et al., 2007, Crockett and Duffy, 2013, Asparouhova et al., 2015, 2016, and Weber et al., 2017).

Our study is related to several recent studies in experimental finance. Lefebvre and Vieider (2014) conduct an experiment to compare the effect of compensation with stock options, versus cash bonuses, on risk taking by CEOs making investment decisions. They find that CEOs paid with stock options take more risk than those paid with cash bonuses. Similar results are reported by Holmen et al. (2014) and Kleinlercher et al. (2014). They observe that fund managers in experimental markets buy more shares when they are paid under option-like incentives, and that this behavior leads to greater asset price overvaluation. Unlike these studies, the CEOs in our paper decide on their effort level rather than on how much risk to take.

[4] In the US, a CEO is permitted to trading shares of her own firm as long as the trade does not rely on material information not in the public domain and she submits a filing to the SEC. Indeed, according to a report by CNBC (https://www.cnbc.com/2016/04/26/the-ceo-stock-buying-bump.html), between 2003 and April of 2016, there were more than 200 different instances of CEOs buying at least $1 million of their own company's stock. Regulations in other countries usually follow the spirit of US law, though are often different in some details. For example, the China Security Regulatory Commission explicitly bans CEO short-turn trading (buying and reselling within 6 months) and any transaction of more than 25% of the total shares of the firm within the term of the CEO.

Fullbrunn and Haruvy (2013) conduct an experiment on the dividend puzzle, and the initial endowment of shares of the management team is a key dimension of the experimental design. They study whether the management team votes more in the interest of shareholders (such as voting to pay dividends instead of reinvesting profits or conducting self-dealing) if they own more shares themselves. However, they find the opposite result. Pferiffer and Shields (2015) study the effect of a CEO's choice between performance-based and non-performance-based compensation on the market price of the stock. They observe that the choice reflects the CEO's private information about the firm's future profitability, and that the market is able to correctly incorporate the private information into the asset prices. In their experiment, there is also a treatment where the dividend of the firm depends on the effort of the CEO, but there are only two levels of effort (zero and one), and the CEO can not overinvest in effort due to the nature of the experimental design. Jaworski and Kimbrough (2016) conduct an experiment in which the dividend of a monopoly firm is contingent upon the pricing decision of the CEO. They find that introducing endogenous fundamental value leads to slightly larger price bubbles and a slower process of bubble mitigation as subjects become more experienced. The difference between the results in their paper and ours may be caused by the fact that the shape of the fundamental value in their paper is downward sloping as in Smith et al. (1988), while the one in our paper is flat if the CEO chooses the optimal level of effort. According to Kirchler et al. (2012), the price discovery is in general easier when the shape of the fundamental value is flat. In addition, the pricing decision Jaworski and Kimbrough (2016) appears to be more difficult to solve than the utility maximization problem for the CEOs, which may increase the likelihood of price bubbles.

Since the fundamental value of the stock in our experiment is determined by the effort of the CEO, our paper is also related to experimental studies on labor contract and effort choice by employees. Most studies in this literature (e.g. Fehr et al., 1998, Brandts and Charness, 2004, Cohn et al., 2014) investigage gift exchange in labor markets (Akerlof, 1982). The most closely related paper in this literature is Fehr and Falk (1999) who also study the interaction between competitive equilibrium via double auction and wage-effort relationship in labor contracts. The main result of this literature is that fairness and reciprocity play a very important role in labor contracts. The employees will choose higher/lower effort when the wages are high/low even when the wages are fixed and hence their optimal choice should always be the minimum effort. The difference between our paper and studies in this literature is that the CEOs in our experiment respond to incentive contracts where the optimal effort is not the minimum level.

Our study is also related to the experimental literature on the role of insider information on stock prices. Plott and Sunder (1982) and Oechssler et al. (2011) investigate situations in which insiders have an informational advantage regarding an asset's liquidation value over other traders. Sutter et al. (2011) study the impact of information assymetry on asset bubbles and find that informational asymmetry actually helps to abate asset bubbles. In this literature, the liquidation value is exogenous. In our paper, we study the

situation where the CEO will always know the liquidation price of the stock before the traders do, as it is endogenously determined by the CEO's effort.

This paper is organized as follows. Section II presents our experimental design and procedure. Section III discusses the results of our experiment, and Section IV concludes the paper.

II. Experimental Design and Procedure

A. General Structure

The experiment was conducted at X University and all 236 subjects were students at the university.[5] The average duration of a session was 2.5 hours. The experiment consisted of four treatments, called L, S, LT and ST. In each experimental session, exactly one treatment was in effect. In every treatment, a group of traders could exchange shares of a company over three consecutive ten-period markets. We refer to each of these consective ten-period markets as a round. Each investor was endowed with cash and shares of stock at the outset of each market, and trading was organized under continuous double auction rules (Smith, 1962). In the L (Linear Compensation) treatment, the CEO of the company was compensated with a linear wage compensation plan. In the S (Stock Ownership) treatment, a stock ownership plan was in effect. The CEO was permitted to trade the stock of her firm in the LT (Linear Compensation with Trading) and the ST (Stock Ownership Plan with Trading) treatments, respectively. Thus, our experiment employed a 2x2 design.

For each treatment, we ran 3 sessions with 8 CEOs in each session. As each CEO can only play once in each market, there are a total of 24 markets in each treatment. We have 4 non-CEOs for every 1 CEO in treatment S and ST, and 5 Non-CEOs for every 1 CEO in Treatment L and LT. As 2 CEOs in treatment S and ST quitted before the experiment was fully completed, we removed the data from these two markets. Consequently, in our analysis, we have 22 markets in S and ST. The market was reinitialized at the start of each round. Across four treatments we thus have a total of 92 total markets (24 markets each in Treatments L and LT, and 22 markets each in Treatments S and ST).

Each period lasted for one hundred seconds, during which all subjects were free to purchase and/or sell, provided that they did not violate the short-selling constraint and maintained a positive cash balance. At the

[5] We, like many other researchers in experimental economics and finance, use data from student subjects to study decisions by professionals. Some existing work has shown that students can deal with very complex trading environments; see, e.g. Asparouhova et al. (2016). In experiments that use both student subjects and professionals, such as that of Haigh and List (2015), the results usually show that professionals exhibit the same level of, if not more, behavioral bias than student subjects. Hence, there are good reasons to believe that the choice of subject pool would not drastically change the qualitative results of the experiment. Fréchette (2015) surveys the experimental literature regarding differences between students and professionals working in the relevant profession, and finds that studying the two groups typically leads to similar conclusions.

end of each period *t*, subjects received a summary of (i) their wealth and (ii) the CEO's effort and holdings at the end of period *t*.[6] The CEO was also informed of (iii) her accumulated salary up to the current period.

The sequence of events in a session was the following. Upon arrival, subjects were seated at visually isolated computer workstations and given a copy of the instructions[7]. After the instructions were read aloud, subjects had to complete a quiz about the experimental procedure, before proceeding to a practice period that did not count toward subject earnings. The experiment would continue only after subjects answered all questions correctly. Subjects were given randomly assigned trading IDs and also an assignment as a CEO or an investor in the practice round, and they retained the same roles in the actual market. At the end of the session, each trader was rewarded based on her final wealth in a randomly selected trading round. Subjects also completed the Holt and Laury (2002) risk aversion measurement protocol as well as a questionnaire, just before the end of the experimental session.

B. The Asset

In all treatments, at the end of period 10, the asset pays out a final liquidation value to the holder of each share. This liquidation value is a function of the CEO's effort over the 10-period life of the asset. The value created by the CEO in period *t* is given by

$$Y_t = f(e_t) = 1000e_t - 2000 \quad (1)$$

where Y_t is the additional value of the firm created in period *t* and e_t is the effort she chooses in period *t*. Similar to Nalbantian and Schotter (1997) and Fehr et al. (1998), the effort decision in our experiment consists of selecting a number instead of expending real effort. This choice was made for simplicity, and to avoid a situation where other traders would need to wait for a long time for the CEO to complete a real effort task. The total number of shares issued by the firm is $N = 200$, so that the additional value per share created by the CEO in one period is equal to $y_t = \frac{Y_t}{N}$. Note that Y_t is negative if $e_t < 2$, and equals 0 if e_t=2. An effort choice of $e_t < 2$ is interpreted as *shirking*, since it lowers the value of the company.

The CEO faces a convex cost function for effort, given by:

[6] In Smith et al. (1988),"(p)rior to each period, traders are reminded of the dividend distribution, and informed of the average, minimum, and maximum possible dividend earnings for each unit held in their inventory for the remainder of the experiment". We adopt a similar protocol by informing traders of the fundamental value and the CEO's effort in each period. In their paper, Smith et al (1988) show that despite the presence of regular information provision, asset price bubbles still arise. This illustrates that the existence of price bubbles may not be abated even when traders are frequently reminded about the fundamental value of the asset.

[7] The complete instructions can be found in the Appendix.

$$c_t(e_t) = 50{e_t}^2 \quad (2)$$

The stock does not pay dividends, and the entire value created by the CEO is added to, or subtracted from, the value of the firm. The stock has an initial value of V_0 = 110 ECU. We shall use the term *Liquidation Value* at time *t*, V_t, to denote the initial value of a share, plus any additional value that the CEO has created up to time *t*.[8] The liquidation value evolves according to the following process:

$$V_t = V_{t-1} + y_t = V_{t-1} + \frac{(1000e_t - 2000)}{200} = V_{t-1} + 5e_t - 10 \quad (3)$$

The liquidation value V_t remains unchanged from its level in period *t* - 1 if $e_t = 2$ in all periods *t*. V_t increases (decreases) in period *t* if e_t is greater (smaller) than 2. At the time the market is operating in period *t*, the CEO's current effort e_t is private information. Otherwise, all parties have equal information.

C. The Treatments

The treatments differ only in the manner in which CEO is compensated and whether she is permitted to trade shares. Exactly one compensation scheme is in effect in each session. In the L (Linear Compensation) treatment, she is compensated with a linear wage compensation plan. In the S (Stock Ownership) treatment, a stock ownership plan is in effect. The CEO is permitted to trade the stock of her firm in the LT (Linear Compensation with Trading) and the ST (Stock Ownership Plan with Trading) treatments, respectively. Thus, our experiment employs a 2x2 design.

Table I

Structure of CEO Compensation in Treatments L and S

The subjects in the role of CEO can choose from five different effort levels as shown in the first column. The second through fifth columns report the change in the liquidation value, the cost, the benefit, and the utility (benefit minus cost) associated with each effort level, respectively.

Effort (e_t)	Change in Liquidation Value (y_t)	Cost at *t* $c(e_t)$	Benefit at t $(a_t + 0.2Y_t)$	Utility at *t* $(a_t + 0.2Y_t - c(e_t))$
0	-10	0	0	0

[8] As we describe later in the paper, the liquidation value does not necessarily correspond to the price at which trade occurs.

1	-5	50	200	150
2	0	200	400	200
3	5	450	600	150
4	10	800	800	0

The CEO receives a fixed salary $a_t = 400$ in each period. Depending on the treatment, she may also receive a cash bonus b_t, and/or a capital gain or loss through changes in her ownership value $s_t y_t$ for holding shares. The cash bonus and capital gain/loss are both proportional to the firm's profit Y_t. In treatment L, we let

$$b_t = 0.2Y_t \tag{4}$$

This means that the cash bonus to the CEO is equivalent to 20% of the profit of the firm. This bonus is credited to the CEO's salary in addition to her salary in each period.

In Treatment S, the CEO has an initial endowment of $s_0 = 40$ shares, and the CEO is not allowed to sell this endowment. A change in the value of shares at time *t* generates a capital gain/loss of

$$\frac{s_0}{N} Y_t = \frac{40}{200} Y_t = 0.2Y_t \tag{5}$$

in each period for the CEO. This implies that, without the possibility of share trading, and holding the CEO's effort e_t equal, the cash bonus in treatment L and capital gain in treatment S are exactly identical. However, unlike the cash bonus in treatment L, the ownership value is not credited as salary to the CEO in each period. Instead, it is only realized at the end of the market after period 10. We provide information about the appreciation or depreciation of traders' shares in the summary screen at the end of each period, so that all participants can track their capital gains in each period.

Therefore, in both treatments L and S, the utility of the CEO can be written as:

$$U_t = a_t + 0.2Y_t - c(e_t) = [400 + (200e_t - 400)] - 50{e_t}^2 \tag{6}$$

The *payoffs* to the CEO for different levels of effort are shown in Table I. If the CEO purely maximizes her individual payoff, she would always choose $e_t = 2$, in which case Y_t=0, and the liquidation V_t of the

stock shares would stay unchanged at 110 over the ten periods. In other words, the optimal effort e_t^* in treatments L and S always equals 2.

Table II
CEO Compensation in Treatments LT and ST

The subjects in the role of CEO can choose from five different effort levels, as shown in the first column. The second through fifth columns report the change in the liquidation value, the cost, the benefit, and the payoff/ utility (benefit minus cost) associated with each effort level, respectively. Differently from L and S, the payoff of the subjects in these treatments depends on the additional shares that they have accumulated, s'_t.

Effort (e_t)	Change in Liquidation Value (y_t)	Cost at t $c(e_t)$	Benefit at t ($a_t + 0.2Y_t + s'_t * y_t$)	Payoff at t ($a_t + 0.2Y_t + s'_t * y_t$- $c_t(e_t)$)
0	-10	0	$-10s'_t$	$-10s'_t$
1	-5	50	$200 - 5s'_t$	$150 - 5s'_t$
2	0	200	400	200
3	5	450	$600 + 5s'_t$	$150 + 5\ s'_t$
4	10	800	$800 + 10s'_t$	$10s'_t$

The CEO's incentives in the LT and ST treatments differed from those in L and S. Let s'_t be the number of stock shares held by the CEO in each period, in addition to her initial endowment in treatments LT and ST. That is, if s_t is the stock position held by the CEO in treatment LT in period t, then $s'_t = s_t$. Similarly, if s_t is the stock position held in treatment ST, then $s'_t = s_t - 40$ (40 is the CEOs initial endowment in ST). The net utility gained from choosing effort e_t can be expressed as a function of effort (e_t) and the number of assets held before the stock trading begins (s'_t):

$$U_t = a_t + 0.2Y_t + s'_t * y_t - c_t(e_t) \quad (7)$$

$$U_t = [400 + (200e_t - 400)] + [5e_t * s'_t - 10s'_t] - 50{e_t}^2$$

$$U_t = -50{e_t}^2 + (200+5s'_t) * e_t - 10s'_t \quad (8)$$

The total utility she receives over a ten-period market is therefore:

$$U = \sum_{t=1}^{10}[-50{e_t}^2 + (200+5{s'}_t) * e_t - 10{s'}_t] \quad (9)$$

Table II shows that an effort level of 2 is the optimal effort for the CEO at the initial level of share holdings. That is, $e_t^*({s'}_{t=1} = 0) = 2$. Consequently, the liquidation value of a share remains at 110 ECU if 1) the CEO does not change her asset endowment (hence ${s'}_t = 0$), and 2) the CEO always chooses the optimal level of effort $e_t^*({s'}_t = 0) = 2$.

Table III
Optimal Effort as a Function of Shares Held

The optimal effort level for a CEO changes with the number of additional shares accumulated, given bys_t'. The first and the second columns give ranges of asset holdings and their definitions. The third column gives the corresponding optimal CEO effort levels.

Additional Shares Accumulated	Notation	Optimal Effort $e_t^*({s'}_t)$
$0 \le {s'}_t < 10$	Low Possession (*LP*)	$e_t^*({s'}_t) = 2$
$10 < {s'}_t < 30$	Medium Possession (*MP*)	$e_t^*({s'}_t) = 3$
$30 < {s'}_t \le 200$	High Possession (*HP*)	$e_t^*({s'}_t) = 4$
The total shares outstanding N=200		

In LT and ST, the CEO has an incentive to purchase and accumulate shares over time and then to exert high effort to increase the value of her holdings. When the CEO owns more shares, it is optimal for her to expend effort greater than $e = 2$. More generally, the optimal effort in period *t* varies depending on ${s'}_t$.[9] Table III summarizes the relationship between optimal effort and CEO share holdings.

D. The Parameters

[9] Investors are able to derive how the optimal effort of the CEO changes with her asset holdings, as they are also given information on how ${s'}_t$ affects the CEO's payoff (that is identical to the information given to the CEOs).

All investors other than the CEO start period 1 of each market with an endowment of 40 shares[10]. Given that the initial share value is 110 ECUs[11], an investor's stake in the firm is 4400 ECUs per trader. In addition, each trader other than the CEO receives an initial cash endowment of 4000 ECUs. Thus, the initial endowment of each non-CEO investor, evaluated at the initial liquidation value, is 8400 ECUs. Thus, the CEO and each investor is equally wealthy at the beginning of the session. All CEOs also receive initial cash amounting to 4000 ECUs at the beginning. In LT and ST, this cash can be used for purchases. In *L* and *S*, this cash is stored in a saving account. This cash endowment means that expected payoff of a CEO in L and S is identical to LT and ST if the latter groups do not change their share holdings.

The initial value of the CEO's shares in each market in treatments S and ST is 4400 ECUs, given the initial endowment of 40 shares. To make the total initial wealth of CEOs in L and LT comparable with S and ST, we endow 4400 ECUs in cash to CEOs in L and LT. This yields a total of 8400 ECUs of initial wealth for all CEOs, which is equal to the initial wealth of a non-CEO investor. The cash endowment of CEOs in L and LT cannot be used for trading, but converts to earnings at the end of the market. In LT and ST, the salary account is separate from the trading account so that the CEOs in treatments LT and ST cannot use their salary income to trade, which ensures that the cash-asset ratio does not vary over time in our experiment.[12] Table IV summarizes the initial endowment of CEO and investors.

[10] We give equal initial asset endowment to both CEO and investors, in order to create a setting where shareholders of the company split the securities equally. Thus, we have one fewer investor in Treatment *S* and *ST*, to ensure that the total number of shares in the market is always equal to 200.

[11] As the asset value can fall by at most 10 ECU in each period, we set 110 ECU as the starting value of asset. This ensures that the asset's terminal value can never be negative or zero.

[12] The cash-to-asset ratio is the ratio of the total amount of cash held by investors, divided by the total value of the assets in market, evaluated at their intrinsic value. Greater cash-to-asset ratios have been associated with higher prices (Caginalp et al., 1999; Haruvy and Noussair, 2006; Kirchler et al., 2012).

Table IV
Initial Endowment of CEO and Non-CEOs

Initial Cash is the cash that the participant can use to purchase shares of stock. *Free Gift* means the "gift" from the experimenter to the subjects to make sure that the CEOs on expectation earn the same payoff across the treatments. *Ownership Value* means the initial value of the endowment in terms of shares.

	CEOs							
Treatment:	L		LT		S		ST	
Type of Account:	Saving	Liquid	Saving	Liquid	Saving	Liquid	Saving	Liquid
Initial Cash	4000	0	0	4000	4000	0	0	4000
Free Gift	4400	0	4400	0	0	0	0	0
Total Initial Cash	8400	0	4400	4000	4000	0	0	4000
Initial Share	0		0		40		40	
Initial Ownership Value	0		0		4400		4400	
Total Initial Endowment Value	8400		8400		8400		8400	
C/A for CEO	-		-		91%		91%	

	Investors (Non-CEO Traders)			
Treatment:	L	LT	S	ST
Type of Account:	Liquid	Liquid	Liquid	Liquid
Total Initial Cash	4000	4000	4000	4000
Initial Share	40	40	40	40
Initial Ownership Value	4400	4400	4400	4400
Total Initial Endowment Value	8400	8400	8400	8400
C/A for Trader	91%	91%	91%	91%

We also standardize the market parameters as much as possible in order to facilitate the comparison across treatments. To create an identical number of shareholders in each market, we set the number of investors in treatment S and ST to four (instead of five as in L and LT), as the CEO in S and ST also acts as one of the company shareholders. Thus, Treatment S and ST have five subjects participating (four non CEO investors and one CEO with share ownership), while L and LT have six participants (with five non CEO investors and one CEO either without share ownership, which is always the case in Treatment L and at least initially with ownership in Treatment LT).

E. Determination of the Fundamental Value Models

The liquidation values in our experiment are *endogenously* determined by the CEO's decisions. In treatments L and S, the liquidation value remains at 110 as long as the CEO does not depart from the choices that maximize her own earnings. However, once the CEO deviates from the optimal choices in any of the trading period, the liquidation value also changes.

In treatments LT and ST, the liquidation value does not necessarily remain at 110, even if the CEOs choose their effort optimally given their holdings, because the CEO may accumulate or de-cumulate assets. The variables e_t , s'_t, and V_t are not observable to the investors when they trade in period *t*. Investors, however, can utilize the information about V_{t-1} and s'_{t-1}, given to them at the end of trading in period *t-1*, to compute a fundamental value model at period *t*, $\widetilde{FV}_t$. As such, we propose *four* plausible candidates for $\widetilde{FV}_t$.

The first candidate model, called *Naïve Expectations* (NE), is based on the assumption that the CEO purchases as many shares as she can using her initial cash endowment, and other investors have Naïve Expectations about the fundamental value of the asset. They are not aware that the CEO plans to acumulate units, and sell their shares to the CEO at any price greater than or equal to 110. In other words, the non-CEO investors have Naive Expectations. If the CEO uses all her cash to buy assets at the price of 110, she can buy 36 additional shares with a market value of 36*110=3960. When she holds 36 additional shares, her optimal effort is 4, and this increases the liquidation value by 10 in each period. Accordingly, the time trajectory of the fundamental value is given by

$$\widetilde{FV}_t = \{110, 120, 130, \dots, 210\} \quad \text{for} \quad t \in \{1,2,3, \dots,10\}$$

The second model, *Rational Expectations* (RE), is also based on the assumption that the CEO attempts to accumulate all the shares that she can. Non-CEO investors, however, have Rational Expectations, and thus anticipate the CEO's behavior. Consequently, investors try to obtain better prices for their shares.[13] When this happens, the shares become more expensive, and the CEO cannot buy enough shares to make her optimal effort equal to 4. The CEO accumulates as many units as possible, and it is optimal for the CEO to choose an effort of 3 in all periods. Because the CEO is given 4000 ECUs worth of cash before trading in the first period commences, the CEO can only purchase 4000/160 = 25 additional shares. The optimal effort $e^*(s_t' = 25) = 3$ when $s_t' = 25$. Therefore, the fundamental value trajectory under the RE model is:

$$\widetilde{FV}_t = \{110, 115, 120, \dots, 160\} \quad \text{for} \quad t \in \{1,2,3, \dots,10\}$$

Under the third model, *Backward-Looking Expectations* (BL), we assume that investors use only the previously prevailing liquidation value V_{t-1}, which becomes observable in period *t*, to estimate the intrinsic value of the shares of asset exchanged in period *t*. That is,

$$\widetilde{FV}_t = V_{t-1}$$

[13] There are two possible better prices. One is 160 ECUs, which is realized when the CEO's effort is equal to 3 for all periods, and the other is 210 ECUs, when the CEO's effort is equal to 4 for all periods. However, when the price is 210 ECUs, the cash endowment of the CEO is insufficient to buy enough shares (30 shares) for e=4 to be conditionally optimal. So 160 ECUs is the only feasible better price, at which the CEO buys 25 additional shares. Her optimal effort is equal to $e_t^* = 3$ when she has accumulated this number of shares.

Such a *backward-looking* rule of estimating the liquidation value is especially applicable for investors who observe $s'_{t-1} = 0$. They might reasonably anticipate no change in the CEO's effort in any later period.

The last candidate for $\widetilde{FV}_t$, called *Forward-Looking Expectations* (FE), assumes that traders believe that the CEO will behave rationally in her future purchase and effort decisions. The expected *optimal* change in the liquidation value between periods $t-1$ and t (hereby denoted as $dV^*(s'_{t-1})$) follows the rule:

(i) $dV^*(s'_{t-1}) = 0$ if $s'_{t-1} < 10$,

(ii) $dV^*(s'_{t-1}) = 5$ if $10 \leq s'_{t-1} < 30$, and

(iii) $dV^*(s'_{t-1}) = 10$ if $s'_{t-1} > 30$.

Thus, $\widetilde{FV}_t$ follows the trajectory:

$$\widetilde{FV}_t = V_{t-1} + dV^*(s'_{t-1}).$$

The first two notions *NE* and *RE* represent the pre-determined fundamental value models for the 10-period life of the asset that are independent of history. The last two candidates, *BL* and *FL*, are one-period ahead, extrapolative models that depend on the history of CEOs' activities. In our subsequent discussions in this paper, we use the term 'extrapolative fundamental value model' to denote the BL and FL models, and the term 'static fundamental value model' to denote the RE and NE models.

F. Testable Hypotheses

The hypotheses that we test in our experiment are based on the arguments above regarding optimal behavior. The first two hypotheses concern CEO behavior. In the L and S treatments, the effort that yields the highest payoff to the CEO is always 2, and the resulting liquidation value is 110. We take as our null hypothesis that the average effort will equal this level. Stating the hypothesis in terms of average behavior allows for some unbiased noise in the effort decisions.

HYPOTHESIS 1*: In treatments L and S, the CEO chooses an average effort $e = 2$, and the liquidation value of the asset averages 110 over the life of the asset.*

Rejection of Hypothesis 1 would indicate that the CEO exhibits biases in her choice of effort. Such a pattern would suggest that the CEO might have other considerations in choosing her effort level other than simply choosing the one that would maximize her earnings. For example, she might feel a need to exercise her fiduciary duty to the shareholders by acting in the best interests of shareholders.

The parameter values in the experiment were chosen so that CEO incentives to exert effort and accumulate units, as well as her capacity to purchase units, are identical under LT and ST. Therefore, we hypothesize that there would be no difference in effort in the two conditions.

HYPOTHESIS 2*: CEOs exert similar effort when they are paid by the stock ownership and when they receive cash bonuses. Thus, average effort is the same between treatments L and S, as well as between treatments LT and ST.*

Rejection of Hypothesis 2 would suggest that the CEOs are indeed influenced by the stock ownership program. In particular, greater effort in the S than the L treatment, and more effort in the ST than the LT treatment, would be consistent with a feeling of responsibility or stewardship.

In the LT and ST treatments, the CEO's optimal effort $e^*(s'_t)$ is increasing in her holdings s'_t. We thus expect that some CEOs accumulate shares and then exert high effort to increase their value, while other CEOs sell their shares and subsequently shirk. The consequence is a positive relationship between share holdings and effort.

HYPOTHESIS 3*: In LT or ST, there is a positive correlation between CEO share holdings and CEO effort.*

The last hypothesis concerns market prices. In the L and S treatments, there is an unambiguous prediction about market prices; these should be equal to 110, the liquidation value under optimal CEO effort. For the LT and ST treatments, we do not advance a hypothesis about which of the expectation rules described above would apply, but rather compare their relative performance. While bubbles have been observed in other experimental designs, it would be interesting to investigate whether they would also occur here. We hypothesize that prices would track liquidation values in the treatments where the liquidation value is unambiguous.

HYPOTHESIS 4*: In the L and S treatments, prices equal the liquidation value of 110.*

III. Results

A. Effort Decisions in the L and S Treatments

Table V reports the average CEO effort, by treatment, with the average effort exerted by each individual in one market taken as a unit of observation. In the L and S treatments, the average effort of the CEO is close to the predicted level of 2. In particular, CEOs choose an average effort that modestly exceeds 2 by 11% and 8% in the two treatments, respectively. The first difference is significant ($t = 2.63$, $p < .05$, two-tailed test), while the second is marginally significant ($t = 1.91$, $0.05 < p < .1$, two-tailed test). A similar pattern of significance is observed under signed-rank tests. We are unable to reject the null hypothesis that the average effort in treatment L is statistically distinct from treatment S, with either a t-test or a signed rank test.

Table V
The Summary Statistics of Effort of CEOs

The first column reports the name of the treatments, and the second through sixth columns report the mean, standard deviation, the *p*-value of the t-test and the signed rank test against the predicted effort of 2, and the number of observations.

Treatment	mean	s.d.	Average Effort Exerted t-test *p*-value (*H0*: Mean Effort = 2)	Signed Rank *p*-value (*H0*: Mean Effort = 2)	n
L	2.22	0.41	0.0151	0.0136	24
LT	2.53	0.54	0.0001	0.0002	24
S	2.16	0.4	0.0694	0.0759	22
ST	2.39	0.77	0.0039	0.003	22
			t-test *p*-value	Mann-Whitney *p*-value	n
H0: L = LT			0.0286	0.034	48
H0: S = ST			0.0724	0.1372	44
H0: L = S			0.6671	0.69	46
H0: LT = ST			0.8195	0.6197	46

We thus show that Hypothesis 1 receives partial support in relation to Result 1:

Result 1*: In the L and S treatments, in which the CEO cannot trade shares, the CEO's effort is close to, though modestly exceeding, the optimal level of 2. The difference is small but significant*.

B. The Impact of Allowing the CEO to Trade on the CEO's Effort Choices

In this subsection, we examine the effort decisions in Treatments LT and ST, where the CEO can participate in share trading. Table VI reports the average value of s'_t in the final period of Treatments LT and ST. The table shows that the CEOs hold on average 18.5 and 18 more shares, in LT and ST respectively, than their initial share endowments. While there is no significant difference between the final s' in LT and ST, both figures are significantly different from zero under both the t-test and the signed rank test. Around 90% of CEOs hold more assets at the end of the market than at the beginning.

Table VI
CEOs' Asset Holdings

This table reports the mean and standard deviation of the average CEO's accumulation of share holdings s'_t. It also contains the *p*-values of the t-test and the signed rank test against a mean value of zero, and the number of observations.

CEO's Final s'_t					
Treatment	mean	s.d.	t-test *p*-value (*H0*: Final $s'_t = 0$)	Signed Rank *p*-value (*H0*: Final $s'_t = 0$)	n
LT	18.46	17.52	< 0.0001	< 0.0001	24
ST	18	12.53	< 0.0001	< 0.0001	22
			t-test *p*-value	Mann-Whitney *p*-value	n
H0: LT = ST			0.9198	0.7495	46

Table VII
The Average Difference between the Observed and the Optimal Effort

The first column lists the name of the treatments, and the second through sixth columns report the mean, standard deviation, the *p*-values of t-test and signed rank test of the hypothesis that observed and optimal efforts are equal, and the number of observations.

Treatment	mean	s.d.	Average of $e_t - e^*(s'_t)$ t-test *p*-value (H0: Deviation = 0)	Signed Rank *p*-value (H0: Deviation = 0)	n
LT	0.08	0.74	0.6030	0.4913	24
ST	-0.09	0.61	0.4929	0.4447	22
			t-test *p*-value	Mann-Whitney *p*-value	n
H0: LT = ST			0.4006	0.3269	46

The increase in the CEO's holdings of asset in LT and ST means that the optimal effort exceeds the level of 2 that would prevail if there were no accumulation of assets. As such, the analysis in Table V provides little insight as to whether CEOs over-or under-exert effort relative to the optimal level in LT and ST. Table VII displays the average difference between observed and optimal effort in the LT and ST treatments $(e_t - e^*(s'_t))$, with the average effort of an individual CEO within one session taken as a unit of observation. Later in the paper, we shall refer to this difference $(e_t - e^*(s'_t))$ as the *effort deviation* at time t. Note that $e^*(s'_t)$ denotes the optimal effort adjusted for actual asset holdings. As shown in the first and second rows of Table VII, we are not able to reject the null hypothesis that the difference between the observed and the asset-holdings-adjusted optimal effort is equal to zero in either treatments LT and ST, with either t-tests or signed- rank tests. In other words, CEOs in both LT and ST exert optimal effort. Nevertheless, the standard deviation in treatment LT (ST) is greater than under L (S). They are, respectively, 0.74 (0.61) and 0.41 (0.17). Thus, when the CEO is able to trade, the variation in the effort levels is greater.

We are not able to reject the null hypothesis that the effort deviation in LT is statistically distinct from that in ST, with either a t-test or a signed rank test. The result, coupled with the lack of difference between L and S, indicates that stock ownership does not significantly increase managerial effort, relative to an equivalent cash bonus. There is no evidence that the CEO behaves like a steward of the firm when she possesses more equity. As stated in result 2, hypothesis 2 is supported.

***Result 2**: Average effort is not significantly different between L and S, and between LT and ST.*

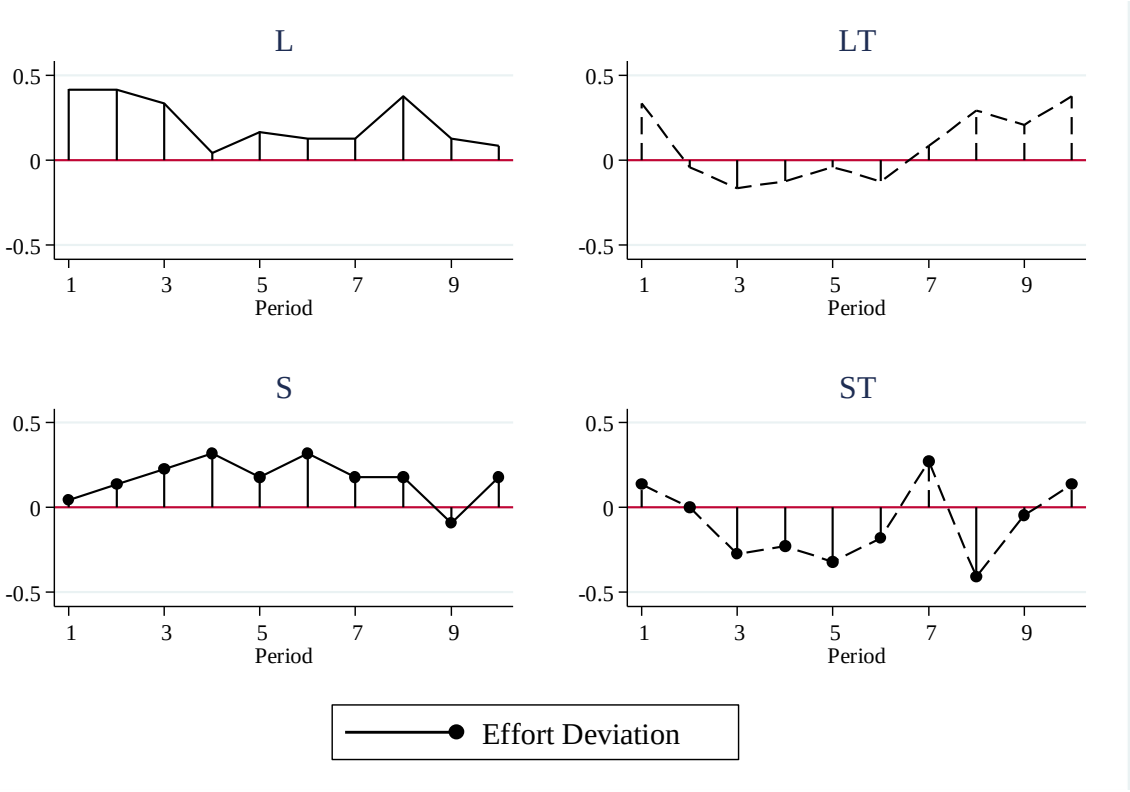


Figure 1: The Average Difference between the Observed and the Optimal Effort. The vertical axis measures the average effort deviations from the conditionally optimal trajectory across all sessions in the same treatment, while the horizontal axis measures the market period for treatment L (top left), S (bottom left), LT (top right) and ST (bottom right). The data series are the average differences between observed and optimal effort in each treatment.

The time profile of effort in LT and ST is shown in Figure 1. In the figure, the vertical axis measures the average deviation of effort from the conditionally optimal trajectory across all sessions in the same treatment, while the horizontal axis measures the market period. As shown in the leftmost panel of the table, the solid line (treatments L and S) hovers close to, though slightly above the horizontal line. This suggests that CEOs consistently exert close to optimal effort throughout the session. While the dashed line (treatments LT and ST) fluctuates above and below the zero deviation line, it remains very close to the optimal trajectory. Overall, hypothesis 3 is supported, as stated in result 3.

Result 3*: In LT and ST treatments, CEOs accumulate assets over time. Effort levels are close to optimal given CEOs' asset holdings.*

C. Market Responses to Endogenously Determined Liquidation Values

In this section we investigate the dynamics of the liquidation values, as well as the relationship between prices and the fundamental value models. We first evaluate how well the the fundamental value models track the liquidation values. Recall that there are two types of model; 1) the extrapolative models (BL and FL) and 2) the static models (RE and NE). In the subsequent analysis, we also include the neutral fundamental value of 110 ECUs as an additional static model.

Figure 2 presents the time series of the average differences between the predicted fundamental values based on the aforementioned models and the actual liquidation values ($\widetilde{FV}_t - V_t$), with the average of all markets within a treatment taken as a unit of observation. The vertical axis measures ($\widetilde{FV}_t - V_t$), while the horizontal axis measures the market period. The closer the time series line is to zero, the smaller the difference between the data and the particular model in question, and thus the better the fit between the model and the actual liquidation values.

As shown in the left side of Figure 2, the series marked with hollow circles is closer to the 0-line than is the dark-square line in treatments L and S. Similarly, the hollow-circle and light- diamond lines are closer to the 0-line than the dashed, cross-dashed, and dark-square lines in treatments LT and ST, shown in the right side of Figure 2. These results suggest that the extrapolative models (BL and FL) correspond more closely to the trajectory of the liquidation value than do the static models (RE and NE).

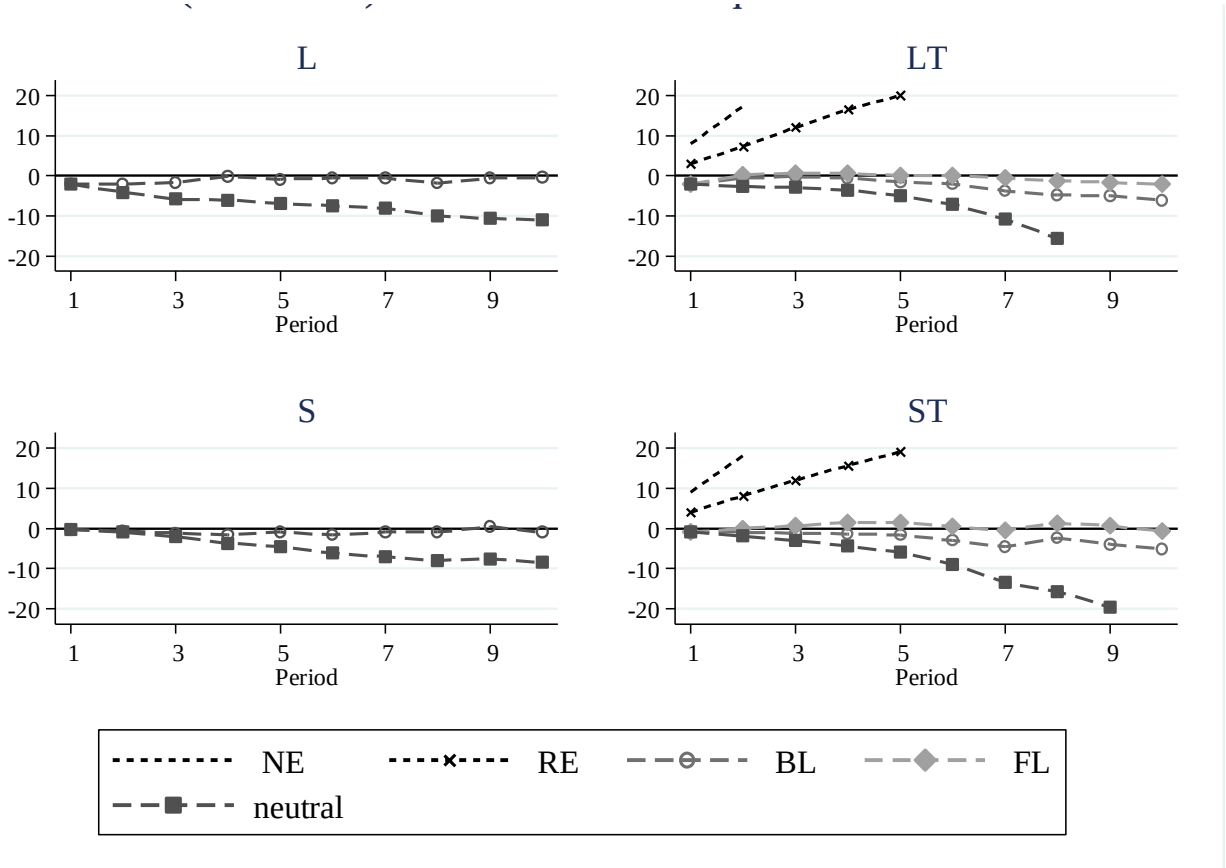


Figure 2: The Difference between Fundamental Value Models and the Liquidation Values ($\widetilde{FV}_t - V_t$). The vertical axis measures ($\widetilde{FV}_t - V_t$), while the horizontal axis is the market period. The data are the average of all markets within a treatment. The closer the time series line is to zero, the better the fit of the model to the liquidation value data. Note that under the L and S treatments, FL cannot be derived because CEOs are not allowed to trade shares, and thus their shareholdings always remain the same.

Table VIII
The Average Difference between the Fundamental Value Models and the Liquidation Values

The first column lists the name of the treatments, and the second through sixth columns report the mean, standard deviation, the *p*-values of t-tests and signed rank tests of the hypothesis that the difference equals zero, and the number of observations, respectively.

(Treatment L) Average Liquidation Value Dispersion from :

	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
Neutral value	-7.23	12.36	0.01	0.01	24
BL	-1.10	2.06	0.02	0.01	24
t-test *p* -value (H0: Neutral = BL)				< 0.01	
Signed rank *p* -value (H0: Neutral = BL)				< 0.01	

(Treatment LT) Average Liquidation Value Dispersion from :

	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
NE	45.29	18.13	< 0.01	< 0.01	24
RE	17.79	18.13	< 0.01	< 0.01	24
Neutral value	-9.71	18.13	0.02	0.02	24
BL	-2.67	2.69	< 0.01	< 0.01	24
FL	-0.63	3.48	0.39	0.41	24
t-test *p* -value (H0: BL = FL)				< 0.01	
Signed rank *p* -value (H0: BL = FL)				< 0.01	
Kruskal-Wallis p-value				< 0.01	

(Treatment S) Average Liquidation Value Dispersion from :

	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
Neutral value	-4.84	12.58	0.09	0.08	22
BL	-0.84	2.06	0.07	0.07	22
t-test *p* -value (H0: Neutral = BL)				0.09	
Signed rank *p* -value (H0: Neutral = BL)				0.10	

(Treatment ST) Average Liquidation Value Dispersion from :

	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
NE	45.20	20.84	< 0.01	< 0.01	22
RE	17.70	20.84	< 0.01	< 0.01	22
Neutral value	-9.80	20.84	0.04	0.05	22
BL	-2.45	3.55	< 0.01	< 0.01	22
FL	0.43	3.07	0.52	0.61	22
t-test *p* -value (H0: BL = FL)				< 0.01	
Signed rank *p* -value (H0: BL = FL)				< 0.01	
Kruskal-Wallis p-value				< 0.01	

We present the gap between each model and the liquidation values in Table VIII, and find statistical evidence showing that the gap between the extrapolative models and the liquidation values is the smallest among the fundamental value models, in market L, LT and ST. We infer from this pattern that the extrapolative fundamental value models (BL and FL) describe the trajectory of the liquidation values more accurately than the static models (RE and NE). The signed rank pairwise test outcome in market S, however, indicates that the difference between the gap of BL and the neutral value is not statistically significant. This result comes as no surprise given that CEO's effort choices are especially close to the optimal effort in the market.

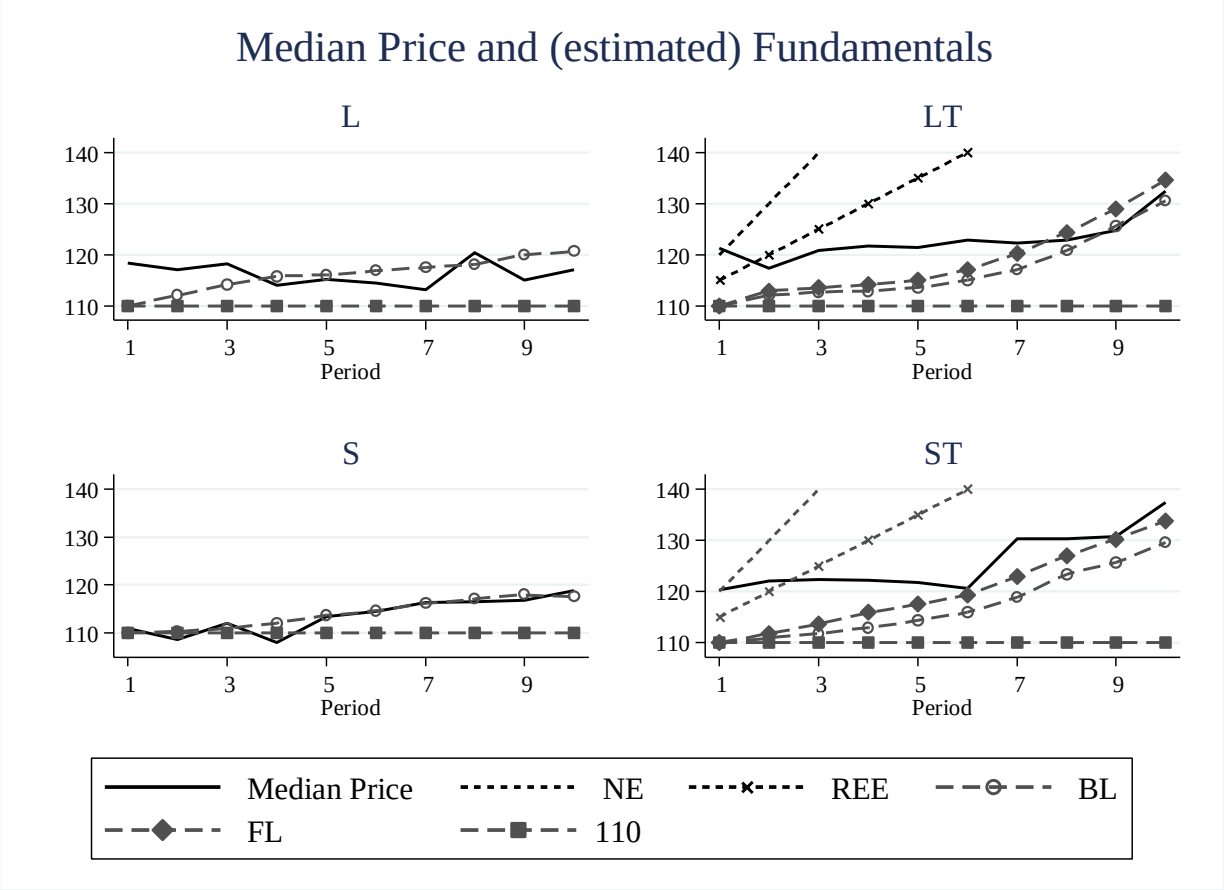


Figure 3: Median Prices and the Fundamental Value Models. The vertical axis measures the predictions of the fundamental value models and observed median prices, while the horizontal axis measures the market period. The data are averages of all markets within a treatment. The solid line is the median realized price, the dashed line is the fundamental value model under naïve expectations, and the cross-dashed line is the value under rational expectations. The line marked with hollow circles indicates the fundamental value under the backward-looking model, the line marked with light diamonds is the forward-looking model, and that with dark squares corresponds to the neutral effort level of two. Note that under the L and S treatments, FL cannot be derived because CEOs are not allowed to trade shares, and thus their shareholdings always remain the same.

Next, we look at the relationship between market prices and the fundamental value models. Figure 3 presents the time series of the median prices and $\widetilde{FV}_t$. The vertical axis measures the fundamental value models and the prices, while the horizontal axis measures the market period. The data are averages of all markets within a treatment. As can be seen in all panels of Figure 3, the gap between the solid line (the median price) and the dotted line (NE, RE and $\widetilde{FV}_t$=110) increases, while the gaps between the solid line

(median price) and the dashed hollowed-circle line ($\widetilde{FV}_t$=*BL*) and the dashed-diamond line ($\widetilde{FV}_t$ =*FL*) close as the market proceeds. The market price seems to increasingly deviate away from the $\widetilde{FV}_t$ = 110, and converges towards the *BL* and *FL* models rather than the *NE* or *RE* models.

Table IX
The Median Price Dispersions from different Fundamental Value Model Predictions

We report the mean of the difference between the realized median market price and the prediction of each of the fundamental value models, the *p*-values of t-tests of the hypotheses that these means are equal to zero, and the number of observations. NE, RE, and 110 represent the static models, while BL and FL represent the extrapolative models.

(Treatment L) Median Price Difference from:					
	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
Neutral value	15.62	17.52	< 0.01	< 0.01	24
BL	-0.42	14.83	0.89	0.27	24
t-test *p* -value (H0: Neutral = BL)				< 0.01	
Signed rank *p* -value (H0: Neutral = BL)				< 0.01	

(Treatment LT) Median Price Difference from:					
	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
NE	-41.26	17.88	< 0.01	< 0.01	24
RE	-14.06	17.27	< 0.01	< 0.01	24
Neutral value	23.14	16.81	< 0.01	< 0.01	24
BL	6.23	14.90	0.05	< 0.01	24
FL	4.20	14.36	0.17	< 0.01	24
t-test *p* -value (H0: BL = FL)				< 0.01	
Signed rank *p* -value (H0: BL = FL)				< 0.01	
Kruskal-Wallis p-value				< 0.01	

(Treatment S) Median Price Difference from:					
	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
Neutral value	13.77	12.08	< 0.01	< 0.01	22
BL	-0.22	6.59	0.88	0.08	22
t-test *p* -value (H0: Neutral = BL)				< 0.01	
Signed rank *p* -value (H0: Neutral = BL)				< 0.01	

(Treatment ST) Median Price Difference from:					
	mean	sd	t-test *p* -value (H0:0)	Signed rank *p* -value (H0:0)	n
NE	-38.86	22.71	< 0.01	< 0.01	22
RE	-11.86	21.71	0.02	0.02	22
Neutral value	25.14	20.96	< 0.01	< 0.01	22
BL	8.21	18.38	0.05	< 0.01	22
FL	5.38	19.16	0.20	0.59	22
t-test *p* -value (H0: BL = FL)				< 0.01	
Signed rank *p* -value (H0: BL = FL)				< 0.01	
Kruskal-Wallis p-value				< 0.01	

Table IX presents the average distance between median prices and $\widetilde{FV}_t$, with each market as a unit of observation. The gap between market prices and $\widetilde{FV}_t$ = 110 is larger than that between market prices and *BL* in treatments L and S. In other words, investors utilize the previously prevailing liquidation value V_{t-1} to anticipate the current liquidation value. They employ past effort trends in forming their

beliefs/expectations of the future liquidation values. We view this as a natural response to CEOs' departures from the optimal effort level of 2, (even though these departures are of a relatively small magnitude. Given that CEOs' asset holdings remain constant for the duration of the round, the only adaptive component the market can use as a predictor of the terminal value of the asset is the lagged effort of the CEO.

Unlike investors in L and S, investors in LT and ST are likely to observe variation in the CEO's prior period asset holdings, s'_{t-1}, over time. From Table IX, we observe that prices follow the extrapolative models more closely than the static models, as demonstrated by the smaller difference of market prices from the former. Indeed, investors price their transactions closer to $V_{t-1} + dV^*(s'_{t-1})$ than to V_{t-1}. The difference between the median price error of *BL* is statistically significantly larger than that of *FL* in both treatments, suggesting that investors utilize the information about s'_{t-1} (on top of the information about V_{t-1}). That is, investors adopt a *forward looking* strategy in estimating the value of their assets when the CEO is able to trade.

It is interesting to note that the difference between price and the *BL* and *FL* models is less than 5% of the actual value of V_{t-1} and $V_{t-1} + dV^*(s'_{t-1})$, respectively. Traders in all markets; L, S, LT, and ST, interpret and react to the endogenous flow of information on CEO's activities accurately. Non-CEOs in market LT and ST might be in a better position than their counterparts in market L and S. The former can incorporate information regarding the CEO's asset holding on top of the lagged effort, to form a better predictor of the liquidation values. Consequently, one might expect LT and ST markets to produce higher efficiency than L and S markets. However, our data show otherwise. We consider this phenomenon further in the next subsection.

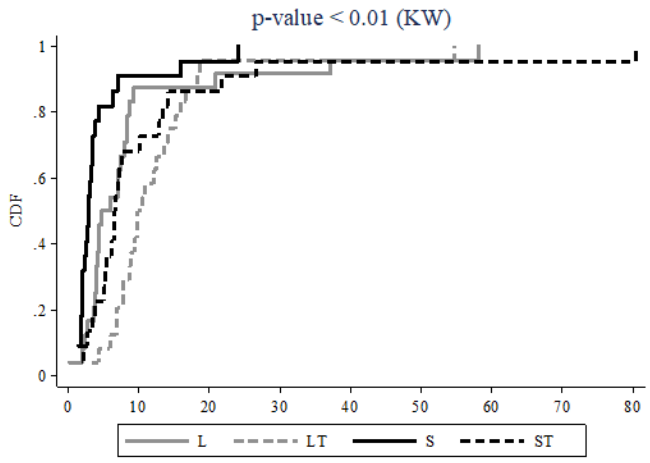
The relative performance of the different models in predicting the trajectory of the actual liquidation value is reported in result 4a. On the basis of the above analysis, we also reject the null of hypothesis 4. This is reported as result 4b, which describes the tendency for the CEO to increase firm value both when she does, and does not, have an opportunity to trade.

Result 4a*: The extrapolative fundamental value models (BL and FL) describe the trajectory of the liquidation values more accurately than the static models (RE and NE).*

Result 4b*: In the L and S treatments, where the CEO is not allowed to trade shares, the backward-looking model fits the price data best. In the LT and ST treatments, where CEO is allowed to trade shares, market prices correctly anticipate the CEO's tendency to exert high effort and increase the firm value*.

Our analysis in the preceding discussion shows that the extrapolative models are informative of CEO's effort choices (and thus asset liquidation values). Consequently, how well actual market prices adhere to

the models becomes the key to the attainment of market efficiency. Our earlier analysis has demonstrated that markets price their transactions close to the FL (BL) models in treatments with (without) CEO's trading capacity. The common information about CEO's lagged effort (and CEO's lagged asset holdings) forms the basis for market expectations about the asset price in the subsequent period. In what follows, we will compare the degree to which the market adheres to the extrapolative models. We will use the term extrapolative model to refer to BL in markets L and S, and FL in markets LT and ST.



Median Price - Extrapolative Models|					
Treatment	mean	sd	min	max	n
L	9.48	12.79	0.20	58.19	24
LT	12.64	9.91	3.39	54.78	24
S	4.59	5.34	1.50	24.11	22
ST	11.72	16.52	2.00	80.35	22

	Mann-Whitney p-value	n
H0: L = LT	< 0.01	48
H0: S = ST	< 0.01	44
H0: L = S	< 0.01	46
H0: LT = ST	< 0.01	46

Figure 4: The Market Price Conformity with the Extrapolative Models. The horizontal axis measures the absolute distance between market prices and the extrapolative models, while the vertical axis measures the CDF for market L (solid grey), LT (dashed grey), S (solid black) and ST (dashed black). The p-values relating to the Mann-Whitney (MW) test for pairwise comparison are presented in the table besides the figure. We also apply the Kruskall-Wallis (KW) test for the multiple comparisons.

Figure 4 shows the empirical cumulative distribution function (CDF) of the absolute distance between market prices and the extrapolative models in market L (solid grey), LT (dashed grey), S (solid black), and ST (dashed black); with one market taken as a unit of observation. It also shows the summary statistics (mean, standard deviation, minimum and maximum) as well as p-values from the pairwise Mann-Whitney tests and the Kruskal-Wallis (KW) for multiple comparisons. The KW tests demonstrate the differences across the four treatments are statistically significant. Comparing markets where CEOs are permitted to trade with markets where they are not, we find that the absolute price dispersion from the extrapolative models in treatment ST (LT) is 11.72 (12.64) ECUs more than it is in treatment S (L), where it equals 4.59 (9.48). The differences are statistically significant at the 1% significance level. This pattern suggests that markets are pricing closer to their extrapolative paths when CEOs are not allowed to trade shares in the markets.

There is also a systematic variation of the absolute deviation of market prices from the extrapolative model under different compensation schemes. As shown in Figure 4, the black lines (which represents market with stock ownership) are closer to the vertical axis than the grey lines (market with linear compensation). The absolute price difference from the extrapolative models in treatment L (LT) is statistically significantly higher than in treatment S (ST) at 1% significance level. Markets appear to be able to price their transactions closer to the extrapolative paths when CEOs are compensated with stock ownership.

The asymmetric reactions exhibited by CEOs and non-CEOs under a SOP are intriguing. While the SOP does not necessarily motivate CEOs to produce higher effort, it influences the market to produce more desirable reactions, which comes in the form of a closer adherence to the extrapolative models. We would expect this to affect the market efficiency as well, which we consider in the next subsection. The following statements summarize our findings in this subsection:

Result 5a*: CEOs invest effort closer to the optimal level when they are allowed to trade. If CEOs are allowed to trade, market prices deviate more from the extrapolative models (BL and FL).*

Result 5b*: CEOs invest similar effort when they are paid by stock ownership or with a cash bonus. However, market prices are more likely to follow the extrapolative models (BL and FL) than the static models (RE, NE, and the neutral value) when CEOs receive stock ownership rather than linear compensation.*

C. Market Efficiency and Price Quality

In this section, we test the conjectures raised in the previous sections by evaluating the following measures of market price discovery: (i) asset mispricing relative to the liquidation values, (ii) the bid-ask spread, and (iii) the price volatility, across the four treatments. The extent of mispricing is measured relative to the current liquidation values using the *Relative Absolute Deviation (RAD)*, *Total Dispersion (TD)*, and *Price Amplitude* (*PA*) indexes (Stöckl et al., 2010; Haruvy and Noussair, 2006; King et al., 1993). We also measure the cost of transactions by the *Absolute Spread* (*AS*) and *Relative Spread* (*RS*) (Amihud and Mendelson, 1986); and price volatility by the *VOLA* index (Stöckl et al., 2015). Table X provides the formal definition of the market quality indexes employed in our analysis.

Table XI presents the computation and the average value of each measure. While the numerical entries reported across the four panels are visibly smaller in magnitude than those typically observed in other studies, we are able to reject the null hypotheses that they are equal to zero. As shown in the first row, the average *RAD* in treatment *S* (*ST*) is 50.5% (4.24%) below that in treatment *L* (*LT*). In a similar fashion, the

average *TD* and *PA* in treatment *S* (*ST*) are 46% and 42.5% (12.7% and 43.8%); which are below those in treatment *LT* and *L*.

Table **X**. Market Efficiency Measurements

Measure	Calculation
Relative Absolute Deviation (*RAD*)	$RAD_r = \frac{1}{10}\sum_{t=1}^{10} \lvert\overline{P_{r,t}} - V_{r,t}\rvert / \overline{V_{r,t}}$
Total Dispersion (*TD*)	$TD_{r,t} = \sum_{t=1}^{10} \lvert\widetilde{P_{r,t}} - FV_{r,t}\rvert$
Price Amplitude (*PA*)	$PA_r = \frac{\max\left(\overline{P_{r,t}} - V_{r,t}\right)}{V_{r,0}} - \frac{\min\left(\overline{P_{r,t}} - V_{r,t}\right)}{V_{r,0}}$
Absolute Spread (*AS*)	$AS_r = \frac{1}{10}\sum_{t=1}^{10} SPREAD_{r,t}$
Relative Spread (*RS*)	$RS_r = \frac{1}{10}\sum_{t=1}^{10} \frac{SPREAD_{r,t}}{ORDERQ_{r,t}}$
Price Volatility (*VOLA*)	$VOLA_r = \frac{1}{10}\sum_{t=1}^{10} \sqrt{\frac{1}{U}\sum_{u=1}^{U} (RET_u - \overline{RET})^2}$

Notes: *t* denotes the *t*-th period in round *r*; $\overline{P_{r,t}}$, and $V_{r,t}$ are the average trading price and the liquidation value in period *t*, respectively. $V_{r,0}$ is the initial asset liqudiation value before CEO exerts effort in period 1 ($V_{r,0} = 110$). $SPREAD_{r,t}$ is the difference between the highest unexecuted ask quote and the lowest

unexecuted bid quote in period t; $ORDERQ_{r,t}$is the average of the bid and ask quotes in period t. $RET_u = \ln(P_u/P_{u-1})$; $\overline{RET}$ is the mean of log-returns in period *t*; U is the number of transactions in period *t*.

Next, we estimate the following regression:

$$y_{i,r} = \alpha + \beta_1 SOP_r + \beta_2 TRADE_r + \beta_3 SOP_r * TRADE_r + X_t'\theta + \varepsilon_r,$$

where $y_{i,r}$ represents our mispricing measure *i* averaged across all periods of market *r*; *SOP* takes the value of 1 under the stock ownership plan and 0 otherwise; and *TRADE* takes the value of 1 when CEO is allowed to participate in the market and 0 otherwise. We also interact the two categorical variables; *SOP*TRADE*. The vector of control variables X'consists of the average market risk aversion level (higher value indicates greater risk aversion); the proportion of participants with Business/Accountancy/Economics majors, who have previously traded stocks outside the laboratory, and who possess experience in asset market experiments. The variable *Round* is included in the estimation to control for any general time trend.

Table XII presents the estimation results, with one market taken as a unit of observation, and the standard errors clustered at the session level. As shown in the first row of Table XII, the estimated coefficients of β_1 of the SOP dummy in Columns 1 to 10 are statistically significant and negative, suggesting that the SOP reduces the difference between prices and actual liquidation values, as well as the overall cost of transactions. Comparison of markets with and without SOP thus indicates a systematic decrease in asset mispricing, the cost of transactions and price volatility.

Table XI
Market Efficiency and Price Quality

This table summarizes the mean, standard deviation, and the p-value of the t-test against zero for some commonly-used mispricing measures: RAD, Total Dispersion (TD), Price Amplitude (PA), Absolute Spread (AS), Relative Spread (RS), and the VOLA index.

	L			*LT*			*S*			*ST*		
	mean	*s.d.*	t-test *p*-value (H0:0)	*Mean*	*s.d.*	t-test *p*-value (H0:0)	*mean*	*s.d.*	t-test *p*-value (H0:0)	*mean*	*s.d.*	t-test *p*-value (H0:0)
Relative Absolute Deviation (RAD)	0.091	0.11	0.0005	0.118	0.09	< 0.0001	0.045	0.04	< 0.0001	0.113	0.17	0.0058
Total Dispersion (TD)	89	116	0.0010	124	106	< 0.0001	48	49	0.0002	110	164	0.0049
Price Amplitude (PD)	0.259	0.29	0.0002	0.372	0.23	< 0.0001	0.149	0.15	0.0001	0.209	0.13	< 0.0001
Absolute Spread	14.723	13.97	< 0.0001	17.748	9.66	< 0.0001	8.911	10.41	0.0006	11.979	9.83	< 0.0001
Relative Spread	0.125	0.12	< 0.0001	0.149	0.10	< 0.0001	0.083	0.10	0.0012	0.100	0.08	< 0.0001
Price Volatility (VOLA)	0.052	0.11	0.0340	0.070	0.08	0.0001	0.029	0.10	0.1741	0.023	0.02	< 0.0001
N	24			24			22			22		

Table XII
Determinants of mispricing

OLS regressions of determinants of mispricing measures. Each market is the unit of observation. SOP denotes that the stock ownership plan is present; and TRADE denotes that the CEO is allowed to trade. The control variables consist of the average risk aversion level among traders (higher value indicates greater risk aversion); the proportion of participants with Business/Accountancy/Economics majors, what proportion of the trader cohort has engaged in stock trading outside the laboratory and whether participants possess previous experience in asset market experiments. The Variable Round is included to control for the effect of prior experience within the same session. Standard errors are clustered at the session level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	RAD		Total Dispersion		Price Amplitude		Absolute Spread		Relative Spread		VOLA	
SOP	-0.0322**	-0.0322**	-23.61*	-23.62*	-0.0848**	-0.0846**	-4.491**	-4.474**	-0.0331*	-0.0329*	-0.0162	-0.0154
	(0.0105)	(0.0106)	(11.96)	(12.03)	(0.0278)	(0.0282)	(1.787)	(1.808)	(0.0151)	(0.0155)	(0.0114)	(0.0119)
TRADE	0.0356**	0.0355**	45.44**	45.44**	0.120**	0.120**	3.141	3.161	0.0220	0.0222	0.0139	0.0148
	(0.0122)	(0.0122)	(15.78)	(15.86)	(0.0503)	(0.0506)	(3.493)	(3.520)	(0.0321)	(0.0324)	(0.0193)	(0.0190)
SOP*TRADE	0.0343	0.0344	21.54	21.54	-0.0615	-0.0619	-0.277	-0.321	-0.00901	-0.00946	-0.0194	-0.0203
	(0.0435)	(0.0440)	(40.95)	(41.32)	(0.0636)	(0.0641)	(4.317)	(4.350)	(0.0374)	(0.0379)	(0.0217)	(0.0219)
Average Risk Aversion (Group)	-0.00156	-0.00194	-8.403	-8.429	0.0121	0.0138	0.699	0.852	0.00748	0.00904	-0.0145	-0.0137
	(0.0128)	(0.0129)	(15.66)	(15.67)	(0.0148)	(0.0169)	(1.074)	(1.243)	(0.00937)	(0.0109)	(0.0142)	(0.0151)
Ratio of Subjects with Bus/Acc/Econ Major	-0.105	-0.104	-100.5	-100.5	-0.249	-0.254	-16.65*	-17.13*	-0.151*	-0.156*	-0.0797	-0.0820
	(0.0670)	(0.0666)	(78.37)	(76.61)	(0.152)	(0.148)	(8.069)	(7.813)	(0.0759)	(0.0745)	(0.0585)	(0.0578)
Ratio of Subjects with Actual Trading Exp.	0.00702	0.00725	10.75	10.76	-0.0769	-0.0779	-5.385	-5.475	-0.0560	-0.0569	-0.0379	-0.0376
	(0.0687)	(0.0688)	(81.95)	(82.80)	(0.0971)	(0.101)	(5.461)	(5.571)	(0.0444)	(0.0444)	(0.0484)	(0.0481)
Ratio of Subjects with Experiment Exp.	-0.00229	-0.00253	7.512	7.495	-0.0420	-0.0409	-5.061	-4.964	-0.0657	-0.0647	-0.0740*	-0.0723*
	(0.0299)	(0.0304)	(42.65)	(43.08)	(0.0617)	(0.0621)	(4.720)	(4.644)	(0.0386)	(0.0370)	(0.0361)	(0.0332)
Round		0.00720		0.473		-0.0302		-2.849*		-0.0291*		-0.0140
		(0.0166)		(17.03)		(0.0309)		(1.475)		(0.0137)		(0.00876)
Constant	0.173	0.160	204.1*	203.3*	0.389**	0.443***	25.16**	30.26**	0.223**	0.275**	0.232**	0.255**
	(0.108)	(0.104)	(113.1)	(109.4)	(0.149)	(0.127)	(10.50)	(10.13)	(0.0959)	(0.0984)	(0.0856)	(0.0913)
Observations	92	92	92	92	92	92	92	92	92	92	90	90
R-squared	0.087	0.090	0.081	0.081	0.186	0.199	0.169	0.212	0.164	0.221	0.118	0.138
Cluster	12	12	12	12	12	12	12	12	12	12	12	12

There are also some indications that allowing the CEO to trade increases the extent of mispricing. Table XI demonstrates that *RAD*, *TD* and *PA* are higher in treatment LT (ST) than in L (S). The differences are statistically significant: the estimated coefficients of β_2 of the TRADE dummy in Columns 1 to 6 are statistically significant and negative at the 5% level. We do not, however, observe significant differences between the spread and price volatility measures between markets with and without CEO trading. We attribute this to the greater incidence of shocks in CEO effort discussed earlier. This result suggests that frequent changes in the liquidation values, which occur in LT and ST, hinder price discovery.

Nevertheless, it should be noted that in all four of our treatments, prices are close to the liquidation values. The highest RAD values at the treatment level do not exceed 0.2. This value is relatively low compared with most existing studies employing exogenously-determined fundamental values that are constant over time, which typically produce average price differences from fundamentals of greater than 20% of the fundamental (Oechssler et al., 2011; Noussair et al., 2001; Smith et al., 2000). To the best of our knowledge, other than our paper, Jaworski and Kimbrough (2016) is the only other paper that studies assets with endogenously-determined fundamental values in the laboratory. In their paper, the average magnitude of price deviations from the fundamental value was in the range of 55% to 71%. Our study produces significantly smaller asset bubbles than those that they found. We observe investors following the extrapolative models closely, enabling them to anticipate the evolving liquidation values more accurately. One difference between our study and theirs that could account for the differences in pricing is in the magnitude of the cash-to-asset ratio. In our study, this ratio is relatively small. It suggests that a possible reason that the magnitude of asset bubbles in our study is relatively small could be this low cash-to-asset ratio; - a resonation of the findings of Kirchler et al. (2012) and Noussair and Tucker (2016). This might imply that the magnitude of cash-to-asset ratio affect prices not only in markets with pre-determined fundamental values, but also in markets with endogenously determined fundamental values. Future research on markets with endogenous fundamental and greater amounts of available cash would be needed to identify or to rule out whether the cash-to-asset ratio is the driving force behind our relatively effective price discovery.

Result 6 below summarizes our findings.

Result 6*: Compensating the CEO with a stock ownership plan improves price discovery and reduces the bid-ask spread.*

IV. Conclusion

Executive compensation has always been at the heart of research in corporate finance and governance. This paper investigated two commonly-held beliefs about CEO compensation. The *first* is that a stock ownership program provides stronger incentives for CEOs to increase the value of the firm than a cash

bonus that is equivalent in magnitude. The *second* is that CEOs should be forbidden to trade stock in their own firms because of the incentive problems resulting from the possibility of insider trading.

Our study allows us to draw four conclusions. The first is that in our environment, the CEO tends to make effort choices that are close to optimal. Under the L and S treatments, average effort is close to the optimal level of 2 units in each period. Furthermore, in ST and LT, in which CEOs can accumulate units, they tend to choose the optimal effort level given their current asset holdings. The performance of a model of optimal decision making in predicting effort levels observed is quite impressive, and suggests that CEOs understand the decision environment very well. In our view, this suggests that our data is of high quality and lends credibility to the other conclusions that we draw.

Secondly, prices in our markets adhere closely to liquidation values in all four of our treatments. Unlike in some other experimental paradigms, such as that of Smith et al. (1988), the prices in our experiment do not tend to exhibit bubbles and crashes. Liquidation values follow the path predicted by extrapolative models, and prices in turn reflect the underlying liquidation values. Of course, there are a number of important differences between our environment and the one studied by Smith et al. (1988). Perhaps the most critical is that the liquidation values are endogenously determined rather than being exogenously specified by the experimenter. While making the liquidation value endogenous may introduce additional strategic uncertainty, and might have been thought to result in poorer price discovery, the results of our experiment suggest that the market is able to price the shares efficiently. Other important differences between our environment and the one studied by Smith et al. (1988) is that the cash-to-asset ratio in our environment is lower than theirs and the fundamental value of the asset in our environment is constant if the CEO chooses the optimal effort in treatments L and S, while the fundamental values in their setting are declining over time. Both of these features of our environment are known to tend to reduce the tendency for markets to exhibit mispricing.

The third main insight from our work is that we observe that allowing the CEO to trade raises the value of the firm. The typical behavior of our CEOs when they are permitted to trade shares is to accumulate units and then exert the optimal level of effort given their increased holdings. This raises the value of the company and benefits other shareholders. Allowing the CEO to trade, however, induces traders to overreact to information about CEO's effort decisions. Traders value the firm's assets above the realized liquidation values, perhaps due to their anticipation of growth in firm value due to future CEO effort.

The fourth result is that awarding stock shares improves price discovery. Though the CEOs effort is no greater under a stock ownership program than under a cash bonus plan, we do find that prices track liquidation values more closely. It may be the case that the effort decisions of CEOs are followed more closely and analyzed more carefully by other traders when the CEO has a stake in the value of the firm. Traders who choose not to base their pricing decisions on the CEO's effort are prevalent only in markets with linear compensation. This may be because of the disconnection between ownership and managerial decisions under linear compensation. Traders who are not sure that the CEO will act in their

interests choose to not base their pricing decisions on CEOs' effort decisions. This causes an exacerbation of asset mispricing in the absence of a SOP.

REFERENCES

Akerlof, G. A. 1982. Labor contracts as partial gift exchange. *Quarterly Journal of Economics*, 97(4), 543-569.

Akiyama, E., Hanaki, N., & Ishikawa, R. (2017). It is not just confusion! Strategic uncertainty in an experimental asset market. *Economic Journal*, 127(605), F563-F580.

Asparouhova, Elena, Peter Bossaerts, Jon Eguia, and William Zame, 2015, Asset pricing and asymmetric reasoning, *Journal of Political Economy* 123, 66-122.

Asparouhova, Elena, Peter Bossaerts, Nilanjan Roy, and William Zame, 2016, "Lucas" in the Laboratory, *Journal of Finance* 71, 2727-2780.

Amihud, Yakov, and Haim Mendelson, 1986, Asset pricing and the bid-ask spread, *Journal of Financial Economics* 17, 223-249.

Brandts, J., & Charness, G. (2004). Do labour market conditions affect gift exchange? Some experimental evidence. *Economic Journal*, 114(497), 684-708.

Bossaerts, Peter, and Charles Plott, 2002, The CAPM in thin experimental financial markets, *Journal of Economic Dynamics and Control* 26, 1093-1112.

Bossaerts, Peter, and Charles Plott, 2004, Basic principles of asset pricing theory: Evidence from large-scale experimental financial markets, *Review of Finance* 8, 135-169.

Bossaerts, Peter, Charles Plott, and William Zame, 2007, Prices and portfolio choices in financial markets: Theory, econometrics, experiments, *Econometrica* 75, 993-1038.

Bloomberg, 2013, Top CEO Pay Ratios, downloaded from http://go.bloomberg.com/multimedia/ceo-pay-ratio/

Caginalp, Gunduz, David Porter, and Vernon Smith, 1998, Initial cash/asset ratio and asset prices: An experimental study, *Proceedings of the National Academy of Sciences* 95, 756-761.

Cohn, A., Fehr, E., & Goette, L. (2014). Fair wages and effort provision: Combining evidence from a choice experiment and a field experiment. *Management Science*, 61(8), 1777-1794.

Copeland, Thomas E., and Daniel Friedman. 1987, The effect of sequential information arrival on asset prices: An experimental study. *Journal of Finance* 42(3), 763-797.

Copeland, Thomas E., and Daniel Friedman. 1991, Partial revelation of information in experimental asset markets. *Journal of Finance* 46(1), 265-295.

Core, John E., Robert W. Holthausen, and David F. Larcker, 1999, Corporate governance, chief executive officer compensation, and firm performance, *Journal of Financial Economics* 51, 371-406.

Crockett, Sean, and John Duffy, 2013, An experimental test of the Lucas asset pricing model. *Review of Economic Studies*, forthcoming.

Davis, James H., F. David Schoorman, and Lex Donaldson, 1997, Toward a stewardship theory of management, *Academy of Management Review* 22, 20-47.

Dufwenberg, Martin, Tobias Lindqvist, and Evan Moore, 2005, Bubbles and experience: An experiment, *American Economic Review* 95, 1731-1737.

Eckel, Catherine C., and Sascha C. Füllbrunn, 2015, Thar she blows? Gender, competition, and bubbles in experimental asset markets, *American Economic Review* 105, 906-920.

Edmans, Alex, and Xavier Gabaix, 2016, Executive compensation: A modern primer. *Journal of Economic Literature* 54, 1232-87.

Edmans Alex, Xavier Gabaix, and Dirk Jenter, 2017, Executive Compensation: A Survey of Theory and Evidence. In: Handbook of the Economics of Corporate Governance, Chapter 9. 383-539.

Fehr, E., & Falk, A. (1999). Wage rigidity in a competitive incomplete contract market. *Journal of Political Economy*, 107(1), 106-134.

Fehr, Ernst, Erich Kirchler, Andreas Weichbold, and Simon Gächter. 1998. When social norms overpower competition: Gift exchange in experimental labor markets. *Journal of Labor Economics* 16(2), 324-351.

Fréchette, Guillaume, 2015, Laboratory Experiments: Professionals Versus Students, in Handbook of Experimental Economic Methodology, G. Fréchette and A Schotter eds., Oxford University Press, United Kingdom.

Frydman, Carola, and Dirk Jenter, 2010. CEO compensation, *Annual Review of Financial Economics* 2, 75-102.

Füllbrunn, Sascha, and Ernan Haruvy, 2013, The Dividend Puzzle: A Laboratory Investigation, in S. M. Collins, R. M. Isaac, D. A. Norton, eds.: *Research in Experimental Economics* 16 (Emerald Group Publishing Limited, Bingley, UK).

Haigh, Michael S., and John A. List. 2005. Do professional traders exhibit myopic loss aversion? An experimental analysis. *Journal of Finance*, 60(1), 523-534.

Haruvy, Ernan, and Charles N. Noussair, 2006, The effect of short selling on bubbles and crashes in experimental spot asset markets, *Journal of Finance* 61, 1119-1157.

Haruvy, Ernan, Yaron Lahav, and Charles N. Noussair, 2007, Traders' expectations in asset markets: experimental evidence, *American Economic Review* 97, 1901-1920.

Holmen, Martin, Michael Kirchler, and Daniel Kleinlercher, 2014, Do option-like incentives induce overvaluation? Evidence from experimental asset markets, *Journal of Economic Dynamics and Control* 40, 179-194.

Jaworski, Taylor, and Erik O. Kimbrough, 2016, Bubbles, crashes, and endogenous uncertainty in linked asset and product markets, *International Economic Review* 57, 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, 305-360.

Jensen, Michael C., and Kevin J. Murphy, 1990a, CEO Incentives-It's Not How Much You Pay, But How, *Journal of Applied Corporate Finance* 3, 36-49.

Jensen, Michael C., and Kevin J. Murphy, 1990b, Performance Pay and Top-Management Incentives, *Journal of Political Economy* 98, 225-264.

King, Ronald, Vernon Smith, Arlington Williams, and Mark Van Boening, 1993, The robustness of bubbles and crashes in experimental stock markets, in I. Prigogine, R. Day, and P. Chen, eds.:*Nonlinear Dynamics and Evolutionary Economics* (Oxford University Press, New York).

Kirchler, Michael, Jürgen Huber, and Thomas Stöckl, 2012, Thar she bursts: Reducing confusion reduces bubbles, *American Economic Review* 102, 865-883.

Kleinlercher, Daniel, Jürgen Huber, and Michael Kirchler, 2014, The impact of different incentive schemes on asset prices, *European Economic Review* 68, 137-150.

Lefebvre, Mathieu, and Ferdinand M. Vieider, 2014, Risk taking of executives under different incentive contracts: Experimental evidence, *Journal of Economic Behavior & Organization* 97, 27-36.

Lei, Vivian, Charles N. Noussair, and Charles R. Plott, 2001, Nonspeculative bubbles in experimental asset markets: Lack of common knowledge of rationality vs. actual irrationality, *Econometrica* 69, 831-859.

Mehran, Hamid, 1995, Executive compensation structure, ownership, and firm performance, *Journal of Financial Economics* 38, 163-184.

Mishel, Lawrence, and Natalie Sabadish, 2012, CEO pay and the top 1%: How executive compensation and financial-sector pay have fueled income inequality, *Economic Policy Institute*, Issue Brief 331.

Nalbantian, Haig R., and Andrew Schotter. 1997. Productivity under group incentives: An experimental study. *American Economic Review*, 87(3), 314-341.

Noussair, C., Robin, S. & Ruffieux, B., 2001. Price Bubbles in Laboratory Asset Markets with Constant Fundamental Values. *Experimental Economics*, 4, 87-105.

Noussair, Charles N. and Steven Tucker, 2016, Cash Inflows and Bubbles in Asset Markets with Constant Fundamental Values, *Economic Inquiry* 54, 1596-1606.

Oechssler, Jörg, Carsten Schmidt, and Wendelin Schnedler, 2011, On the ingredients for bubble formation: informed traders and communication, *Journal of Economic Dynamics and Control* 35, 1831-1851.

Pfeiffer, Glenn M., Timothy W. Shields, 2015, Performance-Based Compensation and Firm Value – Experimental Evidence, *Accounting Horizons* 29, 777-798.

Pierce, Jon L., Tatiana Kostova, and Kurt T. Dirks, 2001, Toward a theory of psychological ownership in organizations, *Academy of Management Review* 26, 298-310.

Plott, Charles R., and Shyam Sunder, 1982, Efficiency of experimental security markets with insider information: An application of rational-expectations models, *Journal of Political Economy* 90, 663-698.

Smith, Vernon L., 1962, An Experimental Study of Competitive Market Behavior, *Journal of Political Economy* 70, 111-137.

Smith, Vernon L., Gerry L. Suchanek, and Arlington W. Williams, 1988, Bubbles, crashes, and endogenous expectations in experimental spot asset markets, *Econometrica* 56, 1119-1151.

Smith, Vernon L., Van Boening, M., and Wellford, C., 2000, Dividend Timing and Behavior in Laboratory Asset Markets. *Economic Theory*, 16(3), 567-583

Stöckl, Thomas, Jürgen Huber, and Michael Kirchler, 2010, Bubble measures in experimental asset markets, *Experimental Economics* 13, 284-298.

Sutter, Matthias, Jurgen Huber, and Michael Kirchler, 2012, Bubbles and information: An experiment, *Management Science* 58, 384–393.

Stöckl, Thomas, Jürgen Huber, and Michael Kirchler, 2015, Multi-period experimental asset markets with distinct fundamental value regimes, *Experimental Economics* 18, 314-334.

Wasserman, Noam, 2006, Stewards, agents, and the founder discount: Executive compensation in new ventures, *Academy of Management Journal* 49, 960-976.

Weber, Matthias, John Duffy, Arthur J. H. C. Schram, 2017, An Experimental Study of Bond Market Pricing, *Journal of Finance*, forthcoming.