Internet Appendix (Not For Publication) to "Agency Costs and Strategic Speculation in the U.S. Stock Market"

Paolo Pasquariello

Ross School of Business, University of Michigan[1]

February 25, 2022

[1]Send correspondence to Paolo Pasquariello, Department of Finance, Suite R4434, Ross School of Business, University of Michigan, Ann Arbor, MI 48109; telephone: 734-764-9286. Email: ppasquar@umich.edu.

In this Internet Appendix to Pasquariello (2022), I present a stylized model of strategic trading in the presence of managerial agency problems (in Section A and Figures IA-1 to IA-3), as well as report additional information and evidence mentioned therein (in Tables IA-1 and IA-2 and Figure IA-4).

A A Model of Agency Problems and Stock Liquidity

In Sections A.1 to A.3 below, I develop a noisy rational expectations equilibrium (REE) model of strategic, informed, one-shot trading — based on Kyle (1985) — in which the liquidation value of the traded asset depends on managerial effort. This is the simplest setting in which to represent the more general notion advocated in Pasquariello (2022) that socially suboptimal managerial behavior may affect liquidity provision in the presence of adverse selection risk from speculative trading. I then derive the model's equilibrium in closed-form and consider its implications for the asset's liquidity in Sections A-4 and A-5, respectively. All proofs are in Section A.6.

A.1 The Basic Economy

The model is a two-date ($t = 0, 1$), one-period economy in which a single risky asset is traded. Trading occurs only at date $t = 1$, after which the asset's payoff v is revealed. The economy is populated by four types of agents: an informed trader (labeled speculator) representing a strategic "speculative sector;" uninformed liquidity traders; perfectly competitive market-makers (or dealers); and an informed firm manager. All agents know the structure of the economy and the decision process leading to payoffs, order flow, and prices.

A.2 The Firm Manager

A vast corporate finance literature links firm value to costly managerial effort and investigates the corporate governance issues leading to "suboptimal" decision-making, that is, to circumstances when (possibly better informed) managers (or insiders) exert (possibly unobservable) effort (or make investment) that, while beneficial to them, is detrimental to outsiders and overall firm value (e.g., Jensen and Meckling 1976; Tirole 2001, 2006).

I capture these agency costs parsimoniously by assuming that: *i)* at date $t = 0$, the firm manager exerts a privately observed, privately optimal effort y affecting the traded asset's liquidation value v according to the following quadratic function $v(y)$:

$$v(y) = uy - \frac{c}{2}y^2, \tag{A-1}$$

where u is a normally distributed random variable (with mean zero and variance σ_u^2) — known exclusively to the manager — representing the firm's technology or environment affecting the productivity of y, while $c > 0$ is a fixed, unit cost of implementing y; and *ii)* the manager's chosen effort (or investment) is the one maximizing the following separable value function $U_M(y)$:

$$U_M(y) = (1 - \gamma) v(y) + \gamma e y, \tag{A-2}$$

where $\gamma \in (0,1)$ and e is a normally distributed random variable (with mean zero and variance σ_e^2) — independent from u but also known exclusively to the manager — representing the manager's (unit) private benefits from her effort that are unrelated to firm value.

The first term in Equation (A-2) motivates the manager to maximize (unit) firm value in the presence of decreasing returns to effort (in line with outsiders' best interests), that is, to maximize $v(y)$. The second term in Equation (A-2) motivates the manager to exert "socially suboptimal" effort (or to make socially suboptimal investment, in conflict with outsiders' best interests), that is, to deviate from "first-best" effort y_{FB} ($\gamma = 0$, the limiting case when the interests of manager and outsiders are perfectly aligned):

$$y_{FB} \equiv \arg\max v(y) = \frac{1}{c}u, \tag{A-3}$$

yielding firm value $v_{FB} \equiv v(y_{FB}) = \frac{1}{2c}u^2$, a gamma distributed random variable with mean $\overline{v}_{FB} = \frac{1}{2c}\sigma_u^2$ and variance $\sigma_{v_{FB}}^2 = \frac{1}{2c^2}\sigma_u^4$. Accordingly, when $\gamma > 0$, the manager's "second-best" (that is, only "privately optimal") effort (or investment) y_{SB} is given by

$$y_{SB} \equiv \arg\max U_M(y) = \frac{1}{c}(u + de), \tag{A-4}$$

where $d = \frac{\gamma}{1-\gamma}$ measures the manager's marginal rate of substitution between common and private benefits of her effort, yielding firm value $v_{SB} \equiv v(y_{SB}) = \frac{1}{2c}(u^2 - d^2e^2)$, a gamma distributed random variable with mean $\overline{v} = \frac{1}{2c}(\sigma_u^2 - d^2\sigma_e^2) < \overline{v}_{FB}$ and variance $\sigma_v^2 = \frac{1}{2c^2}(\sigma_u^4 + d^4\sigma_e^4) > \sigma_{v_{FB}}^2$.[1]

This setting can accommodate a variety of suboptimal managerial actions in the literature. For instance, Figure IA-1 plots firm value v of Equation (A-1) (solid line) as a function of the manager's effort y in the above economy when $\sigma_u^2 = 1$, $\sigma_e^2 = 1$, $u = 1$, $c = 0.62$, and $\gamma = 0.5$. Ceteris paribus, when $\gamma > 0$, a nonzero realization of the private benefit e leads the firm manager to undertake value-destroying actions ($v_{SB} < v_{FB}$): excessive effort (over-investment or "extravagant investment") $y_{SB} > y_{FB}$ if $e > 0$ (the dashed and dotted lines in Figure IA-1, respectively, for $e = 0.5$) — consistent with the notion of "inefficient empire building" (e.g., Jensen 1988) — or "insufficient effort" (under-investment) $y_{SB} < y_{FB}$ if $e < 0$ — consistent with the notion of "enjoying the quiet life" (e.g., Bertrand and Mullainathan 2003). Hence, the more important are private benefits to the manager (higher γ) and/or the less costly is her effort (lower c), the larger are the agency costs of those actions (e.g., greater expected loss of firm value and firm risk).

A.3 Information and Trading

As in Kyle (1985), speculation and competitive dealership are risk-neutral. Sometime between $t = 0$ and $t = 1$, the speculator receives private information about the risky asset's payoff in the form of a noisy signal $S = v_{SB} + \varepsilon$, where ε is normally distributed with mean zero, variance σ_ε^2, and $cov(\varepsilon, u) = cov(\varepsilon, e) = 0$. Equations (A-1) to (A-4) then imply that S is a mixture of gamma and normally distributed random variables with mean $\overline{S} = \overline{v}$ and variance $\sigma_S^2 = \sigma_v^2 + \sigma_\varepsilon^2$.

[1] The second order condition for the maximization of the manager's value function $U_M(y)$ of Equation (A-2), $-(1-\gamma)c < 0$, is satisfied for either $\gamma = 0$ or $\gamma \in (0,1)$ since $c > 0$.

Thus, and realistically (in light of the discussion in Section A.2), the speculator neither precisely observes the extent to which v_{SB} depends on investment productivity (u) or managerial effort (y_{SB}) at date $t = 0$, nor can precisely assess the extent to which that effort is influenced by private benefits (e). I define $\phi \equiv \frac{\sigma_v^2}{\sigma_S^2} = \frac{\sigma_u^4+d^4\sigma_e^4}{\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2}$ as the precision (so the value) of the speculator's private information. Ceteris paribus, the more severe are managerial agency problems (higher γ) and/or the more uncertainty surrounds their severity (higher σ_e^2), the more asset fundamentals v depend on the manager's private benefits — an additional source of risk — and the more precise (and valuable) is the speculator's private signal of v (higher ϕ).[2] The relation between agency considerations and speculation is an important feature of my model, since it allows for changes in managerial agency problems to affect not only γ and σ_e^2 but also the process of price formation for the traded asset. I return to this issue below.

At date $t = 1$, the speculator and liquidity traders simultaneously submit their market orders to the dealers before the equilibrium price p has been set. I define the market order of the speculator to be x, such that her trading profits are $\pi(x, p) = (v_{SB} - p)\,x$. Liquidity traders generate a random, normally distributed demand z, with mean zero and variance σ_z^2; for simplicity, I further impose that z is independent of all other random variables. Dealers do not receive any information, but observe the aggregate order flow $\omega = x + z$ from all market participants and set the market-clearing price $p = p(\omega)$.

A.4 Equilibrium

Given the optimal managerial effort y_{SB} of Section A.2 at date $t = 0$, a Bayesian Nash equilibrium of the game of Section A.3 at date $t = 1$ is made of two functions $x(\cdot)$ and $p(\cdot)$ satisfying the following Conditions:

1. *Speculator's utility maximization*: $x(S) = \arg\max E(\pi|S)$;

2. *Semi-strong market efficiency*: $p = E(v_{SB}|\omega)$.[3]

Unfortunately, y_{SB} of Equation (A-4) makes v_{SB} a nonlinear function of the normally distributed technology (u) and private benefit shocks (e), thus both the speculator's and the dealers' inference problems analytically intractable. The literature proposes several approaches to approximate nonlinear REE models (e.g., Judd 1998; Bernardo and Judd 2000; Sims 2001; Lombardo and Sutherland 2007; Pasquariello 2014). In this paper, as in Pasquariello (2014), I express both conditional first moments $E[v_{SB}|S]$ and $E[v_{SB}|\omega]$ as linear regressions of v_{SB} on S and ω, respectively:

$$E(v_{SB}|S) \approx E(v_{SB}) + \frac{cov(v_{SB}, S)}{var(S)}[S - E(S)], \quad \text{(A-5)}$$

$$E(v_{SB}|\omega) \approx E(v_{SB}) + \frac{cov(v_{SB}, \omega)}{var(\omega)}[\omega - E(\omega)], \quad \text{(A-6)}$$

[2] Specifically, $\frac{\partial\phi}{\partial\gamma} = \frac{8c^2d^3\sigma_e^4\sigma_\varepsilon^2}{[(1-\gamma)(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)]^2} > 0$ and $\frac{\partial\phi}{\partial\sigma_e^2} = \frac{4c^2d^4\sigma_e^4\sigma_\varepsilon^2}{(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)^2} > 0$.

[3] Condition 2 is also commonly interpreted as the outcome of competition among dealers forcing expected profits from liquidity provision to zero (Kyle 1985).

whose coefficients depend on moments of v, S, and ω that can be computed in closed form (e.g., Greene 1997). The intuition of this approach is that rational speculation and dealership use their knowledge of the economy to form conditional expectations about asset fundamentals from linear least squares estimates of the relation between those fundamentals and their private information — for instance, as they would do if constrained by computational ability, by first simulating a large number of realizations of the economy and then estimating a relation between v_{SB} and either S or ω, via ordinary least squares (Hayashi 2000, pp. 138-140; Pasquariello 2014, pp. 303-305). Equations (A-5) and (A-6) may also stem from imposing that speculation and dealership make approximately Bayesian inference, by considering v_{SB} to be normally distributed and then computing its first moment correctly (conditional upon S and ω, respectively; see, e.g., Roşu 2019). Using numerical analysis, Pasquariello (2014) finds this approach to be accurate and the ensuing inference to be unaffected by using higher-order polynomials in Equations (A-5) and (A-6); see also Bernardo and Judd (2000). Proposition A.1 describes the unique linear REE that obtains from Equations (A-5) and (A-6).

Proposition A.1 *There exists a unique linear equilibrium of the model of Sections A.1 to A.3 given by the price function*

$$p = \overline{v} + \lambda\omega, \tag{A-7}$$

where

$$\lambda = \frac{\sigma_u^4 + d^4\sigma_e^4}{2c\sigma_z\sqrt{2\left(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2\right)}}; \tag{A-8}$$

and by the speculator's order

$$x = \beta\left(S - \overline{v}\right), \tag{A-9}$$

where

$$\beta = \frac{c\sigma_z\sqrt{2}}{\sqrt{\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2}}. \tag{A-10}$$

A.5 Market Liquidity

Some of the basic properties of the equilibrium of Proposition A.1 are standard in this class of models based on Kyle (1985); yet, there are also some noteworthy differences. These properties are best illustrated by considering the limiting first-best scenario ($\gamma = 0$) in which $y = y_{FB}$ of Equation (A-3) such that

$$\lambda_{FB} = \frac{\sigma_u^4}{2c\sigma_z\sqrt{2\left(\sigma_u^4 + 2c^2\sigma_\varepsilon^2\right)}} \tag{A-11}$$

and

$$\beta_{FB} = \frac{c\sigma_z\sqrt{2}}{\sqrt{\sigma_u^4 + 2c^2\sigma_\varepsilon^2}}. \tag{A-12}$$

In the above equilibrium, both the speculator's trading aggressiveness (β_{FB}) and the depth of the market ($\frac{1}{\lambda_{FB}}$) depend on the precision of her private signal of v_{FB} ($\phi_{FB} \equiv \frac{\sigma_{v_{FB}}^2}{\sigma_{S_{FB}}^2}$, where $\sigma_{S_{FB}}^2 = \sigma_{v_{FB}}^2 + \sigma_\varepsilon^2$): $\beta_{FB} = \frac{\sigma_z}{\sigma_{v_{FB}}}\sqrt{\phi_{FB}}$ and $\lambda_{FB} = \frac{\sigma_{v_{FB}}}{2\sigma_z}\sqrt{\phi_{FB}}$, respectively. Intuitively, the speculator is aware of the potential impact of her trades on prices. Thus, despite being risk-neutral, she trades on her private information about v_{FB} cautiously ($|x_{FB}| < \infty$, by camouflaging her market order with noise trading z in the order flow) to dissipate less of it — the more so (lower β_{FB}) the more valuable (higher σ_u^2) or noisier (higher σ_ε^2) is her private signal S_{FB}. The market-makers use the order flow's positive price impact λ_{FB} to offset expected losses from trading with better-informed speculation with expected profits from noise trading.

Accordingly, as in Kyle (1985), liquidity deteriorates (higher λ_{FB}) the less intense is noise trading (lower σ_z^2) and the more vulnerable are market-makers to adverse selection — that is, the more uncertain is the traded asset's payoff v_{FB} (higher σ_u^2) and the less noisy is S_{FB} (lower σ_ε^2), making the speculator's private information more valuable.[4] However, differently from Kyle (1985), market-makers' adverse selection risk depends not only on the economy's fundamental (or the speculator's information) technology σ_u^2 (σ_ε^2) but also on the effort exerted (or investment made) by the firm manager (y_{FB} of Equation (A-3)). As discussed in Section A.2, managerial effort is greater the lower is its unit cost c. Ceteris paribus, greater such effort not only increases firm value v (higher $\overline{v}_{FB}$ and $\sigma_{v_{FB}}^2$) but also makes the speculator's private information about it more valuable (higher ϕ_{FB}, as $\sigma_{S_{FB}}^2$ depends less on signal noise σ_ε^2) and her trading activity more cautious (lower β_{FB}), ultimately exacerbating dealers' adverse selection concerns and decreasing equilibrium market liquidity (higher λ_{FB}).[5]

Importantly, in the presence of agency problems ($\gamma > 0$), this relation between managerial effort and speculation makes the traded asset's liquidity sensitive to firm-level agency costs. In particular, Proposition A.1 implies that: *i)* agency problems *worsen* equilibrium market depth ($\lambda - \lambda_{FB} > 0$); and *ii)* equilibrium market depth is *lower* (λ is higher) the more important are private benefits e in the firm manager's value function $U_M(y)$ of Equation (A-2) and in her second-best effort y_{SB} of Equation (A-4) (higher γ), and the greater is the uncertainty surrounding those private benefits among market participants (higher σ_e^2). I discuss the intuition behind these results with the help of Figures IA-2 and IA-3, where I plot first-best (solid line) and second-best (dashed line) private signal precision (ϕ_{FB} and ϕ) and equilibrium trading aggressiveness (β_{FB} and β) and price impact (λ_{FB} and λ) as a function of γ and σ_e^2 in the economy of Figure IA-1. I summarize and formalize all relevant comparative statics in Corollary A.1 and Remark A.1.

Ceteris paribus, when managerial agency problems are more severe (higher γ and d), the manager exerts more suboptimal effort or investment (that is, puts more weight on e in y_{SB}, yielding greater $E(|y_{SB} - y_{FB}|) = \frac{1}{c} d\sigma_e^2 \sqrt{\frac{2}{pi}} > 0$) to increase her private benefits from running the firm. This behavior makes firm value v_{SB} more sensitive to an additional source of risk (e) unrelated to the firm's fundamental technology (u) and volatile, hence the speculator's private signal of v_{SB} (S) more valuable (higher ϕ in Figure IA-2a) and her trading on it less aggressive (lower β in Figure IA-2c).[6] In response to both, the dealers perceive the threat of adverse selection

---

[4]In particular, $\frac{\partial \lambda_{FB}}{\partial \sigma_z^2} = -\frac{\sigma_u^4 \sqrt{2}}{8c\sqrt{\sigma_z^3(\sigma_u^4 + 2c^2\sigma_\varepsilon^2)}} < 0$, $\frac{\partial \lambda_{FB}}{\partial \sigma_u^2} = \frac{\sigma_u^2\sqrt{2}\left(\sigma_u^4 + 4c^2\sigma_\varepsilon^2\right)}{4c\sigma_z\sqrt{(\sigma_u^4 + 2c^2\sigma_\varepsilon^2)^3}} > 0$, and $\frac{\partial \lambda_{FB}}{\partial \sigma_\epsilon^2} = -\frac{c\sigma_u^4\sqrt{2}}{4\sigma_z\sqrt{(\sigma_u^4 + 2c^2\sigma_\varepsilon^2)^3}} < 0$.

[5]More generally, $\frac{\partial \phi}{\partial c} = -\frac{4c\sigma_\varepsilon^2\left(\sigma_u^4 + d^4\sigma_e^4\right)}{(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2)^2} < 0$, $\frac{\partial \beta}{\partial c} = \frac{\sqrt{2}\sigma_z\left(\sigma_u^4 + d^4\sigma_e^4\right)}{\sqrt{(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2)^3}} > 0$, and $\frac{\partial \lambda}{\partial c} = -\frac{4c\sigma_\varepsilon^2\left(\sigma_u^4 + d^4\sigma_e^4\right)}{(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2)^2} < 0$ in correspondence to both first-best ($y = y_{FB}$ of Equation (A-3)) and second-best managerial effort ($y = y_{SB}$ of Equation (A-4)).

[6]I noted in Section A.2 that $\sigma_v^2 = \frac{1}{2c^2}\left(\sigma_u^4 + d^4\sigma_e^4\right)$, while it can be shown from Proposition 1 that $var(p) =$

as more serious and decrease market depth (higher λ in Figure A-3a; the more so the greater are agency costs and uncertainty in the first place). Along those lines, however, less uncertainty (or more transparency) among market participants about the firm's agency problems (lower σ_e^2) alleviates those adverse selection concerns for the dealers, not only because private signal precision deteriorates (lower ϕ in Figure IA-2b) but also because that deterioration induces less cautious speculation (higher β in Figure IA-2d), ultimately improving market liquidity (lower λ in Figure IA-3b; especially if such uncertainty and those costs are initially high).[7]

Corollary A.1 *In the equilibrium of Proposition A.1, second-best market liquidity is lower than in the first-best scenario, as well as (increasingly) decreasing both in the severity of agency problems plaguing managerial effort and in the uncertainty surrounding those problems.*

Further insight about my model comes from examining the effect of shocks to the unit cost of managerial effort or investment (c) on the relation between agency considerations and market liquidity. Figure IA-3 plots the second-best equilibrium price impact λ of Equation (A-8) in the economy of Figure IA-1 as a function of γ (Figure IA-3c) and σ_e^2 (Figure IA-3d) for either low ($c_L = 0.25$, solid line) or high ($c_H = 0.75$, dashed line) such cost. Ceteris paribus, higher c induces firm management to exert lesser effort (or invest less) — whether it be motivated by the outsiders' or her own best interest (e.g., $\frac{\partial E(|y_{SB}-y_{FB}|)}{\partial c} = -\frac{1}{c^2} d\sigma_e^2 \sqrt{\frac{2}{pi}} < 0$) — so making agency problems less important for firm value (e.g., $\frac{\partial|\overline{v}-\overline{v}_{FB}|}{\partial c} = -\frac{1}{2c^2} d^2\sigma_e^2 < 0$) and speculation's private information about it less valuable ($\frac{\partial\phi}{\partial c} < 0$). Intuitively, less managerial effort y (including value-destroying one, when $\gamma > 0$) makes both firm value ($v(y)$) and private fundamental information ($S = v(y) + \varepsilon$) less sensitive to managerial preferences and decisions (including suboptimal ones) and so less volatile (lower σ_v^2 and σ_S^2), ultimately also dampening price fluctuations (lower $var(p)$).[8] Accordingly, not only does market-makers' adverse selection risk decline and market liquidity improve (as noted earlier; e.g., $\lambda(c_H) < \lambda(c_L)$ in Figure IA-3), but also such liquidity provision becomes less dependent upon agency considerations (e.g., a flatter slope for $\lambda(c_H)$ in Figure IA-3).

Remark A.1 *In the equilibrium of Proposition A.1, the positive sensitivity of equilibrium price impact to the severity of, and uncertainty about, firm-level agency problems is decreasing in the cost of managerial effort.*

A.6 Proofs

Proof of Proposition A.1. As standard in this class of models, I restrict my attention to linear REEs of the game between competitive dealership and strategic speculation (e.g., see Kyle 1985; Pasquariello and Vega 2007), given the firm manager's privately optimal effort y_{SB} of

---

$\frac{\left(\sigma_u^4+d^4\sigma_e^4\right)^2}{4c^2(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)}$, such that $\frac{\partial\sigma_v^2}{\partial\gamma} = \frac{2d^3\sigma_e^4}{c^2(1-\gamma)^2} > 0$, $\frac{\partial\sigma_v^2}{\partial\sigma_e^2} = \frac{d^4\sigma_e^2}{c^2} > 0$, $\frac{\partial var(p)}{\partial\gamma} = \frac{d^3\sigma_e^4\left(\sigma_u^4+d^4\sigma_e^4\right)\left(\sigma_u^4+d^4\sigma_e^4+4c^2\sigma_\varepsilon^2\right)}{c^2(1-\gamma)^2(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)^2} > 0$, and $\frac{\partial var(p)}{\partial\sigma_e^2} = \frac{d^4\sigma_e^2\left(\sigma_u^4+d^4\sigma_e^4\right)\left(\sigma_u^4+d^4\sigma_e^4+4c^2\sigma_\varepsilon^2\right)}{2c^2(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)^2} > 0$.

[7] Accordingly, $\frac{\partial\beta}{\partial\gamma} = -\frac{2d^3\sigma_e^4 c\sigma_z\sqrt{2}}{(1-\gamma)^2\sqrt{(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)^3}} < 0$ and $\frac{\partial\beta}{\partial\sigma_e^2} = -\frac{d^4\sigma_e^2 c\sigma_z\sqrt{2}}{\sqrt{(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)^3}} < 0$.

[8] In particular, $\frac{\partial\sigma_v^2}{\partial c} = \frac{\partial\sigma_S^2}{\partial c} = -\frac{\sigma_u^4+d^4\sigma_e^4}{c^3} < 0$ and $\frac{\partial var(p)}{\partial c} = -\frac{\left(\sigma_u^4+d^4\sigma_e^4\right)^2}{2c^3(\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2)} < 0$.

Equation (A-4). Thus, the proof is by construction, in three steps. In the first step, I conjecture general linear functions for pricing and speculation. In the second step, I solve for the parameters of these functions satisfying Conditions 1 and 2 in Section A.4. In the third step, I verify that these parameters and functions represent a REE. I begin by noting that the approximately linear conditional first moment $E\left(v_{SB}|S\right)$ of Equation (A-5) is given by

$$E\left(v_{SB}|S\right) \approx \overline{v} + \phi\left(S - \overline{v}\right). \tag{A-13}$$

Accordingly, I assume that, in equilibrium, $p = A_0 + A_1\omega$ and $x = B_0 + B_1 S$, where $A_1 > 0$. These assumptions and the definition of ω imply that

$$E\left[p|S\right] = A_0 + A_1 x. \tag{A-14}$$

Using Equations (A-13) and (A-14), the first order condition for the maximization of the speculator's expected profit $E(\pi|S) = E\left[x\left(v_{SB} - p\right)|S\right]$ with respect to x is given by

$$\phi S + \left(1 - \phi\right)\overline{v} - A_0 - 2A_1B_0 - 2A_1B_1S = 0. \tag{A-15}$$

For Equation (A-15) to be true, it must be that

$$\begin{aligned}\left(1 - \phi\right)\overline{v} - A_0 &= 2A_1B_0, &\text{(A-16)}\\ \phi &= 2A_1B_1, &\text{(A-17)}\end{aligned}$$

while the second order condition $-2A_1 < 0$ is satisfied if and only if $A_1 > 0$. The distributional assumptions of Sections A.1 to A.3 imply that $E\left(\omega\right) = B_0 + B_1\overline{v}$, $var\left(\omega\right) = \sigma_z^2 + B_1^2\sigma_S^2$, and $cov\left(v_{SB}, \omega\right) = B_1\sigma_v^2$, such that the approximately linear conditional first moment $E\left(v_{SB}|\omega\right)$ of Equation (A-6) becomes

$$E\left(v_{SB}|\omega\right) \approx \overline{v} + \frac{B_1\sigma_v^2}{\sigma_z^2 + B_1^2\sigma_S^2}\left(\omega - B_0 - B_1\overline{v}\right). \tag{A-18}$$

According to Condition 2 in Section A.4 (semi-strong market efficiency), $p = E\left(v|\omega\right)$. Therefore, my prior conjecture for p is correct if and only if:

$$\begin{aligned}A_0 &= \overline{v} - A_1B_0 - A_1B_1\overline{v}, &\text{(A-19)}\\ A_1 &= \frac{B_1\sigma_v^2}{\sigma_z^2 + B_1^2\sigma_S^2}. &\text{(A-20)}\end{aligned}$$

The expressions for A_0, A_1, B_0, and B_1 in Proposition A.1 must uniquely solve the system made of Equations (A-16), (A-17), (A-19), and (A-20) to represent a unique linear Bayesian Nash equilibrium of the model of Sections A.1 to A.3. Rewriting Equations (A-16) and (A-17) with respect to A_1B_0 and A_1B_1, respectively, and plugging the resulting expressions $A_1B_0 = \frac{1}{2}\left[\left(1 - \phi\right)\overline{v} - A_0\right]$ and $A_1B_1 = \frac{1}{2}\phi$ into Equation (A-19) leads to $A_0 = \overline{v}$. Rewriting Equation (A-17) with respect to A_1 and equating the resulting expression $A_1 = \frac{1}{2B_1}\phi$ to Equation (A-20) yields

$$2B_1^2\sigma_v^2 = \phi\left(\sigma_z^2 + B_1^2\sigma_S^2\right). \tag{A-21}$$

Since $\phi \equiv \frac{\sigma_v^2}{\sigma_S^2}$ (see Section A.3), Equation (A-21) implies that $B_1^2 = \frac{\sigma_z^2}{\sigma_S^2}$, such that $B_1 = \frac{\sigma_z}{\sigma_S} = \beta > 0$ of Equation (A-10) as $\sigma_S^2 = \frac{1}{2c^2}\left(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2\right)$. Substituting this expression for B_1 back into Equation (A-17) and solving for A_1, I obtain $A_1 = \frac{\sigma_v^2}{2\sigma_S\sigma_z} = \lambda > 0$ of Equation (A-8) and p of Equation (A-7). Lastly, replacing A_0 with $\overline{v}$ and A_1 with λ in Equation (A-16) yields $B_0 = -\beta\overline{v}$ and x of Equation (A-9). ■

Proof of Corollary A.1. The first part of the statement ensues from Equations (A-8) and (A-11) implying that

$$\lambda - \lambda_{FB} = \frac{1}{2c\sigma_z}\left(\frac{\sigma_u^4 + d^4\sigma_e^4}{\sqrt{2\left(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2\right)}} - \frac{\sigma_u^4}{\sqrt{2\left(\sigma_u^4 + 2c^2\sigma_\varepsilon^2\right)}}\right) > 0, \tag{A-22}$$

since if $f(x) = \frac{x}{\sqrt{x}}$, then $\frac{\partial f(x)}{\partial x} = \frac{1}{2\sqrt{x}} > 0$. The second part of the statement follows from noting that

$$\frac{\partial\lambda}{\partial\gamma} = \frac{d^3\sigma_e^4\sqrt{2}\left(\sigma_u^4 + d^4\sigma_e^4 + 4c^2\sigma_\varepsilon^2\right)}{2c\sigma_z(1-\gamma)^2\sqrt{\left(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2\right)^3}} > 0, \tag{A-23}$$

$$\frac{\partial\lambda}{\partial\sigma_e^2} = \frac{d^4\sigma_e^2\sqrt{2}\left(\sigma_u^4 + d^4\sigma_e^4 + 4c^2\sigma_\varepsilon^2\right)}{4c\sigma_z\sqrt{\left(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2\right)^3}} > 0, \tag{A-24}$$

where it is tedious but straightforward to show that $\frac{\partial^2\lambda}{\partial\gamma\partial\sigma_e^2} > 0$, $\frac{\partial^2\lambda}{\partial\sigma_e^2\partial\gamma} > 0$, and $\frac{\partial^2\lambda}{\partial\gamma^2} > 0$, while $\frac{\partial^2\lambda}{\partial\sigma_e^4} > 0$ for plausible (e.g., non-extreme) parametrizations of the economy (e.g., ceteris paribus, if c or σ_e^2 are not too high, that is, for $c \leq \frac{\sigma_u^2}{\sqrt{2\sigma_\varepsilon^2}}$ or $\sigma_e^2 < \sqrt{\frac{2c^2\sigma_\varepsilon^2(4c^2\sigma_\varepsilon^2+3\sigma_u^4)+\sigma_u^8}{d^4(2c^2\sigma_\varepsilon^2-\sigma_u^4)}}$). ■

Proof of Remark A.1. Given Corollary A.1, the statement ensues from Equations (A-23) and (A-24) implying that

$$\frac{\partial^2\lambda}{\partial c\partial\gamma} = -\frac{d^3\sigma_e^4\sqrt{2}\left[\sigma_u^8 + d^4\sigma_e^4\left(2\sigma_u^4 + d^4\sigma_e^4\right) + 4c^2\sigma_\varepsilon^2\left(\sigma_u^4 + d^4\sigma_e^4 + 4c^2\sigma_\varepsilon^2\right)\right]}{2c^2\sigma_z(1-\gamma)^2\sqrt{\left(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2\right)^5}} < 0, \tag{A-25}$$

$$\frac{\partial^2\lambda}{\partial c\partial\sigma_e^2} = -\frac{d^4\sigma_e^2\sqrt{2}\left[\sigma_u^8 + d^4\sigma_e^4\left(2\sigma_u^4 + d^4\sigma_e^4\right) + 4c^2\sigma_\varepsilon^2\left(\sigma_u^4 + d^4\sigma_e^4 + 4c^2\sigma_\varepsilon^2\right)\right]}{4c^2\sigma_z\sqrt{\left(\sigma_u^4 + d^4\sigma_e^4 + 2c^2\sigma_\varepsilon^2\right)^5}} < 0. \tag{A-26}$$

■

References

Altman, E. 1968. Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *Journal of Finance* 23:589–609.

Amihud, Y. 2002. Illiquidity and stock returns: Cross-section and time-series effects, *Journal of Financial Markets* 5:31–56.

Amihud, Y., H. Mendelson, and B. Lauterbach. 1997. Market microstructure and securities value: Evidence from the Tel Aviv exchange. *Journal of Financial Economics* 45:365–90.

Armstrong, C., K. Balakrishnan, and D. Cohen. 2012. Corporate governance and the information environment: Evidence from state antitakeover laws. *Journal of Accounting and Economics* 53:185–204.

Bernardo, A., and K. Judd. 2000. Asset market equilibrium with general tastes, returns, and informational asymmetries. *Journal of Financial Markets* 3:17–43.

Bertrand, M., and S. Mullainathan. 2003. Enjoying the quiet life? Corporate governance and managerial preferences. *Journal of Political Economy* 111:1043–75.

Bharath, S., P. Pasquariello, and G. Wu. 2009. Does asymmetric information drive capital structure decisions? *Review of Financial Studies* 22:3211–43.

Bhattacharya, N., H. Desai, and K. Venkataraman. 2013. Does earnings quality affect information asymmetry? Evidence from trading costs. *Contemporary Accounting Research* 30:482–516.

Bradshaw, M., M. Drake, J. Myers, and L. Myers. 2012. A re-examination of analysts' superiority over time-series forecasts of annual earnings. *Review of Accounting Studies* 17:944–68.

Brown, S., and S. Hillegeist. 2007. How disclosure quality affects the level of information asymmetry. *Review of Accounting Studies* 12:443–77.

Chidambaran, N., S. Kedia, and N. Prabhala. 2012. CEO-director connections and corporate fraud. Working Paper, Fordham University.

Chung, K., J. Elder, and J. Kim. 2010. Corporate governance and liquidity. *Journal of Financial and Quantitative Analysis* 45:265–91.

Chung, K., and H. Zhang. 2014. A simple approximation of intraday spreads using daily data. *Journal of Financial Markets* 46:247–73.

Cooper, S., J. Groth, and W. Avera. 1985. Liquidity, exchange listing, and stock return performance. *Journal of Economics and Business* 37:19–33.

Easley, D., S. Hvidkjaer, and M. O'Hara. 2010. Factoring information into returns. *Journal of Financial and Quantitative Analysis* 45:293–309.

Easley, D., N. Kiefer, M. O'Hara, and J. Paperman. 1996. Liquidity, information, and infrequently traded stocks. *Journal of Finance* 51:1405–36.

Frydman, C., and D. Jenter. 2010. CEO compensation. *Annual Review of Financial Economics* 2:75–102.

Gabaix, X., A. Laundier, and A. Sauvagnat. 2014. CEO pay and firm size: An update after the crisis, *Economic Journal* 124:40–59.

Gallo, L. 2013. The more we know about fundamentals, the less we agree on price? Evidence from earnings announcements. Working Paper, University of Maryland.

George, T., G. Kaul, and M. Nimalendran. 1991. Estimation of the bid-ask spread and its components: A new approach. *Review of Financial Studies* 4:623–56.

Gompers, P., J. Ishii, and A. Metrick. 2003. Corporate governance and equity prices. *Quarterly Journal of Economics* 118:107–55.

Gormley, T., and D. Matsa. 2016. Playing it safe? Managerial preferences, risk, and agency conflicts. *Journal of Financial Economics* 122:431–55.

Greene, W. 1997. *Econometric Analysis*. Upper Saddle River, NJ: Pearson-Prentice Hall.

Hasbrouck, J. 2009. Trading costs and returns for U.S. equities: Estimating effective costs from daily data. *Journal of Finance* 64:1445–77.

Hayashi, F.. 2000. *Econometrics*. Princeton, NJ: Princeton University Press.

Jensen, M. 1988. Takeovers: Their causes and consequences. *Journal of Economic Perspectives* 2:21–48.

Jensen, M., and W. Meckling. 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3:305–60.

Judd, K.. 1998. *Numerical methods in economics*. Cambridge, MA: MIT Press.

Kyle, A. 1985. Continuous auctions and insider trading. *Econometrica* 53:1315–35.

Lesmond, D., J. Ogden, and C. Trzcinka. 1999. A new estimate of transaction costs. *Review of Financial Studies* 12:1113–41.

Llorente, G., R. Michaely, G. Saar, and J. Wang. 2002. Dynamic volume-return relation of individual stocks. *Review of Financial Studies* 15:1005–47.

Lombardo, G., and A. Sutherland. 2007. Computing second-order accurate solutions for rational expectations models using linear solution methods. *Journal of Economic Dynamics and Control* 31:515–30.

O'Brien, P. 1988. Analysts' forecasts as earnings expectations. *Journal of Accounting and Economics* 10:53–83.

Panousi, V., and D. Papanikolaou. 2012. Investment, idiosyncratic risk, and ownership. *Journal of Finance* 67:1113–48.

Pasquariello, P. 2014. Prospect Theory and market quality. *Journal of Economic Theory* 149:276–310.

Pasquariello, P. 2022. Agency costs and strategic speculation in the U.S. stock market. *Review of Corporate Finance Studies*, Forthcoming.

Pasquariello, P., and C. Vega. 2007. Informed and strategic order flow in the bond markets. *Review of Financial Studies* 20:1975–2019.

Pastor, L., and R. Stambaugh. 2003. Liquidity risk and expected stock returns. *Journal of Political Economy* 111:642–85.

Roll, R. 1984. A simple implicit measure of the effective bid-ask spread in an efficient market. *Journal of Finance* 39:1127–39.

Roşu, I. 2019. Dynamic adverse selection and liquidity. Working Paper, HEC Paris.

Sims, C. 2001. Solving linear rational expectations models. *Computational Economics* 20:1–20.

Sloan, R. 1996. Do stock prices fully reflect information in accruals and cash flows about future earnings? *Accounting Review* 71:289–315.

Tirole, J. 2001. Corporate governance. *Econometrica* 69:1–35.

———. 2006. *The theory of corporate finance*. Princeton, NJ: Princeton University Press.

Venter, J., and D. de Jongh. 2006. Extending the EKOP model to estimate the probability of informed trading. *Studies in Economics and Econometrics* 30:25–39.

Table IA-1. States adopting a business combination law

This table reports the 33 U.S. states adopting a business combination (BC) law as well as the year of adoption (in chronological order), as listed in Bertrand and Mullainathan (2003) and Gormley and Matsa (2016).

U.S. state	Year of BC law adoption	U.S. state	Year of BC law adoption
New York	1985	Connecticut	1989
Indiana	1986	Illinois	1989
Missouri	1986	Kansas	1989
New Jersey	1986	Maryland	1989
Arizona	1987	Massachusetts	1989
Kentucky	1987	Michigan	1989
Minnesota	1987	Pennsylvania	1989
Washington	1987	Wyoming	1989
Wisconsin	1987	Ohio	1990
Delaware	1988	Rhode Island	1990
Georgia	1988	South Dakota	1990
Idaho	1988	Nevada	1991
Maine	1988	Oklahoma	1991
Nebraska	1988	Oregon	1991
South Carolina	1988	Iowa	1997
Tennessee	1988	Texas	1997
Virginia	1988		

Table IA-2. Variable definition

Variable	Definition
ABNACCR	Based on Sloan (1996), Bhattacharya, Desai and Venkataraman (2013); computed from COMPUSTAT as (100 times) the absolute difference between the ratio *accruals* / *at* and its corresponding two-digit SIC cross-sectional median, where *accruals* = [*act* − *act*(-1)] − [*che* − *che*(-1)] + [*lct* − *lct*(-1)] + [*dlc* − *dlc*(-1)] − *dp*, item *che* = cash and short term investments, *lct* = current liabilities, *dlc* = debt included in current liabilities, *dp* = depreciation and amortization, *at* = total assets.
AGE	Computed as one plus the difference between a firm's available year in the sample and the year of its initial listing on CRSP.
AMIHUD	Based on Amihud (2002), Hasbrouck (2009); computed from CRSP as the annual average of (10^6 times) the daily ratio between a firm's absolute stock return (abs(*ret*)) and its positive dollar volume (the product of its absolute stock price [abs(*prc*), since CRSP replaces missing closing prices with negative bid-ask averages; see http://www.crsp.org/products/documentation/data-definitions-b] and its trading volume [*vol*], *dollarvol* > 0), when at least 60 daily observations are available in a year.
AMIVEST	Based on Cooper, Groth, and Avera (1985), Amihud, Mendelson, and Lauterbach (1997), Bharath, Pasquariello, and Wu (2009); computed (in millions of U.S. dollars) from CRSP as (the negative of) the annual average of the daily ratio between a firm's *dollarvol* (divided by 10^6) and its abs(*ret*) > 0, when at least 60 daily observations are available in a year.
ASYPBA	Based on the notion in George, Kaul, and Nimalendran (1991) that liquidity trading (better-informed speculation) induces a temporary (permanent) revision in stock prices, hence generating negatively (positively) autocorrelated returns; computed from CRSP as (100 times) one minus the coefficient of an annual regression of the *bid-adjusted* ROLL (that is, computed for *ret* net of its bid-based return) over a 60-day rolling window on the average PBA over that same window, when at least 60 daily such observations are available in a year.
ASYROLL	Based on the aforementioned decomposition in George, Kaul, and Nimalendran (1991); estimated from CRSP as (100 times) one minus the square of the coefficient of an annual regression of the *filtered* ROLL (that is, computed on the residuals of a regression of *ret* on expected returns from a market model estimated over the previous year) over a 60-day rolling window on the actual ROLL (that is, for *ret*) over that same window, when at least 60 daily such observations are available in a year.
BOARDSIZE	Based on Chidambaran, Kedia, and Prabhala (2012); computed from BOARDEX as the number of board members of a firm (those where *seniority* = *Executive Director* or *seniority* = *Supervisory Director*) in a year.
CASHFLOW	Computed from COMPUSTAT as (100 times) the ratio (*oiadp* − *accruals*) / *at*, where item *oiadp* = operating income after depreciation and amortization.
CEOCOMP	Based on Frydman and Jenter (2010), Gabaix, Laundier, and Sauvagnat (2014); computed from EXECUCOMP as (100 times) the ratio between the total compensation of each CEO of a firm (*ceoann*) in a year (*totalcomp* = *base salary* + *restricted stock grants* + *options granted* + *long term incentive payouts*, where *base salary* = *total_curr*, *restricted stock grants* = *rstkgrnt* [*stock_awards_fv* in 2006], *options granted* = *option_awards_blk_value* [*option_awards_fv* in 2006], *long term incentive payouts* = *ltip* [*noneq_incent* in 2006]) and the firm's end-of-year market capitalization (MKTCAP).

Table IA-2. (Continued). Variable definition

Variable	Definition
CEOINC	Based on Frydman and Jenter (2010), Gabaix, Laundier, and Sauvagnat (2014); computed from EXECUCOMP as (100 times) the ratio between the incentive-based compensation (*inccomp* = *restricted stock grants* + *options granted* + *long term incentive payouts*) and the total compensation (*totalcomp*) of each CEO of a firm (*ceoann*) in a year.
COVERAGE	Based on Armstrong, Balakrishnan, and Cohen (2012); computed from I/B/E/S as the number of available analyst forecasts of the annual EPS of a firm (*value*) in a year (*anndats*) entering INACCURACY and UNCERTAINTY.
C2	Based on the notion in Llorente et al. (2002) that the cross-sectional variation in stocks' volume-return autocorrelation dynamics is related to the relative importance of better-informed speculation in stock price formation; computed from CRSP as (100 times) the coefficient of an annual regression of *ret* on the product of daily (log) turnover (*logturn*, the natural logarithm of the ratio between daily trading volume [*vol*] and total shares outstanding [*shrout* times 10^3]) and *ret*(-1) after controlling for *ret*(-1), when at least 60 daily observations are available in a year.
DEBT	Computed from COMPUSTAT as (100 times) the ratio (*dltt* + *dlc*) / *at*, where item *dltt* = long-term debt.
DISPERSION	Based on Gallo (2013); computed from I/B/E/S as (100 times) the standard deviation of the available analyst forecasts of the annual EPS of a firm (*value*) announced in a year (*anndats*) divided by its CRSP's end-of-year abs(*prc*).
EC	Computed by Hasbrouck (2009; http://people.stern.nyu.edu/jhasbrou/Research/GibbsEstimates2006/Liquidity%20estimates%202006.htm) from CRSP as (100 times) the Gibbs estimate of the percentage effective cost of a trade (or one-half the percentage effective bid-ask spread of Roll, 1984) for a firm in a year as the coefficient for changes in trade direction indicators in a basic market-factor model for daily *ret*, when at least 60 daily observations are available in a year.
EXCOMP	Based on Frydman and Jenter (2010); computed from EXECUCOMP as (100 times) the ratio between the sum of the total compensation of all firm executives in a year (*totalcomp*) and the firm's end-of-year market capitalization (MKTCAP).
EXINC	Based on Frydman and Jenter (2010); computed from EXECUCOMP as (100 times) the average of the ratio between the incentive-based compensation (*inccomp*) and the total compensation (*totalcomp*) of each firm executive in a year.
GINDEX	Computed by Gompers, Ishii, and Metrick (2003); missing observations for each covered firm in any year between 1987 and 2006 are replaced by the simple average of its available observations over up to three lead and lag available years.
IDIOVOL	Computed by Hasbrouck (2009; http://people.stern.nyu.edu/jhasbrou/Research/GibbsEstimates2006/Liquidity%20estimates%202006.htm) from CRSP as (100 times) the annualized (that is, multiplied by the square root of 252) Gibbs estimate of the standard deviation of the residuals of the basic market-factor model for daily *ret* used to estimate EC, when at least 60 daily observations are available in a year.

Table IA-2. (Continued). Variable definition

Variable	Definition
INACCURACY	Based on Bradshaw et al. (2012); computed from I/B/E/S as (100 times) the absolute difference between the consensus (median) of the available analyst forecast of the annual EPS of a firm (*value*) in a year (*anndats*) and its corresponding actual EPS (*actual*) divided by its CRSP's end-of-year abs(*prc*).
INDBOARD	Based on Chidambaran, Kedia, and Prabhala (2012); computed from BOARDEX as (100 times) the fraction of board members of a firm (those where $seniority$ = *Executive Director* or $seniority$ = *Supervisory Director*) in a year who are labeled as independent (those where $seniority$ = *Supervisory Director*).
INSOWN	Based on Panousi and Papanikolaou (2012); computed from THOMSON REUTERS 13-F as (100 times) the fraction of a firm's year-end shares outstanding (*shrout* times 10^3) that are held by firm insiders ($sharesheld \geq 0$, or zero otherwise in sample).
INSTOWN	Based on Chung, Elder, and Kim (2010); computed from THOMSON REUTERS 13-F as (100 times) the fraction of a firm's year-end shares outstanding (*shrout* times 10^3) that are held by institutional investors ($shares \geq 0$, or zero otherwise if in sample).
INSTRADE	Based on Chung, Elder, and Kim (2010); computed from THOMSON REUTERS 13-F as (100 times) the ratio between the number of a firm's shares that are traded by firm insiders in a year ($shares \geq 0$, or zero otherwise if in sample) and its year-end shares outstanding (*shrout* times 10^3).
INVTURN	Computed from CRSP as the natural logarithm of the inverse of average daily turnover (the ratio between daily trading volume [*vol*] and total shares outstanding [*shrout* times 10^3]), when at least 60 daily observations are available in that year.
MKTCAP	Computed (in millions of U.S. dollars) from CRSP as the product of a stock's year-end *shrout* and abs(*prc*) (divided by 10^3).
PBA	Based on George, Kaul, and Nimalendran (1991), Chung and Zhang (2014); computed from CRSP as (100 times) the annual average of the daily ratio between a firm's closing quoted bid-ask spread (when available; see http://www.crsp.org/products/documentation/data-definitions-b) and its price midquote $(askhi - bidlo) / [0.5 \times (askhi + bidlo)]$ if its exchange code $exchcd = 1$ (NYSE) or 2 (AMEX) and $prc < 0$ or $(ask - bid) / [0.5 \times (ask + bid)]$ if $exchcd = 3$ (NASDAQ), when at least 60 daily observations are available in a year.
PIN	Based on Easley et al.'s (1996) sequential model of trading in which dealers' perceived probability of the arrival of better-informed speculation is driven by the frequency and magnitude of buy-sell imbalances; computed as an equal weighted average of (100 times) estimates of annual PIN from two sources, when available: Easley, Hvidkjaer, and O'Hara's (2010) basic PIN measure of Easley et al. (1996; https://sites.google.com/site/hvidkjaer/data) from ISSM and TAQ intraday data (over 1983-2001), and Brown and Hillegeist's (2007) extended PIN measure of Venter and de Jongh (2006; https://scholar.rhsmith.umd.edu/sbrown/pin-data), accounting for the strong positive correlation between buy and sell orders in that dataset (over 1993-2006), when at least 60 daily observations are available in a year.

Table IA-2. (Continued). Variable definition

Variable	Definition
PROPZERO	Based on Lesmond, Ogden, and Trzcinka (1999); computed from CRSP as (100 times) the fraction of days in a year with zero returns ($ret = 0$) but positive trading volume ($vol > 0$), when at least 60 daily observations are available in that year.
PS	Based on the notion in Pastor and Stambaugh (2003) that the greater is a stock return's expected reversal for a given dollar volume, the lower is that stock's liquidity; computed from CRSP as (10^9 times the negative of) the coefficient of an annual regression of daily stock returns in excess of the CRSP value-weighted market return (*eret*) on the product of their sign (sign(*eret*)) and the corresponding dollar volume (*dollarvol*), after controlling for *ret*(-1), when at least 60 daily observations are available in a year.
RETVOL	Computed from CRSP as (100 times) the annualized (that is, multiplied by the square root of 252) standard deviation of a stock's daily *ret* over a year, when at least 60 daily observations are available in that year.
ROA	Computed from COMPUSTAT as (100 times) the ratio *ni* / *at*, where item ni = net income.
ROLL	Based on Roll's (1984) random-walk model of prices in which one-half the percentage effective bid-ask spread is given by minus the covariance of price changes from trading costs; computed from CRSP as (200 times) either the square root of (the negative of) the first-order daily return (*ret*) autocovariance cov[*ret*,*ret*(-1)] over a year if cov[*ret*,*ret*(-1)] < 0 or (the negative of) the square root of cov[*ret*,*ret*(-1)] over a year if cov[*ret*,*ret*(-1)] > 0, when at least 60 daily observations are available in a year.
UNCERTAINTY	Based on O'Brien (1988); computed from I/B/E/S as (100 times) the average of the square of the difference between each available analyst forecast of the annual EPS of a firm (*value*) in a year (*anndats*) and its corresponding actual EPS (*actual*) divided by its CRSP's end-of-year abs(*prc*).
ZSCORE	Based on Altman (1968); computed from COMPUSTAT as $\{[(3.3 \times oiadp) + (0.999 \times sale) + (1.4 \times re) + (1.2 \times wcap)] / at\} + [(0.6 \times csho \times prcc\_f) / lt]$, where item $sale$ = sales, re = retained earnings, $wcap$ = working capital, $csho$ = number of shares outstanding, $prcc\_f$ = share price, lt = total liabilities.

Figure IA-1. Managerial effort and firm value

This figure plots firm value v of Equation (A-1) (solid line) as a function of managerial effort y in the economy of Section A when $\sigma_u^2 = 1$, $\sigma_e^2 = 1$, $u = 1$, $c = 0.62$, and $\gamma = 0.5$, as well as both the corresponding first-best (y_{FB} of Equation (A-3); dotted line) and second-best effort (y_{SB} of Equation (A-4); dashed line) when $e = 0.5$.

$v(y)$ versus y

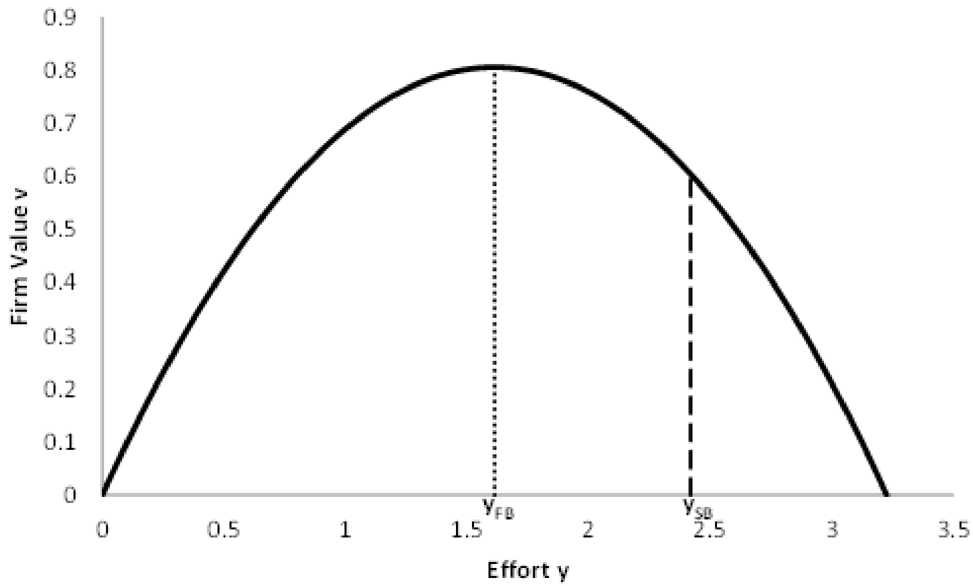
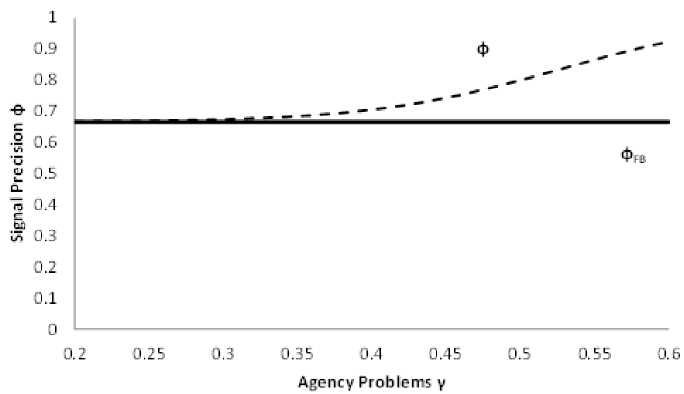


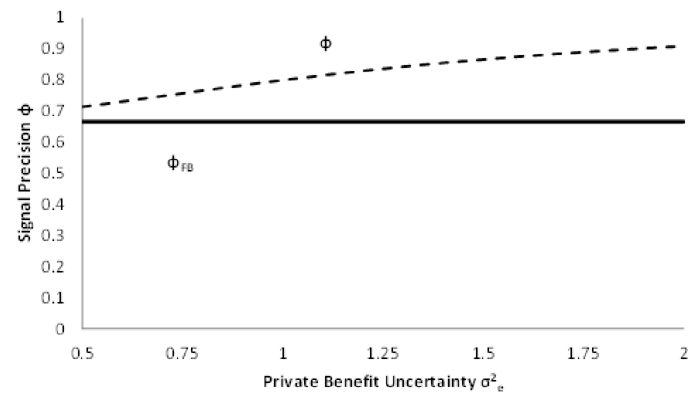
Figure IA-2. Agency considerations and speculation

This figure plots first-best (solid line) and second-best (dashed line) precision of the speculator's private signal ($\phi_{FB} = \frac{\sigma_u^4}{\sigma_u^4+2c^2\sigma_\varepsilon^2}$ and $\phi = \frac{\sigma_u^4+d^4\sigma_e^4}{\sigma_u^4+d^4\sigma_e^4+2c^2\sigma_\varepsilon^2}$) and her trading aggressiveness (β_{FB} of Equation (A-12) and β of Equation (A-10)) in the economy of Section 5 (when $\sigma_u^2 = 1$, $u = 1$, and $c = 0.62$) as a function of the severity of agency problems affecting managerial effort (γ, in Figures IA-2a and IA-2c, respectively, when $\sigma_e^2 = 1$) and of marketwide uncertainty about the firm manager's private benefits (σ_e^2, in Figures IA-2b and IA-2d, when $\gamma = 0.5$).

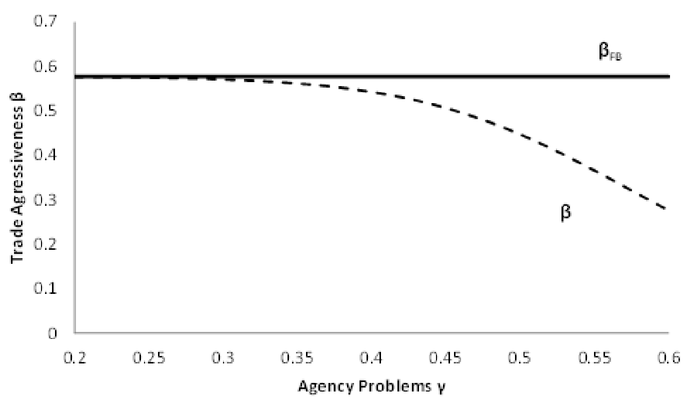
a) ϕ_{FB}, ϕ versus γ



b) ϕ_{FB}, ϕ versus σ_e^2



c) β_{FB}, β versus γ



d) β_{FB}, β versus σ_e^2

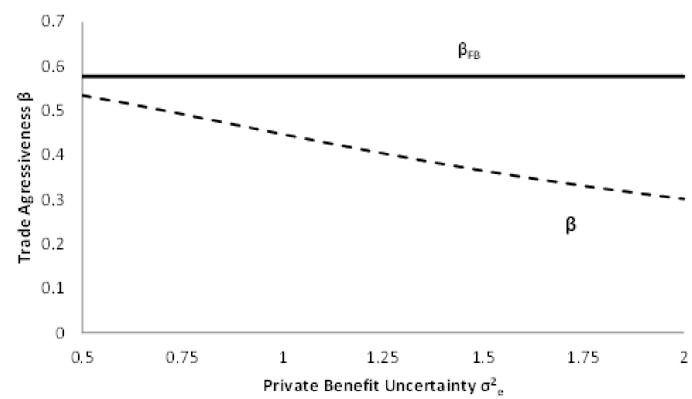
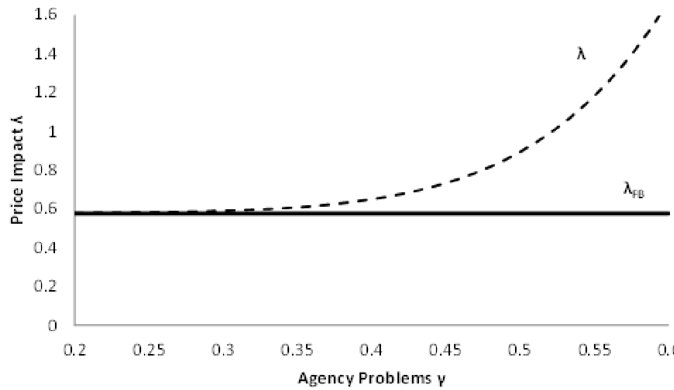


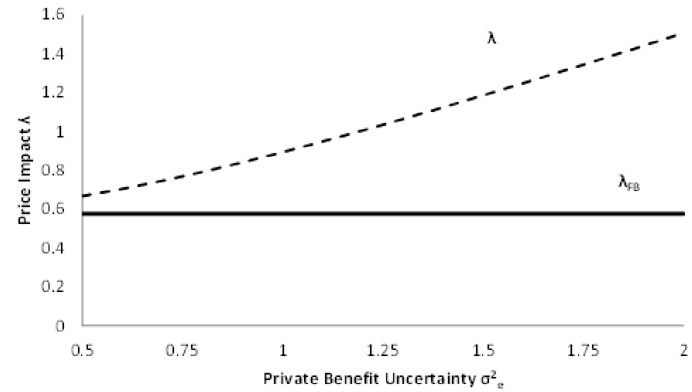
Figure IA-3. Agency considerations and market liquidity

This figure plots first-best (solid line) and second-best (dashed line) equilibrium price impact (λ_{FB} of Equation (A-11) and λ of Equation (A-8)) in the economy of Section 5 (when $\sigma_u^2 = 1$, $u = 1$, and $c = 0.62$), as well as second-best equilibrium price impact when the unit cost of managerial effort (or investment) is either low ($c_L = 0.25$; solid line) or high ($c_H = 0.75$; dashed line), as a function of the severity of agency problems affecting managerial effort (γ, in Figures IA-3a and IA-3c, respectively, when $\sigma_e^2 = 1$) and of marketwide uncertainty about the firm manager's private benefits (σ_e^2, in Figures IA-3b and IA-3d, when $\gamma = 0.5$).

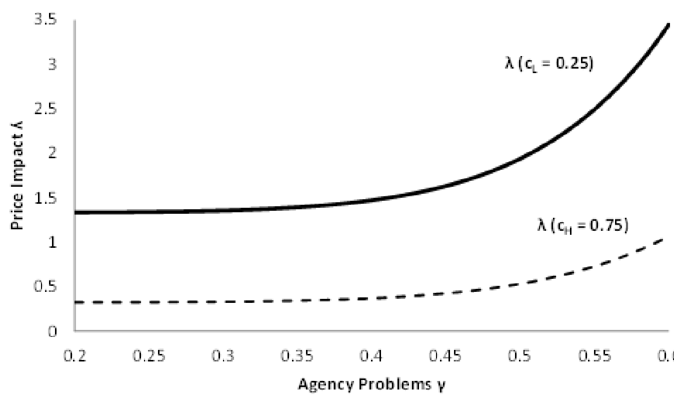
a) λ_{FB}, λ versus γ



b) λ_{FB}, λ versus σ_e^2



c) λ versus γ



d) λ versus σ_e^2

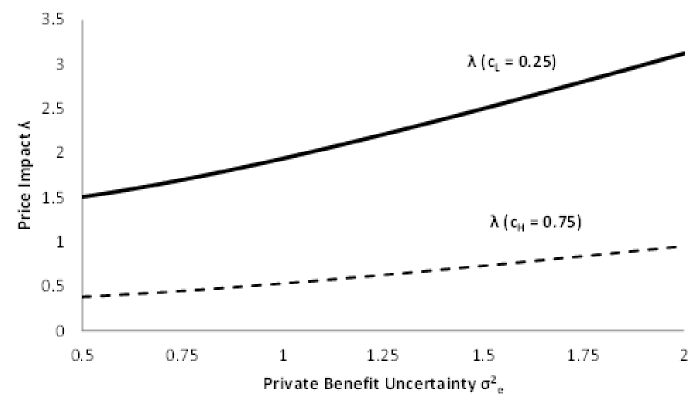
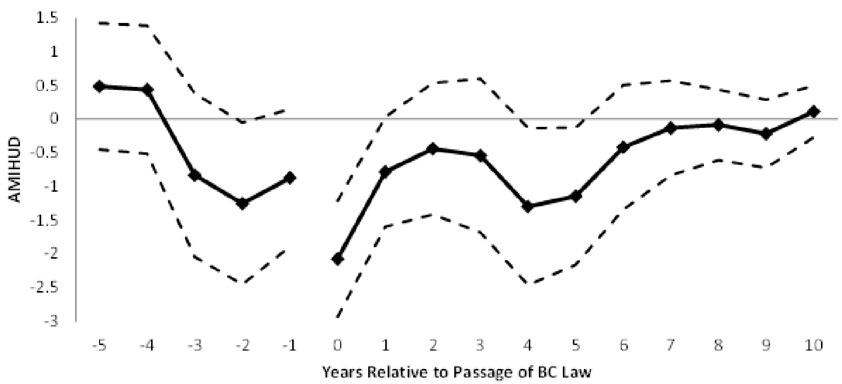


Figure IA-4. Illiquidity and BC laws in event time

This figure plots estimates for the coefficient (δ_n, solid lines and markers) of firm-year regressions (long model, Equation (3), as in columns (3) and (6) of Table 3 in Pasquariello 2022) of stock illiquidity ILLIQ (AMIHUD [Figure IA-4a] or ILLIQ_3 [Figure IA-4b] of Section 2.1) on a dummy variable (BC) equal to one if a firm is incorporated in a state that has adopted a BC law and equal to zero otherwise — when allowing those estimates to change by year, in event time n, from five years before to ten years after the event, after accounting for firm, state-year, and industry-year fixed effects, baseline controls, and confounding effects dummies — as well as their 90% confidence intervals (dashed lines) from robust standard errors adjusted for clustering at the state-of-incorporation level.

a) δ_n for AMIHUD



b) δ_n for ILLIQ_3