When Do CEO's Require "High-Powered" Incentives *

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Abstract

The fundamental finding of all classical agency models such as Holmström (1979) and Holmström and Tirole (1993) is that the agent's pay-for-performance sensitivity rises with improvements in the stock-based signal-to-noise ratio. Hence, more precise signals allow for better-aligned incentives. However, at the heart of Holmström and Tirole's model is a logical problem: the equilibrium stock price is found prior to the agent making his effort choice in response to his incentive contract. Naturally, it is the effort choice that determines the stock price, not the topsy-turvy alternative. Correcting the logic in their model reverses their finding: the agent's pay-for-performance sensitivity always falls with improvements in the stock-based signal-to-noise ratio. This reversal makes sense, as high-power contracts are far from being a desirable goal. They impose too much risk on the agent, which requires compensation by higher pay. Reconciling theory with practice, all available empirical evidence finds that the agent's pay-for-performance sensitivity is also falling in the signal-to-noise ratio. Importantly, inside ownership in most large, listed companies is low. This is not because incentives are unimportant, but because informed speculators align the stock price in liquid companies with the manager's (agent's) actions. With the entire absence of stock-based information in share price, the contract terms in my model reduce to those of informationless models such as Holmström and Milgrom (1987). The findings have significant implications for incentive design, corporate governance, and the evolving role of financial markets in managerial oversight.

Keywords: Liquidity, Agency, Incentives, Signal-to-Noise, Franchise.

JEL Classification: G34, J41, J44, L25.

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1 Introduction

In the absence of asymmetric information, moral hazard arises when the risk neutral principal in an agency contract is unable to observe the actions of the agent, who must necessarily be risk averse (Harris and Raviv, 1979). To focus purely on the incentive problem, the agent remains no better informed than the principal. The agent, unlike the principal (shareholders), usually has much greater difficulty in diversifying, such that the agent is almost certainly more risk averse. If, supposing that the agent could also be risk neutral, then the principal would place sizable risk on the agent without cost. The contracting problem could then disappear in its entirety.[1] More than 45 years ago, Holmström (1979) provided a celebrated theory of agency incentives under moral hazard, which even today guides much theoretical and empirical research into agency issues.

According to this theory, the contract weight, for example, the agent's percentage share allocation, or pay-for-performance sensitivity, increases in the sensitivity of the particular performance measure to the agent's actions. That is, more precise signals allow for better-aligned incentives. However, my concern in this paper is not with Holmström's (1979) Nobel Prize-winning paper *per se* but rather with asking under what circumstances will sizable "high-powered" equity-based incentives be utilized? Will the incentive weight be higher due to a price signal from an informed speculator who predicts the agent's actions with little noise, that is, a high signal-to-noise ratio, as Holmström's (1979) model implies? At the other extreme, a relatively uninformative stock price signal that fails to predict future managerial performance indicates a low signal-to-noise ratio due to the preponderance of noise in the signal. Of course, the agent's response depends entirely on the incentive weight conferred by his contract. If an informative signal is highly weighted relative to an uninformative one, the agent will respond more, and *vice versa*.

Hence, fundamental to Holmström's (1979) model is the belief that the incentive weight increases in the signal-to-noise ratio. Recognizing that it was necessary to provide more structure with respect to an informative signal, the original paper was followed by Holmström and Tirole (1993), which incorporated the Kyle (1985) model into the analysis. Importantly, the same basic conclusion was reached with respect to the signal-to-noise ratio. I denote this signal-to-noise ratio sensitivity finding as the "classical" belief, which is fundamental to classical agency theory. In contrast, I utilize the superlative framework provided by Holmström and Tirole (1993) to show that the incentive weight must of necessity *fall* (not rise) in the signal-to-noise ratio. Hence, my ambitious objective is to show that the classical fundamental agency theory needs to be completely reversed and turned on its head.

The logical problem with Holmström and Tirole's (1993) model is exceedingly subtle, explaining why it has remained undetected for over 30 years, together with many thousands of citations. The model assumes that the equilibrium stock price is determined before considering how the agent reacts to the incentive tied to the stock price incorporated in his contract. This is, of course, impossible because the purpose of the incentive is to induce the agent to raise the stock price by performing actions considered to be productive "effort". The sequence is the reverse. Once the agent has determined his "effort" level, the stock price is then adjusted to reflect this. Only by incorporating the agent's out-of-equilibrium actions prior to the stock price equilibrium being determined can one reveal the agent's equilibrium actions. The stock price equilibrium is the last thing to be established and only after

[1] If the agent is both risk-neutral and well-endowed then he could simply buy the firm and thus obtain a first-best contract to obviate incentive issues.

the agent has fully responded to his out-of-equilibrium incentives.

Unsurprisingly, in the following, I show that to induce more, or for that matter, any effort, the agent must be rewarded by a responsive stock price whose magnitude depends on the informativeness of the stock price, reflecting the incorporation of private information from the informed speculator into the stock price. This is determined by the product of the informed speculator's demand (Beta) coefficient of trader aggressiveness and the Kyle Lambda coefficient of stock market demand responsiveness. By neglecting the process by which the agent creates wealth, that is, out-of-equilibrium decision-making by the agent as a function of stock price informativeness, it proves impossible for the Holmström and Tirole (1993) model to arrive at the correct equilibrium solution. Once out-of-equilibrium decision-making is incorporated, the findings are reversed.

By their very nature, agency contracts are "second-best", with the agent having to assume more risk than is ideal (Grossman and Hart, 1983). A fundamental feature of any valid agency contract is that, as the risk neutral principal becomes more informed about the agent due to monitoring, the first-best contract is approached. By definition, it is impossible to improve on a first-best contract. In such an ideal contract, the agent bears no risk. This outcome could also be achieved by means of a "forcing contract" to obtain the ideal level of "effort" put in by the agent. In the unachievable first-best contract, the principal observes the entirety of the manager's actions via costly monitoring, with the agent receiving a flat wage, and the entire risk is shifted to the risk-neutral, or less risk-averse, principal. As the principal becomes more informed, the noisiness in the principal's observation of the agent is ameliorated, and the signal-to-noise ratio necessarily improves (the ratio rises) with the agent's flat wage ultimately achieved.

Hence if, as contended by Holmström (1979) and Holmström and Tirole (1993), the contract weight were to be increasing in the signal-to-noise ratio, then the first-best contract with a noiseless signal would shift virtually all of the risk to the agent. Clearly, the traditional finding is impossible. The incentive contract weight must always be falling, not rising, in the signal-to-noise ratio, as I contend. High-powered incentives, such as assigning a sizable share weight to the agent, are only required when the signal-to-noise ratio is weak. As noted by Eisenhardt (1989), this is in contrast to Jensen and Meckling (1976), for whom higher inside ownership is the salve for agency problems as it reduces managerial opportunism.

Yes, it is true that inside ownership reduces opportunism, but this is costly to both management and shareholders. A better alternative is a liquid market that promotes informed share trading. With an informative share price, a much higher outside shareholding is both possible and desirable. Hence, ameliorating the conflict due to the separation of ownership and control. Morck, Shleifer, and Vishny (1988) found a more nuanced pattern than envisioned by Jensen and Meckling (1976): Tobin's Q falls with higher inside ownership from 5 percent to 25 percent and then rises as inside ownership improves further. Zeckhauser and Pound (1990) found evidence that large shareholders monitor by freeing up management to pursue better policies, such as growing earnings. Kang and Kim (2022) found that high-powered CEO incentives encourage unproductive risk-seeking activities.

At the other extreme, as the signal-to-noise ratio deteriorates to zero, classical theory maintains that the incentive weight and hence pay-for-performance sensitivity will be low. But such a poor-quality signal perfectly describes start-ups and small illiquid firms who, of necessity, must provide a sizable incentive weight to the agent

(founder/CEO). In contrast, my contract converges to that of Holmström and Milgrom (1987) for which there is no information about the agent's actions. In the absence of information about the agent's actions, the incentive weight must always be higher than when there is an informative stock price.

Not only can traditional findings be ruled out on logical grounds, empirical observations also rule them out. To maintain credibility, theory and evidence must be reconciled. Larger and more liquid companies enjoy a lower contract weight (falling pay-for-performance sensitivity) as the signal-to-noise ratio improves. Hence, reconciliation of the underlying theory with real-world observations also requires that the theory be critically reexamined with the need to reverse all the main findings.

Like Holmström and Tirole (1993), my model merges agency theory with the Kyle (1985) model of informed stock market trading. This is important as market makers in this framework efficiently extract information from informed trades while stabilizing price movements from purely "noise" traders. In Kyle's (1985) model, the informed trader drives the stock price closer to the fundamental value determined by the hidden actions of the manager. Buy when the speculator infers that the manager is creating value. Sell when the speculator infers that the manager is destroying value. While it is hard to overstate the contribution of informed trading to good corporate governance, this does not mean that board composition is irrelevant. Boards must ensure that management is appropriately incentivized according to the degree of liquidity in the stock market. The more liquid is trading in the firm's stock, the lower the CEO's pay-for-performance sensitivity.

My major findings are: (i) the introduction of a stock price, but without the benefit of either liquidity or informed speculation by stock traders, requires a sizable and inefficient price weight that shifts too much risk to the manager; (ii) incentives improve with the introduction of a signal provided by informed traders in the stock market resulting in a higher signal-to-noise ratio with a corresponding *fall*, not rise, in the contract's price weight (*i.e.*, reduced pay-for-performance sensitivity); and (iii), in the limit with the entire absence of stock-based information in share price, contract terms in my model reduce to those of information-less models such as Holmström and Milgrom's (1987, p.323, Equation (32)) simple linear solution and to a host of simple related models such as Rosen (1992) and Garen (1994).

Correcting the causal logic in classic agency models reveals that as stock prices become more informative—-thanks to informed traders—-the need for high pay-for-performance sensitivity diminishes, fundamentally reshaping our understanding of optimal managerial incentives and reinforcing the governance role of liquid, information-rich capital markets.

When neither the principal, *i.e.*, the board representing shareholders, nor the informed speculator, can effectively monitor the manager or observe his actions, the stock price becomes a very poor-quality signal with a low signal-to-noise ratio requiring a much higher share of equity assigned to the manager (agent) to motivate him adequately. The agent perfectly observes his own actions. Hence, assigning a sizable share to the agent helps to overcome agency problems, but at a high cost to the principal. Thus, higher-powered incentives need to be called forth, to bring the manager's actions more into line with the principal's objectives, when the required departure from the first-best contract is most extreme, and direct monitoring presents insuperable problems.

This paper fundamentally revisits and reverses the core findings of traditional agency theory, offering a new

perspective aligned with observed patterns in managerial compensation and corporate structure.

2 Literature Review

I focus on the agency literature highlighted primarily but not exclusively in accounting journals. This is important because accountants are very concerned with the empirical task of explaining firm performance. Hence, they have always sought transparent theories that yield testable hypotheses. Building on Holmström's (1979) classical model, Banker and Datar (1989) find for the exponential family of distributions that the weight on a given performance measure increases in the sensitivity of the performance measure to the agent's actions and diminishes in its variance. Thus, it is increasing in the signal-to-noise ratio, as it also does in Core, Guay, and Verrecchia's (2003) version of their model.

Since these authors lack a satisfactory signal-to-noise measure, their empirical tests focus on measures of variance on the assumption that the signal-to-noise ratio remains constant. However, this is problematic, as the signal-to-noise ratio cannot be held constant but increases with the stock price variance. This is because there is no point in the speculator making forecasts of future agent (manager) actions if the stock price is invariant (constant). Unsurprisingly, none of the empirical findings in Banker and Datar (1989) or Core, Guay, and Verrecchia (2003) are at all supportive of the classical agency model.

The CEO's of larger and well-established listed firms enjoy a far higher signal-to-noise ratio than do recent start-ups because, not only do informed traders have more time and opportunity to become familiar with the CEO's characteristics, there is more scope for informed traders to hide in the larger trading crowd. Hence, according to classical theory, the pay-for-performance sensitivity of CEO's in well-established firms should be far higher than in IPO start-ups. Gao and Jain (2011) report that for their sample, founder-CEO's have 22.2% inside ownership, while nonfounder CEO's have a more modest 7.65% ownership. Contrary to classical theory, in more established firms, inside ownership decreases rapidly with size to often less than 1% but with improved governance rather than the deterioration predicted by classical theory. Gao and Jain (2011) find evidence to indicate that founder-CEO led high-tech firms provide significantly higher long-run returns relative to high-tech nonfounder CEO led firms. Presumably, this is because high-tech firms tend to be relatively opaque and risky in contrast to low-tech firms making it necessary for the founder-CEO to be awarded a very sizable stock grant.

Although it is true that the dollar reward for effort in a very sizable firm is higher than in a small firm, as Baker and Hall (2004) emphasize, pay-for-performance sensitivity must always be measured as a percentage of the manager's ownership. In principle, without any information in the stock price, a manager's low percentage ownership in a large firm could spell disaster with extremely large dollar losses due to inadequate managerial effort.

Suppose that there are two stocks. One is small and highly volatile, and the second is large and less volatile. The small "noisy" stock will necessarily have a low signal-to-noise ratio, and the large stock will have a lower volatility and a higher signal-to-noise ratio. According to classical agency theory, the pay-for-performance sensitivity (*i.e.*, incentive weight) for the small stock should be low relative to the large and less volatile stock. But Jensen and Murphy (1990), Schaefer (1998), and Baker and Hall (2004), together with many others, find that incentive weights in the form of the pay-for-performance sensitivity always substantially decline with firm size, hence contradicting

the claimed theoretical implication. Core, Guay, and Verrecchia (2003, p.975) also find that CEO equity incentives are positively related to the variance of stock returns in contradiction to the classical model but supportive of my model. This is not surprising, as small stocks and start-ups are highly volatile and rely largely on sizable equity incentives, as already indicated. In contrast, large stocks with low pay-performance sensitivity are less volatile.

No literature review would be complete without a mention of the three articles, Kang and Liu (2008, 2010) and Jayaraman and Milbourn (2012), which claim to empirically support Holmström and Tirole's (1993) apparent finding that the price incentive weight is rising in the signal-to-noise ratio. Kang and Liu (2008, 2010) is reliant on the Probability of Informed Trading (PIN) model of Easley, Hvidkjaer, and O'Hara (2002) as a proxy for information in the stock price despite Duarte, Han, Harford, and Young's (2008) finding that PIN is a proxy for illiquidity. Jayaraman and Milbourn (2012) show that higher-turnover firms which are generally small have low cash-based pay and high incentive-based pay, consistent with the well-known result that small firms with noisy share prices rely on high-powered incentives. Hence, none of these studies actually supports Holmström and Tirole (1993), but they are all supportive of my own model.[2]

Although there have been many theoretical attempts to explain the high inside share ownership in start-ups, for example, Bolton, Scheinkman, and Xiong's (2006) over-confident investors and Peng and Röell's (2008, 2014) stock price manipulation, they invariably instigate inefficiency and depart from fully rational agents. By contrast, all the agents modeled here are fully rational and there is no manipulation. Moreover, unlike Prendergast (2002), the agents modeled here also preserve the necessary requirement of being risk-averse, without which there could be no "second-best" problem and thus less to explain. The model has the virtue of explaining Prendergast's (2002) empirical observations concerning the difficulty of monitoring the agent in illiquid start-up firms and the observed high pay-for-performance sensitivity of agents in such risky environments.

Fang, Noe, and Tice (2009) show that stock liquidity results in higher firm performance, as measured by Tobin's Q, due largely to higher operating profitability, and the relationship is causal. Importantly, they find that it operates via the entry of informed traders who make stock prices more informative and by enhancing the value of performance-incentive managerial compensation exactly as in my model developed in Section 3 below. Moreover, they are able to rule out other possible explanations, such as blockholder intervention. Hence, their findings unambiguously support the hypothesis put forward in this paper that the dominance of stock markets and global markets generally by large, highly liquid firms with low inside ownership is due to conferred contracting benefits.

More broadly, large, liquid firms dominate global markets because liquidity reduces agency costs and supports efficient contracting, even with low inside ownership and lower-powered incentives.

3 The Model

In order to provide a valid solution to the agency problem posed by Holmström and Tirole (1993), it is necessary to make several specification changes to their model, which I note. The model has three dates, an initial date $t = 0$, in which the firm is founded by a risk-neutral insider (principal) and the appointed risk-averse manager (who cannot trade) signs his contract that is not subject to renegotiation, and undertakes his aggregate effort (actions), denoted

[2] As Todd Milbourn has confirmed in correspondence.

e, to produce revenue. At date $t = 1$, there is a stock trader (speculator) who generates an informed order flow based on imperfect signals, s, received by the trader and specified in Equation (1) below, of the manager's actions in the initial period which will generate a noncontractible terminal cash flow in the final period, $t = 2$, when the firm is disbanded. In order to focus on the manager's incentive payment, I neglect Holmström and Tirole's (1993) capital gain/loss accruing to the manager in the final period. This payment adds undesirable nonlinearity to the manager's contract without adding any insight relevant for this paper. I also neglect Holmström and Tirole's (1993) contrast between short- and long-term incentives, which, for the purposes of this paper, adds unnecessary complication.

The manager makes his effort choice by allocating effort to promote a higher stock price according to the incentives provided in the contract. The incentive chosen by the principal consists of a positive weight, $0 \leq A < 1$, placed on stock price, entitling the manager to a share of any gains resulting from his efforts in the terminal (second) period. The non-negativity of the contract weight arises from the requirement to model incentives, not penalties, for performing well. Incentive compatibility also requires an upper bound to be established on the contract weight so that prospectively the agent cannot receive as much or more than he has contributed to the enterprise and its principal. Finally, at $t = 2$, a payment is made to the manager from the aggregate net profits of the firm that are realized. These depend on the noncontractible level of effort, e, which must be measured net of the contractual obligations to the manager.

The principal's objective is the simple one of maximizing her expected wealth from floating her company. To maximize the liquidity (trading) of her company's shares, all shares, other than those assigned in one form or another to the manager, are floated. Her wealth depends on the expected gross stock price $E(p)$, where p is the stock price that capitalizes the gross company earnings e, and is measured net of the expected cost of hiring the manager, $E(I)$, where I is the manager's income made up of his incentive payment and his fixed wage, W. Hence, in effect, the principal chooses the incentive weight, A, to maximize the expected (*ex ante*) firm profit given by:

$$E(\Pi) = E(p) - E(I).$$

3.1 Determinants of the Equilibrium Stock Price

Drawing on Kyle (1985), there is one partially informed homogeneous strategic trader (speculator). At $t = 1$ the informed trader submits a market order, $x(\tilde{s})$, after observing an imperfect signal of the true (common) fundamental firm value in the initial period based on the trader's observation of the actual total level of effort, e, and a noisy signal imperfectly describing the stock's future return with terminal cash flow given by the realized value of the price signal:

$$\tilde{s} = e + \tilde{\theta} + \tilde{\eta}, \tag{1}$$

with the normally-distributed "intrinsic" stock volatility term described by $\tilde{\theta} \sim \mathcal{N}(0, \sigma_{\theta}^2)$, subject to an independent normally-distributed observational error, $\tilde{\eta} \sim \mathcal{N}(0, \sigma_{\eta}^2)$.[3] The counterparties to the informed trader are "liquidity" traders who do not possess information. The normally distributed demands are described by

[3] Equation (1) could easily be generalized by making terminal cash flow some function of effort plus random terms but this would not add significantly to the insights.

$\tilde{y} \sim \mathcal{N}(0, \sigma_y^2)$.[4]

Although one might be tempted to think of $\tilde{\theta}$ as "noise" and the resulting intrinsic volatility σ_θ^2, as undesirable, it provides an essential foundation for informed trading, as the greater the volatility, the greater the trading profit reward for successfully predicting future price movement. Importantly, in Holmström and Tirole's (1993) model, the actual *i.e.* observed volatility is generally less than the intrinsic level due to the stabilizing trades undertaken by the market maker with the upper limit, specified by the "intrinsic" volatility, occurring when the maximum amount of information is included in the stock price. That is, informative stock prices are more volatile because there is a market maker capable of extracting or eliminating random noise, who must nevertheless leave volatility due to information intact. It would be impossible for an informed trader to operate in the absence of stock price volatility, as the price would immediately converge to the true price and never vary. Paradoxically, stock markets require volatility for incentives to perform well, or even at all.

The principal observes a performance outcome of the manager's effort, namely the stock price,[5] $p(\tilde{q})$, as a function of the total order flow, $\tilde{q}$, of the publicly traded firm at time $t = 2$. At the beginning of the initial period, $t = 0$, she therefore writes a simple linear incentive contract in which the manager (agent) is allocated an incentive dollar amount $Ap(\tilde{q})$. Hence in deciding on the optimal incentive weight $\bar{A}$, the founder in essence delegates the monitoring of her manager to the stock market operating in period $t = 1$.

The market maker conjectures a linear pricing rule:

$$p(\tilde{q}) = \bar{e} + \lambda(\tilde{q}) - Ap(\tilde{q}),$$

where $\bar{e}$ is the constant value representing the initial price (*i.e.*, intercept of the linear trading demand schedule) and thus the equilibrium effort level which has yet to be determined, the Kyle lambda, λ, is the sensitivity of price to order-flow and is thus a measure of illiquidity, and, as noted, $\tilde{q}$ is the signed total order-flow from both informed and uninformed traders. Hence $p(\tilde{q}) = [\bar{e} + \lambda(\tilde{q})]/(1+A)$, and is therefore grossed-up by unity plus the incentive weight. Defining for purposes of convenience and without loss of generality, $\alpha \equiv A/(1+A)$, thus $A \equiv \alpha/(1-\alpha)$, and $1/(1+A) \equiv 1-\alpha$. Consequently, stock price is given by:

$$p(\tilde{q}) = (1-\alpha)(\bar{e} + \lambda(\tilde{q})). \tag{2}$$

The grossing-up term, $(1-\alpha)$, represents the proportion of the firm value available to outside shareholders in the form of the "free" float, as the proportion, α, is reserved for insiders, namely the agent or manager. These outside shareholders receive no portion of the amount paid to the manager, and hence they place no value on the manager's incentive payment, over and above the manager's effort commitment which of course does depend on the incentive payment.

The strategic trader conjectures a linear trading strategy that takes the form:

$$\bar{x}(\tilde{s}) = \beta(\tilde{s} - \bar{e}),$$

[4] The tilde simply distinguishes a random variable $\tilde{y}$ from its actual drawing, in this case y.
[5] Measured gross of the cost of hiring the manager.

where the accent on x indicates the optimum solution and β represents the positive coefficient of trader aggressiveness. Only the total signed order flow $\tilde{q}$ is visible to the market maker with $\tilde{q} = x(\tilde{s}) + \tilde{y} = \beta(\tilde{s} - \bar{e}) + \tilde{y}$, where $\tilde{y}$ represents uninformed liquidity trades.

The partially-informed speculator maximizes her expected end-of-period trading profits $E(\pi)$:

$$\underset{x}{Max} : E(\pi) = \left[\tilde{s} - (1-\alpha)(\bar{e} + \lambda y)x - \lambda x^2 \,|\tilde{s} = s\right],$$

which is an ordinary least squares regression (projection) with:

$$Cov\left(\tilde{\theta}, \tilde{\theta} + \tilde{\eta}\right) / Var\left(\tilde{\theta} + \tilde{\eta}\right) = \sigma_\theta^2 / \left(\sigma_\theta^2 + \sigma_\eta^2\right).$$

On evaluating the conjecture, the first-order condition gives rise to:

$$\bar{x} = \beta(\tilde{s} - \bar{e}) = \left[\sigma_\theta^2 / 2\lambda\left(\sigma_\theta^2 + \bar{\sigma}_\eta^2\right)\right]\left(e + \tilde{\theta} + \tilde{\eta} - \bar{e}\right). \tag{3}$$

Utilizing β from Equation (3), and the projection of λ derived from Equation (2) given by:

$$Cov\left[\tilde{\theta}, \beta\left(\tilde{\theta} + \tilde{\eta}\right) + \tilde{y}\right] / Var\left[\beta\left(\tilde{\theta} + \tilde{\eta}\right) + \tilde{y}\right], \tag{4}$$

Kyle's lambda measure of illiquidity becomes:

$$\lambda \equiv \sigma_\theta^2 / \left[\beta^2\left(\sigma_\theta^2 + \bar{\sigma}_\eta^2\right) + \sigma_y^2\right]. \tag{5}$$

On solving Equations (3) and (5) for β by eliminating λ, the partially-informed speculator's demand becomes:

$$\tilde{x} = \beta\left(e + \tilde{\theta} + \tilde{\eta} - \bar{e}\right) = \left[\sigma_y \Big/ \left(\sigma_\theta^2 + \sigma_\eta^2\right)^{1/2}\right]\left(e + \tilde{\theta} + \tilde{\eta} - \bar{e}\right), \tag{6}$$

with Kyle's lambda that is represented by Equation (5), specified by:

$$\lambda \equiv \sigma_\theta^2 / [2\sigma_y \left(\sigma_\theta^2 + \sigma_\eta^2\right)^{1/2}]. \tag{7}$$

3.2 The Nature of the Speculator's Signal

If the speculator invests more in improving the precision of the signal, a higher value of $1/\sigma_\eta^2$, then trading is more aggressive with the speculator's β (demand) coefficient increasing and the price impact of order-flow also increasing, with Kyle's λ rising and its inverse, market depth, falling.

Utilizing λ from Equation (7), the expected profits made by an informed speculator depends on the trading revenue provided by the product of the variance of liquidity trader demand and price impact given by Kyle's lambda less the cost of becoming informed, $c_I \equiv (1/2)c_\eta(1/\sigma_\eta^2)^2$, which is diminishing in the volatility of the signal. The

speculator's expected profit becomes $E(\Pi_S) = \sigma_y^2 \lambda - c_I$:

$$\underset{\sigma_\eta^2}{Max} : E(\Pi_S) = \sigma_y \sigma_\theta^2 / 2 \left(\sigma_\theta^2 + \sigma_\eta^2\right)^{1/2} - (1/2)\, c_\eta \left(1/\sigma_\eta^2\right)^2.$$

The equilibrium level of investment in information becomes:

$$f\left(\bar{\sigma}_\eta^2, c_\eta, \sigma_y, \sigma_\theta^2\right) = c_\eta - \left(\bar{\sigma}_\eta^2\right)^3 \sigma_y \sigma_\theta^2 \Big/ 4\left(\sigma_\theta^2 + \bar{\sigma}_\eta^2\right)^{3/2} = 0, \tag{8}$$

with the accent on the signal error volatility term, $\bar{\sigma}_\eta^2$, indicating the speculator's optimal choice.

The partial derivative of the first-order condition with respect to that variable is denoted by the subscripted variable of the function $f\left(\bar{\sigma}_\eta^2, c_\eta, \sigma_y, \sigma_\theta^2\right)$. Since $d\bar{\sigma}_\eta^2 / dc_\eta = -f_{c_\eta} \Big/ f_{\bar{\theta}_\eta^2} > 0$, as $f_{c_\eta} > 0$ and $f_{\bar{\theta}_\eta^2} < 0$ by the second-order condition for a maximum, naturally informativness is diminishing in the cost of the informed speculator acquiring more information.

Similarly, an increase in liquidity trading, σ_y, also raises the precision of the speculator's signal, and thus also increases information content. Since $d\bar{\sigma}_\eta^2 / d\sigma_\theta^2 = -f_{\sigma_\theta^2} \Big/ f_{\bar{\sigma}_\theta^2} < 0$, as $f_{\sigma_\theta^2} < 0$, a rise in intrinsic equity volatility, σ_θ^2, raises precision. This is because the informed trader's advantage stems from being able to forecast future stock return, which becomes more advantageous the higher the degree of intrinsic volatility. Hence, informed traders will devote more resources to predict the future returns of hard-to-value stocks with high intrinsic volatility. This improves contracting for smaller stocks and start-ups.

3.3 Stock Price Informativeness

The stock price prior to the deduction for the manager's cost is evaluated from Equation (2) and the projection:

$$\tilde{p}(\tilde{q}) = E\left[\tilde{\theta} \,|\tilde{q} = q\right] = (1-\alpha)\left[\bar{e} + \frac{Cov\left(\tilde{\theta}, \tilde{\theta} + \tilde{\eta}\right)}{Var\left(\tilde{\theta} + \tilde{\eta}\right)} \left(\tilde{q} - E(\tilde{q})\right)\right],$$

Hence the contemporaneous (dynamic) stock price is a function of the product of the informativeness of stock price, namely μ, and manager's contemporaneous out-of-equilibrium effort choice, e, prior to equilibrium being established:

$$\tilde{p}(e) = (1-\alpha)\left[(1-\mu)\,\bar{e} + \mu\left(e + \tilde{\theta} + \tilde{\eta}\right) + \lambda \tilde{y}\right], \tag{9}$$

where $0 \leq \mu \leq 1/2$ is the impact of the speculator's informed trades, β, on stock price. The informativeness parameter μ, taken from Holmström and Tirole (1993, p.691, Equation (17)), is defined as the product of β from Equation (6) and λ from Equation (7), with both components increasing in informed trader precision:

$$\mu \equiv \lambda\beta \equiv \sigma_\theta^2 / 2\left(\sigma_\theta^2 + \bar{\sigma}_\eta^2\right). \tag{10}$$

Consequently, since greater informed trading induces greater price volatility, μ represents the information contained in the stock price and, once again, $\bar{e}$ is the unknown fixed equilibrium effort hypothesized and e the actual out-of-equilibrium effort level chosen by the manager due to the stock price incentive. Thus, importantly, con-

temporaneous actual effort is weighted by μ with an increment to the effort-raising price by an amount $(1-\alpha)\mu$ representing the free float.

Although Equation (9) should represent the foundation stone of Holmström and Tirole's (1993) model and their Equation (11), p.689, should be equivalent, unfortunately, this is not so. Theirs is the equilibrium price evaluated when $e = \bar{e}$ such that the manager's effort is fixed at its unknown equilibrium value. In my notation, Holmström and Tirole's price is:

$$\tilde{p} = (1-\alpha)\left[\bar{e} + \mu\left(\tilde{\theta} + \tilde{\eta}\right) + \lambda\tilde{y}\right], \tag{11}$$

with the difference being the absence of the critical contemporaneous out-of-equilibrium weighted effort variable, μe. Without the inclusion of the effort variable weighted by stock price informativeness, it is impossible to solve Holmström and Tirole's problem as there exists no valid expression for the manager's wage as a function of his contemporaneous *i.e.*, actual, effort, e. Logically, one cannot proceed to the equilibrium price $\bar{p}$, before solving for the manager's optimal response to his incentive contract, as the equilibrium price is a function of the manager's out-of-equilibrium effort response.

It is clear from this fundamental dynamic pricing equation that the price of the stock depends on the manager's supply of contemporaneous effort e which in turn is a function of the principal's choice of incentive structures. Only in equilibrium does the stock price depend on the optimal effort, $\bar{e}$. The efficacy of the equity incentive depends critically on the exogenously given (from the principal's perspective) stock price informativeness term μ, which in turn depends on the factors specifying the microstructure of the market.

Increases in the effort level due to the stock price incentive always result in a higher stock price. This is the mechanism by which informed markets discipline managers with an exposure to stock price. An important characteristic of the Kyle model can be noted. While the aggressiveness of the informed trader increases in the liquidity of the stock represented by σ_y, the informative term μ is independent of σ_y. This is because informed traders in this model fully exploit liquidity to raise trader aggressiveness and this increased aggressiveness is precisely offset by the corresponding fall in the lambda impact, giving rise to an exceedingly simple and intuitive relationship.

The information embedded in stock price, parameter μ, is increasing in the intrinsic volatility, σ_θ^2, and in the precision of the informed trader's information, the inverse of the variance of the optimal forecast error term, $1/\bar{\sigma}_\eta^2$. Since

$$\partial\mu/\partial\theta_\theta^2 = \left[1/2\right]\left[\bar{\sigma}_\eta^2 \Big/ \left(\sigma_\theta^2 + \bar{\sigma}_\eta^2\right)^2\right] > 0, \tag{12}$$

informativeness is less sensitive to intrinsic volatility, the smaller is the prediction error volatility, σ_η^2. Holmström and Tirole's (1993) expression for μ, (Equation (14), p.690), is easily shown to be identical to mine.

Thus, while stock price volatility is ameliorated by the manager's incentive grossing-up factor, $(1-\alpha)^2$, it is increasing in the precision of the informed signal due to greater investment in information, and in the intrinsic volatility, σ_θ^2, over which the informed trader possesses a signal. As the imperfectly informed trader becomes more accurate in his ability to predict future price movements with $\mu \to 1/2$, the actual price volatility largely reflects the intrinsic volatility which is ameliorated by grossing-up, $(1-\alpha)^2\left(\sigma_\theta^2 + \bar{\sigma}_\eta^2\right)$, and is incapable of reduction other than by reducing the incentive weight. It has nothing to do with the actions of the manager.

If, as is the case here, a more precise signal with an improved signal-to-noise ratio increases the stock-price risk imposed on the manager, it would be perfectly natural to find that improvements to the signal-to-noise ratio have the effect of lowering the price weight in the manager's contract so as not to impose unnecessary cost on the risk-averse manager requiring compensation by the principal.

When the informed speculator incurs an additional cost to receive a more precise signal with the decrease in volatility of the random error term, σ_{η}^2, the more favorable becomes the signal-to-noise ratio as the ratio $\sigma_{\theta}^2\left(\sigma_{\theta}^2+\bar{\sigma}_{\eta}^2\right)^{-1}\rightarrow 1$ in the expression for informativeness given by Equation (10) above.

Proposition 1 can now be stated:

Proposition 1 *Stock price informativeness, $\mu\equiv\lambda\beta$, which can be contracted upon, is increasing in improvements in the precision of the informed traders' return forecasts (*i.e.*, reductions in the speculators' forecast error). As the volatility of the speculator's forecast error approaches infinity, the informativeness of the stock price approaches zero, $\mu\rightarrow 0$.*

Since the agency literature commencing with Holmström and Milgrom (1987) excludes information from stock price, this limiting case of my model should and does correspond to the traditional incentive contract result.

3.4 Determinants of the Optimal Incentive Contract

Using my pricing equation (9) inclusive of effort, the firm's optimization problem can either be solved directly or by utilizing the normalization of the pricing equation, namely the transform $z()$ provided by Holmström and Tirole (1993, pp. 691-2, Equations (17) to (19)). In either way, the solutions are identical, as indeed they must be in the absence of logical error. $z()$ is defined by:

$$z\equiv\left[(1-\mu)\,\bar{e}+\mu\left(e+\tilde{\theta}+\tilde{\eta}\right)+\lambda\tilde{y}-(1-\mu)\,\bar{e}\right]/\mu. \tag{13}$$

Hence:

$$z\equiv e+\tilde{\theta}+\tilde{\eta}+\frac{\tilde{y}}{\sigma_y}\left(\sigma_{\theta}^2+\bar{\sigma}_{\eta}^2\right)^{1/2}, \tag{14}$$

with an expected value of z of $E\left(z\right)=\bar{e}$, which corresponds to Holmström and Tirole's Equation (17) (p. 691). But Holmström and Tirole seem to have accidentally omitted the bar denoting the manager's equilibrium effort level in their Equation (17), as it is impossible to specify contemporaneous effort from a transform of the manager's equilibrium effort. Thus, the equilibrium level of effort is treated incorrectly as if it were endogeneous and, consequently, capable of being determined.

Given my simplification of Holmström and Tirole's problem, the stock weight A is related to their transformed stock weight by $A\equiv b/(\mu-b)$ and my transform $\alpha\equiv b/\mu$.

Having laid the foundations, the contract design issues faced by the principal can now be addressed. She has to choose the optimal price weight, $\bar{A}$, to maximize her expected profit after she bears the cost of providing the manager with an optimal incentive contract. In the transformed contract, the principal has to choose the optimal weight, $\bar{b}$. The income of the manager depends primarily on the product of the informativeness coefficient, μ and

his actual but unobservable effort level, e, not his equilibrium effort, $\bar{e}$, until such time as equilibrium is reached. It consists of the product of the incentive weight, A, and the contemporaneous (actual) price, $p(e)$. Based on the contemporaneous price provided by Equation (9), the dollar value of the incentive depends on the product of the free-float proportion, $(1-\alpha)$, with the product of stock price informativeness μ and contemporaneous effort, e, rather than the given equilibrium effort, $\bar{e}$. The manager's expected payment is also inclusive of the fixed wage, W:

$$I \equiv W + Ap \equiv W + \left[\alpha/(1-\alpha)\right](1-\alpha)\mu e \equiv W + \alpha\mu e. \tag{15}$$

In the alternative transformed problem, the manager's incentive payment is $bz(e)$ and the transformed fixed wage is denoted by Holmström and Tirole (1993, Equation (20)) as d with the transformed wage d always higher than the untransformed wage W, that is, with $d > W$. But it is impossible for a simple transformation to increase the fixed wage as the wage must be identical in both the original specification and in the transformed problem. The transformed income:

$$I \equiv d + bz(e)d + be \equiv d + \alpha\mu e, \tag{16}$$

in Equation (16) is identical to the initially specified income, Equation (15), with an identical fixed wage, $W \equiv d$. Thus, naturally a minor normalization change cannot alter the fundamentals of the contract by systematically distorting the value of the fixed wage. Holmström and Tirole's problem arose because their price equation (11) (p. 689) is a description of the equilibrium price rather than the required contemporaneous (dynamic) out-of-equilibrium price given by my Equation (9) above. The manager's income equation indicates that the equity incentive payment depends on the weight chosen by the principal and the product of the strength of the information contained in the stock price about the agent's actions, μ, and the unobservable effort that the agent puts into increasing the stock price, e.

Since neither the manager's fixed pay, $W \equiv d$, nor his compensation for bearing risk, is directly a function of his effort, the manager's objective is, clearly, to choose his effort level, e, to maximize the value of his fixed wage plus his incentive pay less his quadratic cost of effort:

$$\underset{e}{Max}: \alpha\mu e - ce^2/2 \equiv be - ce^2, \tag{17}$$

where c is his constant marginal cost of effort. The optimal solution to the manager's concave and binding incentive compatibility constraint is:

$$\bar{e} = \alpha\mu/c \equiv b/c, \tag{18}$$

with the incentive payment given by $(\alpha\mu)^2/c \equiv b^2/c$.

Consistent with Holmström and Tirole (1993, Equation (18) p. 692), the variance of the manager's income, I, is:

$$Var(I) = \alpha^2\mu\sigma_\theta^2 \equiv b^2\sigma_\theta^2/\mu \equiv 2b^2\left(\sigma_\theta^2 + \bar{\sigma}_\eta^2\right). \tag{19}$$

The manager's certainty equivalence utility consists of his expected total pay, which is made up of his fixed pay,

plus his incentive pay, and less the risk cost based on Equation (19) and effort cost based on Equation (18):

$$[\bar{U}(I,c)] = W - \left(\alpha^2\mu/2c\right)\rho c\sigma_\theta^2 \equiv W - \left(b^2/2\mu c\right)\rho c\sigma_\theta^2 = \bar{U} = 0, \tag{20}$$

which will be binding in equilibrium. Hence on solving this equation for the manager's fixed pay, the fixed wage component becomes the cost of risk bearing less half the manager's incentive pay:

$$W \equiv \left(\alpha^2\mu/2c\right)\left(\rho c\sigma_\theta^2 - \mu\right) \equiv \left(b^2/2\mu c\right)\left(\rho c\sigma_\theta^2 - \mu\right).$$

Thus, on adding the fixed wage to the manager's incentive payment, the expected total cost to the principal of hiring the manager given by the manager's participation constraint is simply half his incentive pay plus his risk cost:[6]

$$E(I) = \left(\alpha^2\mu/2c\right)\left(\mu + \rho c\sigma_\theta^2\right) \equiv \left(b^2/2\mu c\right)\left(\mu + \rho c\sigma_\theta^2\right). \tag{21}$$

The principal's objective can be expressed as her expected firm profit, $E(\Pi) = E(p) - E(I)$:

$$\underset{\alpha}{Max} E(\Pi(\alpha)) : \left(\alpha\mu/2c\right)\left[2 - \alpha\left(2 + \mu + \rho c\sigma_\theta^2\right)\right] \equiv \underset{b}{Max}\Pi(b) : \left(b/2\mu c\right)\left[2\mu - b\left(2 + \mu + \rho c\sigma_\theta^2\right)\right], \tag{22}$$

made up of the difference between the expected stock price, which is equal to the grossed-up revenue given by the product of the grossing-up factor, $(1-\alpha)$, and effort, $\bar{e} = (\alpha\mu)/c$ as specified in equation (18), and the expected cost of hiring the manager, $E(I)$, given by Equation (21) above.

The solution to the optimization problem, Equation (22), is the optimal transformed price weight:

$$\bar{\alpha} \equiv \bar{b}/\mu] = 1/\left(2 + \mu + \rho c\sigma_\theta^2\right). \tag{23}$$

The solutions from the original and transformed problems are naturally identical, as logic dictates they must be.

Utilizing Equation (22), the firm's maximum profit becomes:

$$\bar{\Pi} = \bar{\alpha}\mu/2c \equiv \bar{b}/2c = \left(1/2\right)\bar{e}. \tag{24}$$

Hence, given the exceedingly simple way in which the problem is formulated, the principal (shareholders) earn half the wealth created by the venture, with the remaining half providing compensation to the manager for his costly risk-bearing and effort.

My main result is the groundbreaking raw optimal price weight:

$$\bar{A} \equiv \bar{b}/\left(\mu - \bar{b}\right) = 1/\left(1 + \mu + \rho c\sigma_\theta^2\right). \tag{25}$$

As the signal-to-noise ratio, μ, rises due to the speculator better able to predict the manager's actions, the optimal

[6] In an analyzes of executive contracts, Gayle, Golan, and Miller (2015, p.2295) find that over two-thirds of executive compensation takes the form of the firm's shares and options, not cash. Due largely to the use of this equity-based incentive pay, 82% of executive pay represents compensation for bearing risk (p.2340), leaving only 18% for effort cost.

incentive weight, $\bar{A}$, given by the contract falls, along with the pay-for-performance sensitivity. In the limit, as the denominator in the contract, Equation (25), increases, the first-best outcome with a fixed wage and zero pay-for-performance sensitivity is approached.

Given that $0 \leq \mu \leq 1/2$ and for many relatively illiquid companies and especially start-ups μ will be quite small, the CARA factor $\rho > 0$ in the contract is normally considered to be approximately 2, with the intrinsic volatility, $\sigma_\theta^2 > 0$. Unfortunately, little seems to be known about the cost, c, of the manager taking action with its positive magnitude likely to be quite small, as indicated by the relatively small share of compensation outlays devoted to the manager's effort compensation.

This novel and important result can be illustrated diagrammatically by an extension of Lundesgaard's (2001) diagrammatic solution to the Holmström and Milgrom (1987) model. Equation (25) can be rearranged into two, a left-hand and a right-hand component, which in equilibrium are equated:

$$LHS = (1 - \mu - A)/c = RHS = \rho \sigma_\theta^2 A. \tag{26}$$

The two components of the optimal weight and the optimal price weight itself are displayed in Figure 1 below. A rise in stock price informativeness, μ, due to greater stock liquidity contracts both the vertical and horizontal intercepts of the LHS component of Equation (26) shown in Figure 1 with a corresponding fall in the equilibrium price weight, $\bar{A}$, on the horizontal A axis. Larger stocks with more noise traders, the counterparties to informed traders, benefit from better contracting with lower incentive weights and a redistribution of risk from the manager to shareholders. Higher "intrinsic" volatility, σ_θ^2, is also advantageous to informed traders and will improve contracting by raising μ. A rise in c, the coefficient representing the slope of the marginal managerial effort cost curve, contracts the vertical intercept to also lower optimal effort. As manager effort is now more costly, there will be less equilibrium effort, $\bar{e}$, exerted. A rise in either the CARA coefficient of risk aversion, ρ, or "intrinsic" stock volatility, σ_θ^2, rotates the RHS component of Equation (26) around the origin in an anticlockwise direction to once again lower the optimal price weight.

Given the remarkable simplicity of the optimal contract, the comparative-static findings are immediately apparent. They are conveniently summarized in the form of Proposition 2:

Proposition 2 *(i) The equity incentive weight, $\bar{A}$, is falling in the stock price signal-to-noise ratio, μ; (ii) greater precision in the price signal due to lower intrinsic volatility, $1/\sigma_\theta^2$, increases the price weight, $\bar{A}$ as the informed speculator is less able to forecast future performance; and (iii) greater risk aversion (*i.e.*, higher CARA coefficient, ρ), or higher cost of effort, c, each lowers the incentive weight.*

Proof of (ii): Since $\partial \bar{A}/\partial \sigma_\theta^2 < 0$, the inverse of volatility raises the price weight. Thus, according to (i), large and highly liquid stocks will have relatively low (as a percentage) equity incentives, despite the potential dollar value being high due to size.

Notice the surprising finding that the degree of stock price informativeness, μ, which directly alters the volatility of stock price due to the actions of the informed trader, $\mu \sigma_\theta^2$, nonetheless, has no influence on the agent's willingness to bear risk, as represented by the weight on the CARA value, ρ. The CARA coefficient ρ does not enter the

Figure 1: The Impact of Informativeness on the Price Incentive Weight

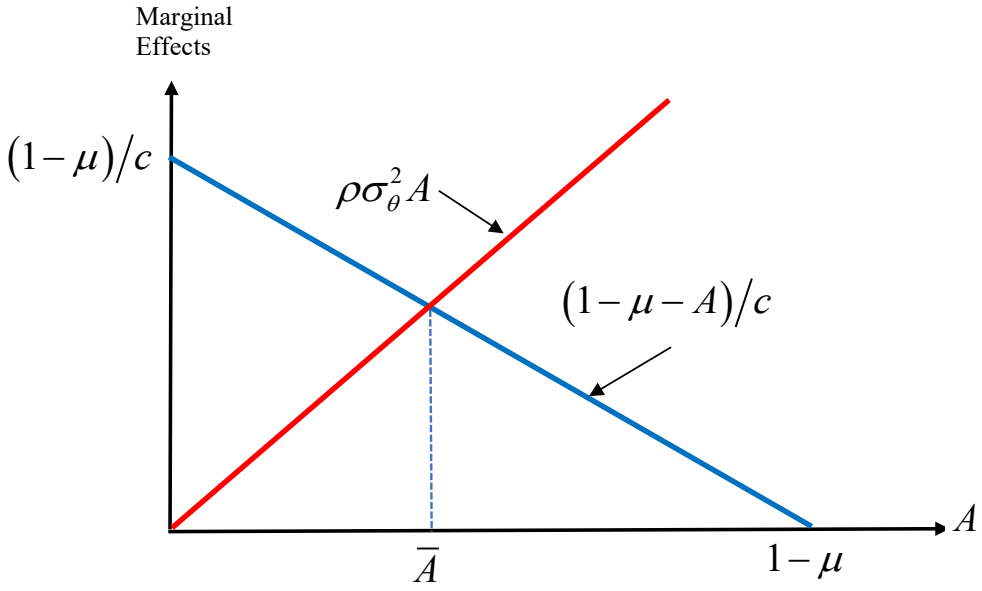


Figure 1

informativness term μ. It is only intrinsic volatility, σ_θ^2, that prices risk, $\rho c\sigma_\theta^2$, due to the manner in which the optimal contract reduces the weight on stock price as the informative content of stock price improves. The reason for this comes back to the manner in which the market maker in the Kyle (1985) model extracts information about informed trades from the aggregate order flow while cushioning market movements from random noise trader volatility.

The comparative statics can now be summarized:

Proposition 3 *Higher market liquidity induces higher stock market informativeness, μ, which not only lowers the optimal equity incentive weight, $\bar{A}$, but also raises the manager's effort level, $d\bar{e}/d\mu > 0$, firm profitability, managerial pay, stock price, and stock price volatility, but with only the intrinsic stock price volatility, not the observed stock price volatility, $\mu\sigma_\theta^2$, being priced in the contract.*

Consequently, in a more informative stock market with the speculator better observing the manager's actions, the optimal incentive contract moves closer to the first-best contract, in which the actions of the manager can be directly observed, with lower pay-for-performance sensitivity but with no effect on the priced risk borne by the risk-averse manager. Since private equity lacks an informed stock price, or any stock price for that matter, the larger the firm, the greater the likelihood that it will be listed so as to gain contracting benefits unobtainable by any other means. This prediction is evidenced by Doidge, Karolyi, and Stulz (2017) who indicate that firms at the extreme positive end of the firm size distribution are far more likely to be listed.

At the other extreme in which information in stock price is vanishingly small, $\mu \to 0$, can be recognized as Garen's (1994) explicit and simple solution based on Holmström and Milgrom (1987) and Rosen (1992). My groundbreaking solution, Equation (25), is recognizable as a simple extension of the classical second-best optimal

risk sharing agency model based on stock market incentives, but with the introduction of information into the stock price. As must always be the case with just the equity-based incentive, the greater the informativeness of the stock price, the lower its weight in an optimal contract. Intuitively, if neither the principal nor informed traders possess information about the agent's actions, the only person who does is the agent himself, requiring higher inside ownership of the firm by the agent to provide adequate motivation, in addition to imposing more risk onto the agent which needs to be compensated for by higher pay.

Given that Equation (8) above and Kyle (1985) demonstrate that informativeness increases in firm size, my theoretical finding that pay sensitivity must decline in informativeness is consistent with the empirical findings already cited of the effect of increasing firm scale in reducing pay sensitivity.

4 Applications and Tests of the Incentive Model

This section reports attempts to empirically test the relationship between the manager's incentive contract and information in stock price. It also addresses a number of applications of the optimal agency contract developed here to issues such as when franchise contracts will be used rather than in-house managerial contracts, and the existence of the modern corporation.

4.1 Some Empirical Tests

There are at least three articles which purport to empirically support Holmström and Tirole's (1993) apparent and now rejected finding that the incentive weight is rising in the signal-to-noise ratio. Firstly, Kang, and Liu (2008) provide empirical support for Holmström and Tirole (1993) using the PIN (Probability of Informed Trading) based on Easley, Hvidkjaer, and O'Hara (2002) as a proxy for information in the stock price and, additionally, analyst forecast errors and forecast dispersion. They concluded that pay-for-performance sensitivity is increasing in information in the stock price. However, their use of PIN as a measure of private information in the stock price is questionable as Duarte, Han, Harford, and Young (2008), show that PIN captures asymmetry of information in illiquid stocks. Hence, Kang and Liu's (2008) findings are in reality supportive of the new model's demonstration that illiquid stocks with low information content must have high pay-for-performance sensitivity.

Second, Kang and Liu (2010) extend Holmström and Tirole (1993) by allowing an endogenous number of informed traders but model only Holmström and Tirole's transformed incentive and pay sensitivity. They concluded that price sensitivity is always increasing in stock price informativeness. They differ slightly from Holmström and Tirole by assuming that the realized firm value perfectly measures the accounting earnings signal and is independent of stock price (Kang and Liu (2010, p.686)). They present both a calibrated model and empirical tests, once again based on a version of the PIN measure. Hence, once again, their findings are actually supportive of the finding in the present paper, that is, liquidity not only raises stock price informativeness but also lowers the price incentive weight.

Finally, motivated by Holmström and Tirole (1993), Jayaraman and Milbourn (2012) provide new empirical tests to support their belief that stock market liquidity raises rather than lowers managerial incentives. Since they forsake any direct measure of information in stock price, they need to adopt a measure of stock market liquidity.

For this purpose, they choose stock turnover as their measure of market liquidity, to show that higher turnover firms rely less on cash-based compensation. Although they produce convincing evidence in support of such a relationship, in effect, what they show is that smaller firms, which generally enjoy higher turnover rates, are naturally relatively illiquid and thus lack informed traders, have low cash-based pay and high incentive-based pay. This is because, as has been known since Kyle (1985), informed traders hide in the crowd and are thus not prevalent in the smaller firms in Jayaraman and Milbourn's (2012, p.546) sample that have high turnover rates. Hence, it is pleasing that their empirical results actually support my reinterpretation of the Holmström and Tirole (1993) findings, as the authors acknowledge in recent correspondence.

Also supportive of my reformulation of Holmström and Tirole's (1993) model developed here, Chordia, Roll, and Subrahmanyam (2008) find that liquidity stimulates arbitrage activity, which, in turn, enhances market efficiency. Moreover, they find that the efficiency of the large cap sector has increased with the reduction in minimum tick size, and following decimalization, the degree of market efficiency is greater for larger firms. Hence, their findings support the idea that the presence of informed trading is highest in large, liquid stocks as opposed to small stocks, even those with higher turnover rates.

4.2 Control Issues

Holmström and Tirole (1993, p.698) examine control issues such as vertical integration that may require high inside ownership, thus reducing both the free-float and noise-trader demand to induce low stock price informativeness. Proposition 2 shows that the manager is likely to be highly incentivized and therefore far from a Pareto-efficient first-best contract due to a lack of informed speculators forcing price to the fundamentals determined by managerial action. Thus, illiquidity carries with it the need to provide high-powered incentives, imposing high risk-bearing costs on shareholders due to them having to compensate the manager for bearing this risk. By its very nature, private equity inclusive of leveraged management buy-outs (LBOs) is illiquid, requiring exceedingly high managerial and board incentives (as shown, *e.g.*, by Leslie and Oyer (2009) and many others).

Holmström and Tirole (1993, p. 698) refers to the reluctance of the subordinate to make relationship-specific investments as a potential cost of vertical integration, as identified by Grossman and Hart (1986), and rightly add that monitoring issues may represent an even greater obstacle to efficient vertical integration. Relative to Holmström and Tirole (1993), the model developed here sees vertical integration as being far more problematic, since high-powered incentives may be required to make up for the absence of price-based divisional incentives driven by informed trading and thus departing further from the first-best contract.

As Holmström and Tirole (1993, p. 699) point out, dual-class shares enable the inside shareholder to enjoy her control rights cake and eat it too, but the interpretation in this current paper is quite different. Insiders predominantly hold subordinate, control-rich shares while cash-rich shares are widely held and traded, increasing informativeness and enabling more efficient and lower cost, lower-powered managerial incentives.

4.3 Large Shareholders, Inside Monitoring, and Takeovers

Holmström and Tirole (1993, p. 699) argued that there may be reasons for high inside ownership, and thus lower liquidity and what they term *speculative* information due to informed market trading if *strategic* information is more important. One can agree that strategic information is likely to be important in relation to takeovers and that a sizable shareholder may make negotiating a successful takeover easier. However, what this forgets is that the acquiring firm will benefit from having informed speculators value the acquisition announcement and assess the likelihood of the match succeeding.

4.4 In-house versus Franchise Contracts and Multitasking

Holmström and Milgrom (1987, 1991, 1994) make important contributions to understanding agency issues but may fall short because there are no semi-public informative signals in these models, unlike the model developed in this paper in which this signal is provided by informed traders. Holmström and Milgrom (1991, 1994) and Holmström (2017) argue that "higher-power" incentives provided to commission agents, independent contractors and in franchise contracts can be explained by multitasking. It is asserted that employees within the firm have substitutable easy-to-measure and important difficult-to-measure tasks with lower precision of estimation due to high signal variance. Thus, in order to avoid misallocating too much effort to more easily assessed tasks, in-house employees are given only lower-power incentives rather than higher-power incentives observed in franchise contracts. In contrast, in the new contractual solution, Proposition 2 and Equation (25) above, there is only one task with no multitasking issues treated here. Why should it be impossible to explain the coexistence of in-house and franchise contracts when the task is the same? Moreover, could this reflect the difficulty faced by classical agency models in explaining real-world contracting problems?

When it comes to franchise agreements, Holmström and Milgrom (1994, p.988) are puzzled by the evidence they cite from Brickley and Dark (1987) which shows that the "harder it is to monitor a unit (as proxied by its distance from headquarters), the *more likely* it is that the unit is franchised." While they points out that *"the relationship is opposite*" (italics added) to their own model (Holmström and Milgrom, 1994) it is supported by the implications of Proposition 2 above showing that, the weaker the signal of manager effort stemming from a paucity of informed traders, *i.e.*, the harder it is to monitor internally due to the absence of such signals, the greater the reliance on high-powered incentives. Consequently, my model predicts that, in order to facilitate more effective and closer to face-to-face monitoring, in-house outlets will be located closer to the company headquarters, where "face-to-face" management may be possible. In contrast, franchisee outlets will be farther away.

Similarly, multiple units belonging to any such multiunit franchisee contractor will be located close to the contractor's headquarters (see Kalnins and Lafontaine, 2004). To put it simply, distant outlets are deficient in "face-to-face monitoring" and thus require high-powered franchise incentives, just as illiquid listed stocks and hi-tech IPOs also require high-powered price-based incentives.

Krueger (1991) showed that company-owned outlets pay their shift managers 9% more than franchise outlets, and the tenure-earning profile is steeper at company outlets with this deferred reward presumably required to provide adequate incentive given that the franchisee owner has a much stronger monitoring incentive than does the com-

pany manager. Hence, once again, we see Proposition 2 in action. The in-house worker incentive contract has to be higher powered to compensate for the low-powered incentives of the internal manager. Other characteristics of franchise contracts compared with in-house operations are also consistent with Proposition 2 above. For example, Lafontaine and Bhattacharyya (1995) find more output variability and lower sales under franchising than under company management and contracting which makes use of the franchisee's information. This precisely describes the high-powered incentives that the model presented in the current paper predicts for smaller, relatively illiquid firms.

My explanation is much simpler and more direct than the multitasking explanation: in-house business units such as fast-food outlets can be monitored, at least partially, whereas independent contractors are more difficult to monitor. In the much more uncertain and less monitored independent contractor (franchise) regime, similar to a start-up firm in a stock market with only a low level of informed trading, my Proposition 2 shows that exceedingly higher rather than lower pay-for-performance is required.

4.5 Explanation for the Existence of the Modern Corporation

The influential work of Holmström and Tirole (1993) has captivated economists by highlighting how informed trading and liquid stock markets contribute to the efficient functioning of large public firms. This paper revisits, corrects, and extends their framework by emphasizing the dynamic interplay between market liquidity, stock price informativeness, and managerial incentive design. I show that as liquidity rises, so does informed trading, resulting in more volatile but more informative prices. For a risk-averse manager, this improved signal-to-noise ratio reduces the need for high-power incentives and large equity stakes. Interestingly, I show that these conclusion would naturally follow from Holmström and Tirole's model, had the timing of managerial effort choice and price determination been logically reversed.

The presence of a stock price and informed stock trading are the main distinguishing features of listed equity compared to private equity. This informed trading has made possible the separation of ownership and control with sizable essential monitoring of management delegated to the market, enabling inside ownership to fall due to improved contract efficiency, while passive outside ownership has greatly expanded. The falling pay-for-performance sensitivity with increases in firm size resulting from the improved signal-to-noise ratio is fundamental to the existence and growth of the modern corporation, as is its reliance almost exclusively on price-based incentives.

Nearly 250 years ago Adam Smith (1776, p.405-406), observing the South Seas bubble at first-hand, pointed to what should have been the fatal flaw in joint stock companies: they manage other people's money, not their own, and thus ought to fail to take proper care of their outside investors.[7] The governance problem due to the dilution of inside ownership alluded to by Adam Smith worsens with increases in firm size as more relatively passive outside shareholders dominate the share register.

Berle and Means (1932) built on Smith's insight to propose corporate governance failure due to the separation of

[7] Smith states: "The directors of such [joint-stock] companies, however, being the managers rather of other people's money than of their own, it cannot well be expected, that they should watch over it with the same anxious vigilance with which the partners in a private company frequently watch over their own." Smith (1776) provides many examples of poorly managed joint stock companies, such as the South Seas company with its immense number of proprietors, for which "folly, negligence, and profusion, should prevail in the whole management of their affairs", but at that time there was little in the way of informed trading on the stock market.

ownership and control. Yet, the large joint-stock corporate form has become the modern corporation, which not only persists but also thrives. Jensen and Meckling (1976, p.330) ask: "Why, given the existence of positive costs of the agency relationship, do we find the usual corporate form of organization with widely diffuse ownership so widely prevalent?" Moreover, they point out (p.348) that "the larger the firm becomes, the larger are the total agency costs because it is likely that the monitoring function is inherently more difficult and expensive in a larger organization."

But Jensen and Meckling (1976, p.356) admit that their analysis requiring either inside ownership or (internal) monitoring is not applicable to "the very large modern corporation whose managers own little or no equity." It is interesting that six of the world's largest companies, Alphabet (Google), Apple, Amazon, Berkshire Hathaway, Meta (Facebook), and Microsoft, retain a sizable founder ownership which undoubtedly helps, but does not explain why the majority of large companies have negligible inside ownership and why it is mainly very large enterprises that thrive on listed markets.

How is it then that when outside owners largely replace inside owners, effective monitoring of management not only continues but seems to improve? Fama and Jensen (1983) refer broadly to market monitoring as a possible solution, but provide no specific model. Jensen (1986) points to severe conflicts between management and shareholders over payout policy and seeks high debt as a substitute for equity to help overcome the conflict with "going private" and leveraged buyouts as possible solutions.[8] Cornelli, Kominek, and Ljungqvist (2013) demonstrate how effective is the board structure and monitoring of the CEO by unlisted private-equity backed firms with largely "soft" information used to displace nonperforming CEOs. Such strong internal governance systems are not surprising, as these firms lack the benefit of market monitoring by informed speculators.

Market monitoring can help to account for the failure of Smith's (1776, p.700) dire prediction that, due to the separation of ownership and control, "negligence and profusion ... must always prevail, more or less, in the management of the affairs of [joint stock] companies."

The answer to Adam Smith (1776), Berle and Means (1932), Jensen and Meckling (1976), Jensen (1986), and many other theorists is that sizable inside ownership is not a requirement for the large modern corporation as external, third-party, informed traders can be a better substitute for inside ownership in terms of demonstrated ability to monitor. Inside ownership is there to provide incentives for monitoring, but if outside parties are better at it because they force the share price to reflect the actions of the manager–both good and bad–then it can be largely, but critically, never dispensed with, even as passive outside ownership comes to dominate.

5 Conclusion

The findings presented in this paper suggest that the interplay between managerial risk aversion and the substantial dollar volatility of returns, which is a characteristic of large and publicly traded firms, renders high-powered incentive schemes not only largely impractical, but also unnecessary and potentially counterproductive. Consequently, the empirically observed decline in inside ownership with increasing firm size should not be regarded

[8] If the success of large companies were simply due to reaping scale economies rather than due to an informative stock price that disciplines management and complements board monitoring then, according to this theory, the global economy could equally be dominated by illiquid private equity rather than giant listed corporations, the latter the beneficiaries of informed trading.

as a governance anomaly, as posited by theorists from Adam Smith onward. Rather, this pattern emerges as a rational response to the structural conditions of modern capital markets. The persistent comparative success of these large corporations, despite minimal inside ownership and limited direct oversight, relative to illiquid private equity firms, is thereby demystified, resolving a conceptual puzzle that has persisted for nearly two and a half centuries.

This study demonstrates that increasing the informativeness of stock prices significantly enhances the effectiveness of managerial incentive mechanisms. Specifically, greater price informativeness leads to reduced pay-performance sensitivity, improved firm performance (as measured by Tobin's Q), increased CEO compensation, and elevated managerial effort. Within this framework, market-based information embedded in stock prices serves as a substitute for direct monitoring traditionally provided by inside shareholders. These shareholders, now largely supplanted by passive external investors with limited monitoring capacity, are no longer essential for effective governance.

In contrast to classical agency theories, most notably those articulated by Adam Smith (1776), Berle and Means (1932), Jensen and Meckling (1976), and Jensen (1986), this paper posits that substantial inside ownership is not a necessary condition for aligning managerial and shareholder interests in large firms. Instead, informed third-party traders can serve as more effective monitors by ensuring that managerial actions are rapidly and accurately reflected in share prices. Although some degree of inside ownership remains critical and cannot be entirely eliminated, its role is increasingly complemented, and in many cases surpassed, by the monitoring function performed through informed trading.

This perspective introduces a novel conceptual synthesis that integrates agency theory, corporate governance, and market microstructure, offering a comprehensive framework for understanding how "governance through trading" (as explored by Gallagher, Gardner and Swan, 2013) supplements and, in some contexts, replaces traditional mechanisms of managerial oversight such as board supervision and insider ownership.

In summary, this paper reframes the decline in inside ownership observed in large firms not as a symptom of governance failure but as a rational adaptation to the superior monitoring capabilities provided by informed trading. It advances the proposition that external market participants, through their contribution to price informativeness, can serve as effective substitutes for direct shareholder oversight in the disciplining of managerial behavior. As a word of warning, board composition remains a critical factor in promoting good corporate governance, as an inappropriate board structure can give rise to destructive and costly high-powered incentives or, at the other extreme, the absence of necessitating incentive alignment.

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