Cancellable Insider Trading Plans: An Analysis of SEC Rule 10b5-1*

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Rule 10b5-1 enables insiders to preplan future trades before becoming informed. Within a strategic rational expectations equilibrium framework, I characterize an insider's unique optimal trading plan, which balances portfolio diversification against exploitation of the rule's selective termination option. Because the rule reduces adverse selection and provides insurance against bad outcomes, the rule generally improves welfare for both the insider, who later becomes informed, and uninformed outsiders, provided there exists a sufficient degree of information asymmetry. Eliminating the rule's selective termination option results in an even greater welfare improvement under a large subset of parametric conditions. (*JEL* G14, G18)

Received March 9, 2018; editorial decision January 11, 2019 by Editor Wei Jiang.

Informed trading can have profound effects on financial markets, and the merits of insider trading laws, which generally prohibit insiders from trading on the basis of material nonpublic information, are vigorously debated. Since at least Manne (1966), advocates of insider trading argue that the information content of informed trades leads to more efficient markets, whereas opponents of insider trading contend that it reduces liquidity and harms overall market integrity by creating adverse selection. SEC Rule 10b5-1 incorporates beneficial elements from both sides of this debate by simultaneously allowing some information to flow to the market through trade while limiting the degree of adverse selection.

Rule 10b5-1, the relevant text of which is reproduced in Appendix A, essentially enables an individual to avoid liability for insider trading if he preplans future trades before becoming informed. Under the rule, an insider may legally trade even when he possesses private information if he trades pursuant to a predetermined plan, with such plan stipulating the amount (or an algorithm to determine the amount) of securities to be traded on a particular date in the future. Importantly, while Rule 10b5-1 plans must be adopted before becoming informed and must be "entered into in good faith," terminating a

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doi:10.1093/rfs/hhz035 Advance Access publication March 15, 2019

trading plan while aware of material nonpublic information does not result in insider trading liability because such liability arises only "in connection with the purchase or sale of any security."[1] Thus, an insider is not obligated to execute his planned trade, and the ability to cancel a planned transaction creates a selective termination option whereby, after becoming informed, he may choose to execute his planned transaction if he receives favorable news or cancel his planned trade if he receives unfavorable news.

The aim of this article is to gain a better understanding of the fundamental economic effects of Rule 10b5-1, which is important for several reasons. Empirical evidence indicates that Rule 10b5-1 plans are used extensively in practice, with Sen (2008) reporting that roughly 30% of insider transactions (45% for top executives) in his sample were made pursuant to a plan. Given this widespread usage by individuals who are likely to be well informed and, therefore, able to influence markets, the rule could potentially have a substantial effect on many important equilibrium attributes and the general functioning of the financial market.

Additionally, Rule 10b5-1's influence extends beyond the immediate microstructure effects of informed trading. For example, Fos and Jiang (2016) find that the rule's termination option influences the market for corporate control by permitting insiders to cancel a planned option exercise-and-sell during proxy contests. The rule could also affect activism by assisting activists in unwinding their positions following an intervention. Bonaimé et al. (2018) find that the rule influences corporate payout policy by making repurchases more attractive to firms, and Shon and Veliotis (2013) find that the rule may incentivize firms to manipulate earnings. Moreover, the rule could affect executive compensation and incentives by facilitating the divestiture of option and equity grants. Better understanding the rule's fundamental impact on markets may lead to a greater appreciation of these broader influences.

The policy implications are also significant and timely, because policy makers are currently contemplating amendments to Rule 10b5-1 that would limit insiders' ability to adopt, modify, and cancel Rule 10b5-1 trading plans (H.R. 6320, 115th Congress, 2018). As will be detailed below, my analysis provides guidance for policy makers by describing conditions under which eliminating the rule's selective termination option may enhance welfare.

To analyze the effects of Rule 10b5-1 and, more generally, the impact of cancellable preplanned trades under asymmetric information, I construct a

[1] See §10 of the Securities Exchange Act of 1934. Although the termination of a plan in and of itself does not result in liability, the cancellation of a plan transaction could limit the availability of the defense for prior plan transactions if it raises doubts about whether the plan was entered into in good faith (SEC Division of Corporate Finance: Manual of Publicly Available Telephone Interpretations, Fourth Supplement, 2001). However, Milian (2016) reports that the median plan in his sample consists of only four trades, so terminating a planned trade should not generate much litigation risk even if it were to raise concerns about the validity of an entire plan. Veliotis (2010) discusses court decisions in which Rule 10b5-1 shielded insiders from liability if they simply terminated planned trades, but not if they modified an existing plan. See, for example, Swanson (2003) or Horwich (2007) for a detailed discussion of the history and legal requirements of Rule 10b5-1 plans.

strategic rational expectations equilibrium model in which an informed insider trades pursuant to a predetermined trading plan. A lone informed insider and a continuum of uninformed outsiders who trade a risky stock that yields a random payoff are present in the model. The insider privately observes information pertinent to the stock payoff and receives a random nontradable endowment, the latter of which serves to camouflage his private information when he decides whether to trade. Before observing his private information and endowment shock, the insider adopts a trading plan by selecting a potential stock allocation to which he must adhere if he elects to trade in the future. After observing his private information and endowment shock, the insider decides whether to abstain from trade or to trade pursuant to his plan.

The insider's optimal trading plan, which is unique and endogenously determined in equilibrium, entails planning to purchase stock when he is initially endowed with a small amount of stock but planning to sell when his initial endowment is large. However, the insider executes his planned trade only when he attains greater (expected) utility from doing so than he would from holding his initial endowment; that is, he executes his planned trade if and only if he receives information and/or an endowment shock that is favorable to his planned transaction. The insider is most likely to execute his planned trade when he is endowed with either a very small or a very large amount of stock, as the diversification benefits in these cases are greater. For intermediate endowment levels, the insider is more likely to take advantage of the rule's selective termination option by planning trades that are potentially more profitable but executed only with low probability.

The insider's strategic execution behavior is consistent with several empirical studies which find that trades made pursuant to Rule 10b5-1 plans generate significant abnormal returns and, therefore, imply that insiders use Rule 10b5-1 plans to exploit information advantages in practice (Jagolinzer 2009; Ryan et al. 2016; Mavruk and Seyhun 2016; Hugon and Lee 2016; cf. Sen 2008). Additionally, Jagolinzer (2009) finds that terminated planned sales are associated with positive future performance, indicating that some insiders do indeed take advantage of the rule's selective termination option.[2]

Compared to a benchmark economy wherein the insider trades without a predetermined plan,[3] Rule 10b5-1 constrains the insider's portfolio by forcing him to either abstain from trade and hold his initial endowment or trade according to his plan and hold his preplanned allocation. Under the rule, which acts as a credible commitment mechanism, the insider cannot alter—but

[2] Evidence that insiders may earn abnormal profit even when trading under Rule 10b5-1 is consistent with many other studies that document insiders' ability to earn positive abnormal returns (see, e.g., Lakonishok and Lee Lakonishok and Lee 2001; Jeng et al. 2003; Marin and Olivier 2008; Cohen et al. 2012).

[3] Given the abundant empirical evidence that insiders are able to earn abnormal trading profit, I evaluate the impact of Rule 10b5-1 in an economy wherein the insider trades without a plan. For robustness, I also evaluate the impact of Rule 10b5-1 in an economy wherein the insider is prohibited from trading, that is, autarky, which can be interpreted as an environment with high litigation risk for insider trading.

may terminate—a planned trade. This reduces the insider's trading flexibility, hindering his ability to hedge his endowment shock and exploit his information advantage over outsiders. Consequently, outsiders face less adverse selection under the rule and are, therefore, more willing to trade with the insider. Thus, despite restricting the insider's portfolio opportunity set, which hampers the investors' ability to share risk associated with the insider's nontradable endowment, the rule tends to facilitate trade and, thereby, improve the investors' ability to share risk associated with their initial stock endowments.

The rule also reduces the quality of information that outsiders can infer from the trading outcome because the insider's portfolio constraint censors his true demand. In the benchmark economy, like in traditional strategic rational expectations equilibrium frameworks, outsiders indirectly observe a noisy signal k of the insider's private information from his equilibrium allocation (or, equivalently, from the stock price). Under the rule, however, outsiders can infer only a conditional distribution of k (i.e., whether k is above or below an endogenously determined threshold) rather than the signal k itself because the rule censors the insider's true demand. This causes outsiders to be more optimistic (pessimistic) on average about the stock payoff when the insider buys (sells), as they cannot disentangle moderate signals from more extreme signals given that the insider's demand is censored. Consequently, outsiders require a more favorable price to trade under the rule. Hence, the rule tends to generate a higher stock price when the insider buys (i.e., when his initial stock endowment is small) but a lower price when he sells (i.e., when his initial endowment is large), thereby effectuating a wealth transfer from the insider to outsiders.

This wealth transfer along with the effects on risk sharing and the restrictions on the insider's portfolio all influence Rule 10b5-1's impact on the investors' welfare. Depending on the relative strengths of these effects, the rule may either increase or decrease welfare. I find that permitting the insider to trade only pursuant to a predetermined plan increases ex ante welfare for both the insider and outsiders under a wide set of parameterizations where the benefits of reducing adverse selection are sufficiently large. The rule benefits the insider because it enables him to make better trades (because of less adverse selection) in states in which his marginal utility is high (e.g., when he receives negative information and a positive endowment shock) even though his ex post welfare may decline in a majority of the state space (due to a lack of trading flexibility). Hence, the rule serves as insurance against "bad" realizations of his private information and endowment shock, enabling him to make better trades when trading is most valuable but restricting his ability to trade when trading is less valuable. Better diversification and more favorable transaction prices effectively transfer wealth from the insider to outsiders, benefiting the latter.

Although the rule mostly increases welfare, requiring the insider to adopt a trading plan may reduce welfare under a narrow set of conditions where there is little benefit to reducing adverse selection because in those cases the rule simply hinders the insider's ability to hedge his endowment shock and, therefore, impedes efficient risk sharing. However, when the insider may voluntarily choose whether to adopt a plan (as permitted in practice), the rule weakly improves both his and the outsiders' welfare. Consistent with empirical evidence that Rule 10b5-1 plans are more likely to be adopted when the opportunity for strategic insider trading is greater (Sen 2008; Henderson et al. 2012; Milian 2016; Hugon and Lee 2016), I find that Rule 10b5-1 plans provide greater benefits when the insider's information-based motive for trade is stronger relative to his diversification-based motive.

Rule 10b5-1's selective termination option also influences welfare simply by altering the risk-sharing environment.[4] While the selective termination option provides the insider with greater trading flexibility and, thus, effectively lowers his risk exposure, having the ability to cancel his planned transaction precludes the total elimination of adverse selection. Depending on which effect is stronger, the option may either increase or decrease welfare relative to an alternative regulatory regime in which the insider's trading plan is noncancellable. This result has important policy implications regarding the design of Rule 10b5-1 plans. Because the conditions under which the insider elects to adopt a plan often coincide with the conditions under which the termination option reduces welfare, an alternative regulatory framework wherein the insider could adopt a noncancellable plan (and, thereby, credibly commit to execute his planned trade) would improve the investors' welfare under a wide set of circumstances. This implication is particularly relevant given that policy makers are currently considering whether to limit the availability of the rule's selective termination option.

To the best of my knowledge, existing theoretical models do not examine Rule 10b5-1 trading plans.[5] Huddart et al. (2010) and Lenkey (2014) examine potential regulations that would require insiders to publicly disclose their trades before they occur. However, unlike under Rule 10b5-1, where an insider may devise a cancellable trading plan only before acquiring private information, the potential regulations examined in those articles provide an insider with more flexibility by allowing him to formulate and predisclose a trade after acquiring information. While both Rule 10b5-1 and advance disclosure reduce adverse selection, the former may actually decrease welfare if adverse selection costs are not sufficiently large to begin with because Rule 10b5-1 inhibits the insider from hedging his endowment shock whereas an advance disclosure requirement does not. Lenkey (2017) shows that the short-swing profit rule, which requires insiders to forfeit any trading profit earned from a round-trip

[4] Others argue that the selective termination option may incentivize an insider to manipulate the timing or content of public disclosures for the purpose of executing a planned trade at a more favorable price (see, e.g., Muth 2009; Veliotis 2010; Shon and Veliotis 2013), but my model abstracts from any sort of manipulation.

[5] A Rule 10b5-1 plan is distinct from sunshine trading (Admati and Pfleiderer 1991), because an insider may decide whether to execute his planned trade when he possesses private information.

transaction occurring within a 6-month period, benefits insiders but harms outsiders because the short-swing profit rule inhibits risk sharing and gives rise to a wealth transfer from outsiders to the insider. Conversely, Rule 10b5-1 tends to benefit both insiders and outsiders because Rule 10b5-1 largely enhances overall risk sharing and generates a wealth transfer from the insider to outsiders.[6]

Several other models evaluate the effect of insider trading on the welfare of risk-averse investors. Leland (1992) and DeMarzo et al. (1998) conclude that permitting insider trading benefits insiders at the expense of outsiders, who are harmed by adverse selection. In contrast, Dye (1984) finds that permitting insider trading can improve welfare for both insiders and outsiders by enabling more efficient contracting, and Medrano and Vives (2004) show that insider trading can benefit investors by encouraging information acquisition.

More broadly, my model is related to the literature that examines the impact of portfolio constraints when agents are asymmetrically informed. Similar to the effect of short-sale restrictions, Rule 10b5-1 can distort equilibrium asset prices because the rule constrains the insider's demand, which clouds the outsiders' information inference (see, e.g., Miller 1977; Allen et al. 1993; Chen et al. 2001; Jarrow 1980; Gallmeyer and Hollifield 2008; cf. Diamond and Verrecchia 1987). However, unlike short-sale constraints, which, by definition, result in lower trading volume when such constraints are binding, Rule 10b5-1 can result in greater trading volume in cases in which an insider chooses to execute a planned trade for more shares than he would otherwise trade if he were not subject to any trading restrictions.[7]

As stated above, Rule 10b5-1 acts as a mechanism for an insider to credibly commit to trade less aggressively on his private information so that he may better hedge his endowment. Mechanisms to reduce adverse selection costs associated with trading aggressiveness arise in other contexts, as well. For example, Glosten (1989) demonstrates that a monopolist specialist can lower the aggressiveness of informed traders and improve liquidity. Additionally, DeMarzo and Duffie (1999) show that a precommitment to debt financing,

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6 As discussed above, Rule 10b5-1 generates a wealth transfer from the insider to outsiders, because censoring the insider's true demand leads *outsiders* to command a more favorable price, on average. In contrast, the short-swing profit rule, as analyzed by Lenkey (2017), generates a wealth transfer in the opposite direction, because the endogenous portfolio constraint created through a preliminary round of trade that limits the insider's future trading flexibility causes the *insider* to command a more favorable price. Although Rule 10b5-1 also creates an endogenous portfolio constraint, the constraint is not established by a preliminary round of trade that transfers wealth, as occurs under the short-swing profit rule. Rather, the wealth transfer under Rule 10b5-1 occurs through trade that happens after the constraint already has been established.

7 Short-sale constraints also have been shown to induce market crashes (see, e.g., Barlevy and Veronesi 2003; Hong and Stein 2003; Marin and Olivier 2008). Like with short-sale constraints, outsiders cannot disentangle moderate news from extreme news under Rule 10b5-1. However, unlike short-sale constraints, which prevent an insider from taking an extreme position, Rule 10b5-1 generally prompts the insider to plan to hold a diversified portfolio, so outsiders place a higher probability on moderate news when updating their beliefs. Thus, Rule 10b5-1 is unlikely to generate market crashes.

which is less information sensitive than equity, can reduce adverse selection and lower the cost of capital.

The rule is also related to the literature that examines the breakdown of trade in financial markets (e.g., Dang 2008; Glode et al. 2012; Camargo et al. 2016). While many models in the literature are based on the premise that the breakdown of trade destroys welfare (cf. Lenkey and Song 2018), Rule 10b5-1 can improve welfare even though it may cause trade to collapse because the rule enhances risk sharing when trade occurs.

1. Regulatory Background

The SEC's primary motivation for adopting Rule 10b5-1 was to "increase investor confidence in the integrity and fairness of the market" while also "providing greater clarity and certainty" for insiders (65 FR 165, 2000). Prior to the rule's adoption, U.S. Circuit Courts disagreed about the specific conditions under which insider trading liability could arise.[8] Confronted with differing judicial opinions, the SEC adopted Rule 10b5-1 to set a common standard across jurisdictions and, thereby, eliminate confusion and uncertainty for traders, with an expectation for the rule to improve liquidity and market quality in general. The standard set by the SEC imposes insider-trading liability on individuals who trade while "aware" of material nonpublic information. Recognizing, however, that an "awareness" standard may severely restrict the ability to trade for liquidity or diversification reasons, the SEC created an affirmative defense as part of Rule 10b5-1 that is designed to exempt a trader from liability if he can demonstrate that his trade was not influenced by private information.

Basically, Rule 10b5-1 enables a person to avoid liability by preplanning his trades. While the rule features a few specific legal requirements (as detailed in Appendix A and described by, for example, Swanson 2003 and Horwich 2007), the rule's basic economic requirement is that the insider trade according to a plan that he devises before acquiring private information. Importantly, although the rule precludes an insider from modifying an existing plan after acquiring private information, an insider may cancel a planned trade without subjecting himself to liability because the rule does not obligate an insider to execute his planned trade (see, e.g., Veliotis 2010).[9] In other words, Rule 10b5-1 does not

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8 According to the U.S. Supreme Court, liability may arise if a person trades "on" (*Dirks v. SEC*, 1983) or "on the basis of" (*United States v. O'Hagan*, 1997) material nonpublic information. However, these terms are not explicitly defined by the Court, leaving open to interpretation the question of whether a person must use material nonpublic information or simply be in possession of such information when making a trade for liability to arise. Prior to the adoption of Rule 10b5-1, the Second Circuit suggested that "knowing possession" of material nonpublic information was sufficient to trigger liability (*United States v. Teicher*, 1993), whereas the Ninth Circuit held that "use" must be proven (*United States v. Smith*, 1998). The Eleventh Circuit held that a person must "use" the information when trading but that "possession" constitutes *prima facie* evidence of "use" (*SEC v. Adler*, 1998).

9 The rule requires that a trading plan be "entered into in good faith and not as part of a plan or scheme to evade" insider trading laws. Although the cancellation of a planned transaction could raise questions about whether a

commit an insider to trade but merely provides him with an option to trade. This apparent loophole, which permits an insider to rely on private information when deciding whether to execute a preplanned trade, stems from §10 of the Securities Exchange Act of 1934, which requires fraudulent conduct to occur "in connection with the purchase or sale of any security" to generate legal liability.

2. Model

A single insider and a continuum of outsiders are present in the model. All investors exhibit constant absolute risk aversion (CARA) with risk aversion coefficient δ. Time is indexed by $t \in \{0,1,2\}$. The investors receive their endowments and the insider adopts his trading plan at $t=0$, trade may take place at $t=1$, and consumption occurs at $t=2$.

The financial market comprises a stock and a bond. The stock pays a random amount

$$\tilde{x} = \tilde{y} + \tilde{z} \tag{1}$$

at $t=2$, where $\tilde{y} \sim \mathcal{N}(0, \gamma\varepsilon^2)$ and $\tilde{z} \sim \mathcal{N}(0, (1-\gamma)\varepsilon^2)$. The insider privately observes y, but not z, before trading at $t=1$. In other words, the insider privately observes a fraction $\gamma \in (0,1)$ of the aggregate stock payoff, which is distributed $\tilde{x} \sim \mathcal{N}(0, \varepsilon^2)$. The stock, which is in unit supply, has an endogenous price denoted by P. The bond is in elastic supply with an exogenous interest rate that, for simplicity, is set to zero. The insider's (outsiders') stock and bond holdings from $t=1$ to $t=2$ are denoted by S_i (S_o) and B_i (B_o), respectively.

Investors are exogenously endowed with financial assets at $t=0$. The insider's (outsiders') stock and bond endowments are denoted by W_i^S (W_o^S) and W_i^B (W_o^B), respectively. Additionally, the insider receives a nontradable endowment $\tilde{w} \sim \mathcal{N}(0, \nu^2)$ that he privately observes at $t=1$ before trading. For simplicity, I assume that the payoff from this endowment shock is perfectly correlated with the stock payoff, so the insider's nontradable endowment yields $w\tilde{x}$ at $t=2$. I further assume that $\tilde{w}$, $\tilde{y}$, and $\tilde{z}$ are mutually independent. To ensure well-defined solutions, I impose the following parametric restriction: $\gamma/[(1-\gamma)^2\delta^2\varepsilon^2] < \nu^2 < 1/(\delta^2\varepsilon^2)$. Essentially, this restriction requires that the insider's endowment shock be sufficiently volatile to prevent the market from collapsing (Bhattacharya and Spiegel 1991), but not so volatile that his hedging incentive overwhelms his information-based motive for trading.

As discussed above, the insider can avoid insider trading liability under Rule 10b5-1 by preplanning his trade. Furthermore, because liability cannot

plan was entered into in good faith, the mere termination of a planned trade does not give rise to insider trading liability because a transaction must occur for such liability to arise (see footnote 1). Nonetheless, the rule's main economic implications are qualitatively unaffected by potential litigation risk for terminating a planned trade, as will be discussed in Section 4.4.

arise unless a transaction occurs, the insider may cancel his planned trade after acquiring his private information without subjecting himself to liability. Thus, the rule effectively grants the insider a selective termination option. To account for this optionality feature of the rule, I assume that the insider must adopt a trading plan at $t=0$ before he acquires his private information y or observes his endowment shock w.[10] The insider is not bound by the plan, however. He may choose to cancel his planned transaction and abstain from trade at $t=1$ after he observes y and w. Although outsiders can infer the insider's planned trade in equilibrium, Rule 10b5-1 differs from an advance disclosure requirement (see, e.g., Huddart et al. 2010; Lenkey 2014) because the insider must devise his plan before observing his private information and he may terminate his planned transaction. The rule is also distinct from sunshine trading (Admati and Pfleiderer 1991) because the insider's trade, or at least his decision about whether to execute his planned trade, is partially information based.

The insider adopts a trading plan at $t=0$ by selecting a specific time-1 allocation, denoted by $\bar{S}_i \in \mathbb{R}$, to which he must adhere if he elects to trade at $t=1$. For simplicity, I focus on trading plans that involve specifying only a preplanned allocation (i.e., a market order) even though the rule permits insiders to utilize limit orders and algorithmic trading practices. However, the possibility of using limit orders and/or trading algorithms should not affect the model's qualitative implications because the insider's selective termination option would still exist and the basic economic driver of the results (namely, a reduction in adverse selection, as will be discussed in Section 3) would not be fundamentally affected.

Figure 1 outlines the sequence of events. At $t=0$, the insider and outsiders receive their stock and bond endowments. Then the insider adopts a trading plan $\bar{S}_i$. At $t=1$, the insider privately observes his nontradable endowment w and the first component of the stock payoff, y. Next, based on w and y, the insider decides whether to trade pursuant to the plan he adopted at $t=0$ or to abstain from trade. If he trades, then his time-1 allocation must be the allocation stipulated by the plan (i.e., $S_i=\bar{S}_i$); if he instead decides not to trade, then his time-1 allocation is simply his initial stock endowment (i.e., $S_i=W_i^S$).[11] Finally, the asset payoff is realized, and consumption occurs at $t=2$.

Assuming that the insider adopts his plan before observing his endowment shock enhances tractability, but it also can be reconciled with the fact that insiders often adopt Rule 10b5-1 plans in response to realizations of major endowment shocks in practice (e.g., following a large equity grant or the expiration of a post-initial public offering [IPO] lockup period). Because

[10] In Section 4.1, I will analyze the effects of the rule when the insider may voluntarily adopt a trading plan. Analyzing an economy in which the adoption of a trading plan is mandatory illustrates the key economic trade-offs associated with Rule 10b5-1.

[11] I assume that canceling a planned trade is costless. Although an implicit cancellation cost may exist in reality in the form of greater litigation risk, the inclusion of a cancellation cost would not affect the model's qualitative implications, as will be discussed in Section 4.4.

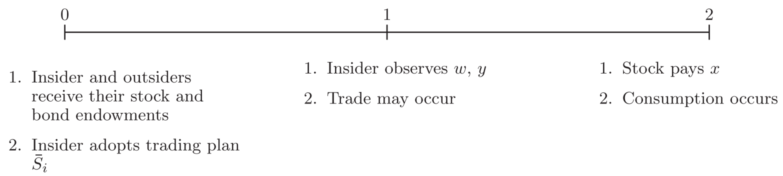

Figure 1
Time line

major endowment shocks are often publicly observable, the insider's initial endowment can be construed as already reflecting a prior endowment shock, such as an equity grant, whereas his nontradable endowment can be construed as representing a future endowment shock.

Additionally, the insider's trading plan is not observable to outsiders, but, as will be described in Section 2.1, outsiders can infer both the insider's planned allocation and whether he executes his planned trade in equilibrium. In reality, insiders are not required to disclose Rule 10b5-1 plans, although some choose to do so voluntarily (see, e.g., Jagolinzer 2009). In cases in which an insider elects not to disclose a plan, outsiders could potentially infer a plan's existence from a pattern of Form 4 filings or an observable event that tends to trigger a plan adoption.[12] Similarly, outsiders could infer the cancellation of a planned trade from an interruption in a pattern of trades. If there were no means whatsoever for outsiders to infer the existence and execution of a trading plan, then many of Rule 105b-1's implications discussed in Sections 3 and 4 below would be relevant only for publicly disclosed plans.[13]

The main analysis considers two distinct regulatory regimes to illustrate the fundamental economic forces driving equilibrium outcomes under Rule 10b5-1. Under the first regime, which is analyzed in Section 2.1, the insider trades pursuant to a Rule 10b5-1 plan. Under the second regime, which is examined in Section 2.2 and serves as a benchmark against which to evaluate the effects of Rule 10b5-1, the insider trades without restrictions. Section 4 considers several extensions of the model to assess the rule's effects when adoption is voluntary, the impact of the rule's selective termination option, and policy implications.

2.1 Equilibrium under Rule 10b5-1

The equilibrium under Rule 10b5-1 is derived recursively. I first characterize the time-1 equilibrium stock price and derive conditions under which the insider

[12] Statutory insiders (i.e., officers, directors, and 10% beneficial owners) must publicly disclose their trades and other changes in ownership status within 2 business days on SEC Form 4.

[13] Although the model has only a single insider, the economic implications of Rule 10b5-1 should be robust to markets in which a handful of insiders possess information, because corporate insiders are likely to possess information unavailable to other market participants, and the adoption of trading plans appears to be correlated among insiders within a firm in practice.

executes his planned trade in Section 2.1.1. I then determine the insider's optimal trading plan in Section 2.1.2.

2.1.1 Time-1 equilibrium under Rule 10b5-1. Rule 10b5-1 does not obligate the insider to execute his planned trade. Instead, he may terminate his planned transaction once he becomes informed. Therefore, the insider chooses to trade pursuant to the plan if and only if he attains a greater expected utility from holding his planned allocation $\bar{S}_i$ at $t=1$ than he attains from holding his initial endowment W_i^S. Hence, the insider's objective at $t=1$ is to choose a time-1 stock allocation $S_i \in \{W_i^S, \bar{S}_i\}$ to maximize his expected utility from consumption C_i subject to a budget constraint:

$$\max_{S_i \in \{W_i^S, \bar{S}_i\}} \quad \mathbb{E}\big[-\exp[-\delta \tilde{C}_i] \,|\, w, y\big], \tag{2}$$

$$\text{s.t.} \quad \tilde{C}_i = B_i + (S_i + w)\tilde{x}, \tag{3}$$

$$B_i = W_i^B + (W_i^S - S_i)P(S_i), \tag{4}$$

where explicitly writing $P(S_i)$ emphasizes that the insider strategically influences the price by deciding whether to execute his planned trade. The insider also exerts strategic control over the price through his choice of $\bar{S}_i$ at $t=0$. Substituting (1), (3), and (4) into (2) and integrating over $\tilde{z}$ provides a closed-form expression for the insider's time-1 expected utility,

$$-\exp\big[-\delta\big(W_i^B + (S_i+w)y + (W_i^S - S_i)P(S_i) - \tfrac{1}{2}(1-\gamma)\delta\varepsilon^2(S_i+w)^2\big)\big]. \tag{5}$$

Because he must choose to either trade according to the plan or abstain from trade altogether, the insider's optimal course of action is determined by substituting either $S_i = \bar{S}_i$ or $S_i = W_i^S$ into (5) and comparing the two resultant expressions. It is straightforward to show that the insider prefers to execute a planned trade rather than abstain if and only if

$$k - \tfrac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S + \bar{S}_i) - P(\bar{S}_i) \begin{cases} <0 & \text{if } \bar{S}_i < W_i^S \\ >0 & \text{if } \bar{S}_i > W_i^S, \end{cases} \tag{6}$$

where

$$k \equiv y - (1-\gamma)\delta\varepsilon^2 w. \tag{7}$$

This condition indicates that the insider prefers to execute a planned sale (purchase) rather than forgo trade if and only if his private information y is sufficiently negative (positive) and/or his endowment shock w is sufficiently positive (negative).

Outsiders do not directly observe the insider's trading activity, but they can infer whether the insider executed his planned trade based on their own equilibrium allocations. Because the insider must choose his planned time-1 allocation $\bar{S}_i$ before acquiring any private information or observing his nontradable endowment, the insider's and outsiders' information sets are identical when the insider selects $\bar{S}_i$. Thus, signaling issues do not arise, and outsiders can infer $\bar{S}_i$ in equilibrium. However, because the insider's decision to execute his planned trade depends on k, the insider's trading activity serves as a noisy signal of his private information y, and outsiders can use this signal to update their beliefs about the stock payoff.

Bayes' theorem implies that the posterior distribution of $\tilde{y}$ conditional on k is

$$\tilde{y}|k \sim \mathcal{N}\left(\frac{\gamma k}{\gamma+(1-\gamma)\beta}, \frac{\gamma(1-\gamma)\varepsilon^2\beta}{\gamma+(1-\gamma)\beta}\right), \tag{8}$$

where

$$\beta \equiv (1-\gamma)\delta^2\varepsilon^2\nu^2 \tag{9}$$

is a constant that simplifies notation. Outsiders beliefs about $\tilde{y}$ are not characterized by (8), however, because they cannot infer the precise value of k in equilibrium. Instead, they can infer only a conditional distribution of $\tilde{k}$ because multiple values of k result in the same trading outcome, as indicated by (6). Specifically, outsiders can infer only whether k is less than or greater than $\frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\bar{S}_i)+P(\bar{S}_i)$ based on the trading outcome.

Outsiders aim to maximize their expected utility from consumption C_o by choosing a time-1 stock allocation $S_o \in \mathbb{R}$ subject to a budget constraint:

$$\max_{S_o \in \mathbb{R}} \quad \mathbb{E}\big[-\exp[-\delta\tilde{C}_o]\,|\,\tilde{k}\big], \tag{10}$$

$$\text{s.t.} \quad \tilde{C}_o = B_o + S_o\tilde{x}, \tag{11}$$

$$B_o = W_o^B + (W_o^S - S_o)P(S_i). \tag{12}$$

Their expected utility is conditioned on $\tilde{k}$ (rather than k) to emphasize that they infer only a distribution of $\tilde{k}$. Substituting (1), (11), and (12) into (10) and integrating over $\tilde{z}$ gives

$$-\exp\big[-\delta\big(W_o^B + S_o\tilde{y} + (W_o^S - S_o)P(S_i) - \tfrac{1}{2}(1-\gamma)\delta\varepsilon^2 S_o^2\big)\big]. \tag{13}$$

Then integrating over $\tilde{y}$, according to a truncated version of (8) (Appendix B provides the details), yields an expression for the outsiders' time-1 expected utility,

$$-\frac{\Phi\left(\frac{\bar{k}+\gamma\delta\varepsilon^2 S_o}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right) - \Phi\left(\frac{\underline{k}+\gamma\delta\varepsilon^2 S_o}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)}{\Phi\left(\frac{\bar{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right) - \Phi\left(\frac{\underline{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)}$$
$$\times \exp\big[-\delta\big(W_o^B + (W_o^S - S_o)P(S_i) - \tfrac{1}{2}\delta\varepsilon^2 S_o^2\big)\big], \tag{14}$$

where $\Phi(\zeta) \equiv \frac{1}{2}\big(1+\text{erf}\big[\frac{\zeta}{\sqrt{2}}\big]\big)$ denotes the normal distribution function and $\underline{k}$ and $\bar{k}$ denote lower and upper bounds (determined by (6)), respectively, on possible values of k. If $\bar{S}_i < W_i^S$, then $\underline{k} = -\infty$ and $\overline{k} = \frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S + \bar{S}_i) + P(\bar{S}_i)$ if the insider decides to trade, but $\underline{k} = \frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S + \bar{S}_i) + P(\bar{S}_i)$ and $\overline{k} = \infty$ if he decides to abstain from trade. Conversely, if $\bar{S}_i > W_i^S$, then the trade-dependent relations are reversed. Differentiating (14) with respect to S_o yields a first-order condition, which is given by (B1) in Appendix B, that characterizes the outsiders' demand function. Finally, imposing the market-clearing condition,

$$S_i + S_o = 1, \tag{15}$$

generates an expression that characterizes the unique equilibrium stock price, as described in the following theorem, with $\phi(\zeta) \equiv \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{\zeta^2}{2}\right]$ denoting the normal density function.

Theorem 1. When the insider may trade only pursuant to a predetermined trading plan, conditional on the insider executing his planned trade $\bar{S}_i$, there exists a unique equilibrium stock price characterized by

$$P(\bar{S}_i) = \begin{cases} -(1-\bar{S}_i)\delta\varepsilon^2 - \dfrac{\gamma\varepsilon^2\phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)}{\sigma\Phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)} & \text{if } \bar{S}_i < W_i^S \quad (16) \\[2em] -(1-\bar{S}_i)\delta\varepsilon^2 + \dfrac{\gamma\varepsilon^2\phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)\right)} & \text{if } \bar{S}_i > W_i^S, \quad (17) \end{cases}$$

where

$$\mu \equiv -[\tfrac{1}{2}(1-\gamma)(W_i^S + \bar{S}_i) + \gamma(1-\bar{S}_i)]\delta\varepsilon^2 \tag{18}$$

$$\sigma^2 \equiv [\gamma + (1-\gamma)\beta]\varepsilon^2. \tag{19}$$

Additionally, $P(\bar{S}_i)$ is monotonically increasing in $\bar{S}_i$. Furthermore, $P(\bar{S}_i)$ is concave in $\bar{S}_i$ if $\bar{S}_i < W_i^S$ but convex in $\bar{S}_i$ if $\bar{S}_i > W_i^S$.

Theorem 1 characterizes the stock price conditional on the insider executing his planned trade; the price is irrelevant if the insider elects not to execute his planned trade because no trade occurs in that case. Because the insider must devise his trading plan $\bar{S}_i$ before observing his nontradable endowment w or acquiring his private information y, the equilibrium price is independent of the actual realizations of $\tilde{w}$ and $\tilde{y}$. Rather, the price is a constant (conditional on $\bar{S}_i$) that reflects the outsiders' updated beliefs about the distribution of the stock payoff given that the insider executes his planned trade. Nonetheless, the price reflects the insider's strategic influence because it depends on both his planned trade $\bar{S}_i$ and his execution decision.

The stock price is increasing in $\bar{S}_i$ because the outsiders' beliefs about the stock payoff rise if the insider either sells fewer shares or purchases more shares. Additionally, the outsiders' beliefs are affected to a greater extent at the margin if the insider trades a greater quantity of stock, resulting in a stock price that is concave (convex) in the insider's planned allocation when he sells (buys). Hence, the implicit cost to the insider of executing a planned trade is an increasing convex function of the size of the trade. Consequently, the insider's optimal trading plan, which is characterized below in Theorem 2, is unique.

2.1.2 Insider's optimal trading plan. When devising his plan at $t=0$, the insider's objective is to select a potential allocation, $\bar{S}_i \in \mathbb{R}$, to maximize his time-0 expected utility. When choosing $\bar{S}_i$, the insider must take into account the likelihood of executing his planned trade at $t=1$ along with his uncertainty regarding his future private information and nontradable endowment, which are not observed until $t=1$. Accordingly, the insider's time-0 expected utility can be written as

$$\begin{aligned}
&-\Pr[S_i=\bar{S}_i]\mathbb{E}\Big[\exp\Big[-\delta\Big(W_i^B+(\bar{S}_i+\tilde{w})\tilde{y}+(W_i^S-\bar{S}_i)P(\bar{S}_i)\\
&\quad -\tfrac{1}{2}(1-\gamma)\delta\varepsilon^2(\bar{S}_i+\tilde{w})^2\Big)\Big]\Big|\,S_i=\bar{S}_i\Big]\\
&-\Pr[S_i=W_i^S]\mathbb{E}\Big[\exp\Big[-\delta\Big(W_i^B+(W_i^S+\tilde{w})\tilde{y}\\
&\quad -\tfrac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\tilde{w})^2\Big)\Big]\Big|\,S_i=W_i^S\Big],
\end{aligned} \tag{20}$$

which follows from (5). Because the probability of the insider executing his planned trade depends on whether the realization of $\tilde{k}$ exceeds the endogenous threshold defined in (6), the insider's expected utility function must be integrated with respect to $\tilde{k}$. This is achieved with the convolution of the distributions of $\tilde{k}$ and $\tilde{w}$. It immediately follows from (7) that

$$y=k+(1-\gamma)\delta\varepsilon^2 w. \tag{21}$$

Substituting (21) into (20) and integrating over $\tilde{w}$ and $\tilde{k}$ (with k-bounds determined by (6)) yields the insider's expected utility at $t=0$. Appendix B provides details of the derivation. Outsiders' time-0 expected utility is derived in a similar fashion.

The insider's optimal trading plan is derived by differentiating his time-0 expected utility with respect to $\bar{S}_i$ and solving the corresponding first-order condition. The following theorem characterizes the insider's optimal trading plan and shows it to be unique.

Theorem 2. When the insider may trade only pursuant to a predetermined trading plan, his unique equilibrium trading plan is characterized by

$$\bar{S}_i = \begin{cases} \dfrac{(1-\delta^2\varepsilon^2\nu^2)\left(W_i^S \frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} - P(\bar{S}_i)\right)}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}} \\ \quad - \dfrac{2\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)}{\left[\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}\right]\bar{\sigma}\,\Phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)} & \text{if } \bar{S}_i < W_i^S \quad (22) \\ \dfrac{(1-\delta^2\varepsilon^2\nu^2)\left(W_i^S \frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} - P(\bar{S}_i)\right)}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}} \\ \quad + \dfrac{2\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)}{\left[\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}\right]\bar{\sigma}\left(1-\Phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)\right)} & \text{if } \bar{S}_i > W_i^S, \quad (23) \end{cases}$$

where

$$\bar{\mu} \equiv \delta\varepsilon^2(1+\gamma+\beta)\bar{S}_i + (1-\gamma)\delta\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)W_i^S + 2(1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i) \quad (24)$$

$$\bar{\sigma}^2 \equiv 4\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta). \quad (25)$$

Theorem 2 indicates that the functional form describing the insider's trading plan depends on whether he plans to buy or sell the stock. The insider's globally optimal plan is determined simply by comparing his expected utility if he were to plan a sale with his expected utility if he were to plan a purchase and selecting the option that generates greater utility. As will be discussed in Section 3, the size of the insider's planned trade and the probability that he ultimately executes his plan are dependent on the level of his initial stock endowment, suggesting that when devising his plan the insider faces a trade-off between better diversification versus greater exploitation of Rule 10b5-1's selective termination option. Section 3 discusses comparative statics with respect to the underlying parameters.

2.2 Equilibrium without Rule 10b5-1

I now analyze a setting in which the insider may trade without any restrictions. This setting serves as an appropriate benchmark for evaluating the effects of Rule 10b5-1 because enforcement of insider trading restrictions is difficult, and insiders may legally trade on private information without having a Rule 10b5-1 plan so long as the information is not "material." I add a circumflex ($\hat{}$) to certain variables to distinguish them from the setup in which the insider must trade pursuant to a predetermined plan.

Unlike when the insider trades pursuant to a Rule 10b5-1 plan, the insider may adjust his stock demand based on his realized private information y and endowment shock w when he trades without any restrictions. Consequently, the insider maintains greater strategic control over the stock price and the amount of information conveyed to the market through his trade when he is not subject to Rule 10b5-1. To allow for such strategic control, I follow Leland (1992) and conjecture (and verify) a price that is a linear function of the insider's demand,

$$\hat{P}(\hat{S}_i)=\eta_1+\eta_2\hat{S}_i, \tag{26}$$

where η_1 and η_2 are constants defined in Appendix B. Restricting attention to a linear equilibrium closely aligns the model with the extant literature and guarantees uniqueness. Moreover, the parameter restriction $\nu^2>\gamma/[(1-\gamma)^2\delta^2\varepsilon^2]$ ensures that the market does not break down (Bhattacharya and Spiegel 1991). To characterize the equilibrium, I first derive the insider's and outsiders' demand functions. I then impose a market-clearing condition.

When the insider may trade without a predetermined plan, his objective is to choose $\hat{S}_i\in\mathbb{R}$ to maximize his expected utility from consumption $\hat{C}_i$ subject to a budget constraint:

$$\max_{\hat{S}_i\in\mathbb{R}} \quad \mathbb{E}\big[-\exp[-\delta\tilde{\hat{C}}_i]\,|\,w,y\big], \tag{27}$$

$$\text{s.t.} \quad \tilde{\hat{C}}_i=\hat{B}_i+(\hat{S}_i+w)\tilde{x}, \tag{28}$$

$$\hat{B}_i=W_i^B+(W_i^S-\hat{S}_i)\hat{P}(\hat{S}_i). \tag{29}$$

Substituting (1), (26), (28), and (29) into (27), integrating over $\tilde{z}$, differentiating the resultant expression with respect to $\hat{S}_i$, and solving the corresponding first-order condition yields the insider's demand function,

$$\hat{S}_i=\psi_1+\psi_2 k, \tag{30}$$

where ψ_1 and ψ_2 are constants defined in Appendix B and k is given by (7). Because the conjectured stock price is a linear function of the insider's demand, it can be rewritten as

$$\hat{P}=\alpha_1+\alpha_2 k \tag{31}$$

after substituting (30) into (26), where α_1 and α_2 are constants. Appendix B defines these constants, which are functions of η_1 and η_2.

Outsiders infer k from the equilibrium price and update their beliefs about the stock payoff using Bayes' rule. Thus, the outsiders' posterior distribution of $\tilde{y}$ conditional on observing the stock price is given by (8). Outsiders' portfolio decisions are based on their updated beliefs about $\tilde{y}$. The outsiders' objective is to select a stock allocation $\hat{S}_o\in\mathbb{R}$ to maximize their expected utility from consumption $\hat{C}_o$ subject to a budget constraint:

$$\max_{\hat{S}_o\in\mathbb{R}} \quad \mathbb{E}\big[-\exp[-\delta\tilde{\hat{C}}_o]\,|\,k\big], \tag{32}$$

$$\text{s.t.} \quad \tilde{\hat{C}}_o=\hat{B}_o+\hat{S}_o\tilde{x}, \tag{33}$$

$$\hat{B}_o=W_o^B+(W_o^S-\hat{S}_o)\hat{P}. \tag{34}$$

The outsiders' demand function is obtained by substituting (1), (33), and (34) into (32), integrating over $\tilde{z}$ and $\tilde{y}$ according to (8), differentiating the resultant expression with respect to $\hat{S}_o$, and solving the corresponding first-order condition, which gives

$$\hat{S}_o = \frac{\gamma k - [\gamma + (1-\gamma)\beta]\hat{P}}{(1-\gamma)(\gamma+\beta)\delta\varepsilon^2}. \tag{35}$$

Aggregating the insider's and outsiders' demand and imposing the market-clearing condition, which is given by (15), provides another expression for the stock price,

$$\hat{P} = \alpha_1' + \alpha_2' k, \tag{36}$$

where α_1' and α_2' are constants. Like α_1 and α_2, these two constants are defined in Appendix B and are functions of η_1 and η_2. Expressions for the equilibrium stock price and allocations in terms of the underlying parameters, as summarized in the following theorem, are obtained by setting $\alpha_1 = \alpha_1'$ and $\alpha_2 = \alpha_2'$ and solving the system of equations.

Theorem 3. When the insider may trade without a predetermined trading plan, there exists a unique (linear) equilibrium in which the stock price and allocations are given by

$$\hat{P} = \theta_1 + \theta_2[y - (1-\gamma)\delta\varepsilon^2 w], \tag{37}$$

$$\hat{S}_i = \lambda_1 + \lambda_2[y - (1-\gamma)\delta\varepsilon^2 w], \tag{38}$$

$$\hat{S}_o = 1 - \lambda_1 - \lambda_2[y - (1-\gamma)\delta\varepsilon^2 w], \tag{39}$$

where

$$\theta_1 \equiv \frac{(\gamma+\beta)\delta\varepsilon^2[(2\gamma+\beta)W_i^S - \gamma - (2-\gamma)\beta]}{[3\gamma + (3-\gamma)\beta]\beta} \tag{40}$$

$$\theta_2 \equiv \frac{2\gamma+\beta}{3\gamma + (3-\gamma)\beta} \tag{41}$$

$$\lambda_1 \equiv \frac{[\gamma + (1-\gamma)\beta](2\gamma+\beta)W_i^S - \gamma^2(1+\beta) + (1-\gamma)\beta^2}{(1-\gamma)\beta[3\gamma + (3-\gamma)\beta]} \tag{42}$$

$$\lambda_2 \equiv \frac{[(1-\gamma)\beta - \gamma]\delta\nu^2}{[3\gamma + (3-\gamma)\beta]\beta}. \tag{43}$$

In contrast to the equilibrium outcome under Rule 10b5-1, the stock price and allocations reflect the precise values of the insider's private information y and nontradable endowment w when he trades without a predetermined plan. This is a result of the insider being afforded greater trading flexibility, which, as will be discussed in Section 3, also enables the insider to better adjust his portfolio to exploit his information advantage and hedge his endowment shock when he is not subject to Rule 10b5-1's restrictions.

The derivations of the investors' time-0 expected utilities, which are provided in Appendix B, are relatively straightforward in the absence of Rule 10b5-1. Unlike when the insider trades pursuant to a predetermined trading plan, a convolution is not needed when the insider's demand is unconstrained. Instead, the insider's (outsiders') time-0 expected utility is obtained by simply substituting (1), (28), (29), (37), and (38) into (27) ((1), (33), (34), (37), and (39) into (32)) and integrating over $\tilde{w}$, $\tilde{y}$, and $\tilde{z}$.

2.3 Numerical analysis

While analytic expressions characterizing the unique equilibrium stock price $P(\bar{S}_i)$ and the insider's unique optimal trading plan $\bar{S}_i$ are attainable (Theorems 1 and 2), both $P(\bar{S}_i)$ and $\bar{S}_i$ are characterized by implicit functions with the other variable as one of the arguments and are, thus, not in closed form. Consequently, the equilibrium outcomes under Rule 10b5-1 are not readily interpretable. Therefore, I assign numerical values to the parameters to evaluate the effects of Rule 10b5-1 on equilibrium attributes such as prices, allocations, and welfare. Other authors who utilize numerical methods to analyze environments where traders face portfolio constraints include, for example, Yuan (2005) and Gallmeyer and Hollifield (2008).

Table 1 lists the parameter values for the numerical analysis. I compute an equilibrium for three distinct parameterizations to assess how the different parameters affect the rule's implications. I verify the robustness of the results over a wider range of parameters, but, to maintain a streamlined exposition, I do not report these results, which are qualitatively similar to those presented below. Because the parameter values must satisfy $\gamma/[(1-\gamma)^2\delta^2\varepsilon^2] < \nu^2 < 1/(\delta^2\varepsilon^2)$ for the investors' time-0 expected utility functions and, thus, the equilibrium to be well defined, the numerical analysis should not be interpreted as a calibrated reflection of reality but rather as providing qualitative insight into the effects of Rule 10b5-1.

In each parameterization, the variance of the stock payoff, ε^2, is normalized to 1, and the investors' risk aversion coefficient δ is set to 3. The quantity of private information observed by the insider, γ, ranges from 0.1 to 0.25 across the different parameterizations, while the variance of the insider's nontradable endowment, ν^2, ranges from 0.05 to 0.06. Because CARA preferences do not exhibit wealth effects, the investors' initial bond endowments, W_i^B and W_o^B, are assigned an arbitrary value of 0. An equilibrium is computed over a range of stock endowments, W_i^S and $W_o^S = 1 - W_i^S$, because the initial endowments

Table 1
Parameter values

Variable	Symbol	#1	#2	#3
Variance of $\tilde{x}$	ε^2	1	1	1
Variance of $\tilde{w}$	ν^2	0.05	0.06	0.05
Quantity of private information	γ	0.25	0.25	0.10
Risk aversion coefficient	δ	3	3	3
Insider's bond endowment	W_i^B	0	0	0
Outsiders' bond endowment	W_o^B	0	0	0

affect the size and direction of the insider's planned time-1 trade and, hence, the impact of Rule 10b5-1.[14]

3. Results

To examine the impact of Rule 10b5-1, I compare the equilibrium outcomes under the rule to the equilibrium outcomes in the unregulated benchmark economy without such a rule. I present results over a range of values for the insider's initial stock endowment W_i^S for three distinct parameterizations. I analyze extensions of the main results in Section 4.

3.1 Optimal trading plan

Under Rule 10b5-1, the insider adopts a trading plan by choosing a potential time-1 stock allocation $\bar{S}_i$ before acquiring his private information. However, the rule permits the insider to terminate his planned trade once he becomes informed. This feature of the rule effectively grants the insider a selective termination option whereby he executes his planned trade if and only if doing so improves his welfare relative to not trading. The selective termination option, whose impact I will analyze in greater detail in Section 4.2, influences the insider's optimal trading plan and, therefore, has a substantial effect on equilibrium outcomes.

Figure 2A plots the insider's optimal trading plan $\bar{S}_i$. The insider's optimal strategy entails planning to purchase stock when his initial endowment is small (i.e., for W_i^S less than roughly 0.36 to 0.40, depending on the parameterization) but planning to sell stock when his initial endowment is large. Notably, $\bar{S}_i$ is not monotonic in W_i^S. This is a direct consequence of the selective termination option.[15] To take advantage of the option, the insider chooses $\bar{S}_i$ so that he may better exploit his information advantage by planning a larger trade, knowing that he can cancel the trade if he ultimately receives information and/or an endowment shock that is adverse to his planned transaction. The result is the

[14] I verify that the results are qualitatively robust to various combinations of parameter values for γ and ν^2 ranging from 0.1 to 0.3 and from 0.04 to 0.08, respectively.

[15] As will be shown by Theorem 4 in Section 4.2, the insider's optimal trading plan is a linear and monotonically increasing function of W_i^S when he cannot cancel his planned trade.

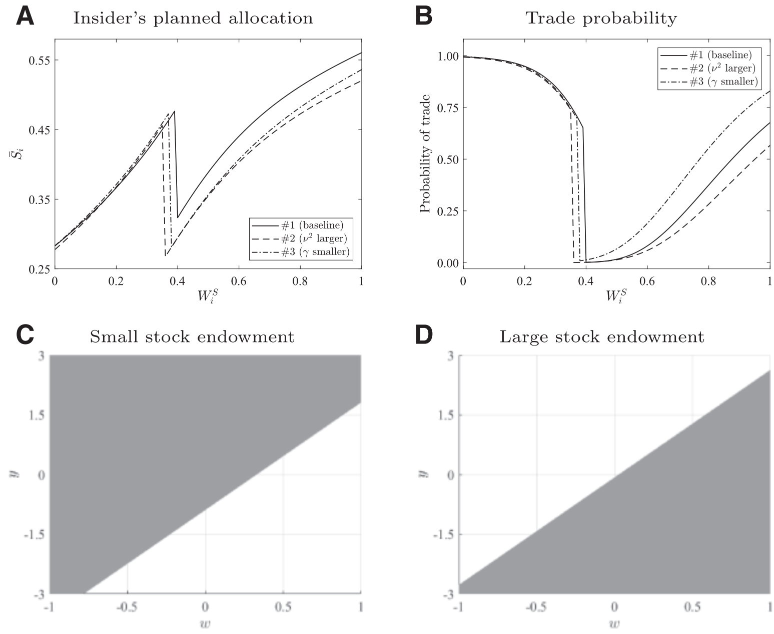

Figure 2
Optimal trading plan, trade probability, and ex post execution
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panel A plots the insider's optimal planned allocation $\bar{S}_i$, and panel B plots the probability of trade occurring at $t=1$ when the insider trades pursuant to a predetermined plan. The shaded regions in panels C and D indicate the realizations of the insider's endowment shock w and private information y for which he elects to execute his planned transaction when his initial stock endowment is small ($W_i^S=0.25$) and large ($W_i^S=0.75$), respectively, for parameterization #3.

development of two distinct regions, one in which the insider plans to buy (i.e., $\bar{S}_i > W_i^S$) and another in which he plans to sell (i.e., $\bar{S}_i < W_i^S$). Within each region, the insider's planned allocation is monotonically increasing in his initial endowment (which is a typical outcome with strategic informed trading; see Theorem 3). As his stock endowment crosses the threshold at which $\bar{S}_i$ changes from a planned purchase to a planned sale, however, the insider's planned allocation drops considerably because the optionality feature of Rule 10b5-1 induces him to plan larger transactions that he will execute only if trading ends up being advantageous ex post.[16]

The probability that the insider executes his planned transaction is determined by integrating $\tilde{k}$, which (7) indicates is conditionally truncated normally distributed,

$$\tilde{k} \sim \mathcal{TN}\big(0, \gamma\varepsilon^2 + (1-\gamma)^2\delta^2\varepsilon^4\nu^2, \underline{k}, \overline{k}\big), \tag{44}$$

[16] For example, as W_i^S increases from 0.39 to 0.40 in parameterization #1, $\bar{S}_i$ drops from 0.476 to 0.323.

over the trade region defined by the boundary in (6). Figure 2B indicates that the insider is more likely to execute his plan when his initial stock endowment W_i^S is either really small or really large, as obtaining an allocation that better reflects his risk preferences (i.e., diversification) is his primary motive for trade in such cases. Notably, the probability of trade becomes very small for stock endowment levels around which the insider switches from planning a purchase to planning a sale. At such endowment levels, the insider receives little diversification benefit from trading, so he exploits the rule's optionality feature by planning a trade that he executes only if he receives extremely negative information or experiences an exceptionally large endowment shock, both of which occur with low probability.

Figures 2C and 2D depict the region of the ex post state space (defined by the realizations of $\tilde{w}$ and $\tilde{y}$), where the insider elects to execute his planned transaction. If the insider is initially endowed with a relatively small (large) amount of stock, then he executes his planned purchase (sale) when he receives positive (negative) information and/or a negative (positive) endowment shock. This follows from (6) and is consistent with empirical evidence that terminated planned sales are associated with positive subsequent returns (Jagolinzer 2009). Because the insider executes his planned trade if and only if trading yields greater expected utility than holding his initial endowment, he may trade even for moderate realizations of his endowment shock and private information.

The insider's optimal trading plan and the probability of execution depend on the underlying parameters, particularly when the insider receives a large stock endowment. Figure 2A shows that the insider plans to sell more stock (i.e., $\bar{S}_i$ is lower) when either his endowment shock is more volatile (i.e., ν^2 is larger; parameterization #1 vs. #2) or he possesses less private information (i.e., γ is smaller; parameterization #1 vs. #3). In each of these cases, the insider places relatively more weight on hedging his endowment shock than he does on exploiting his information advantage, either because he has a larger endowment shock to hedge or because he possesses less private information. As a result, less adverse selection compels the insider to plan a larger trade.

Figure 2B shows that the insider is more likely to execute his planned sale when either ν^2 or γ is smaller. In these cases, trading flexibility is less valuable to the insider because he either has a less volatile endowment shock to hedge or has less private information to exploit. Therefore, he devises a trading plan under which trade occurs with greater likelihood so that the benefits of diversification can be achieved with greater probability.

3.2 Allocations, risk sharing, and adverse selection

Rule 10b5-1 drastically constrains the insider's portfolio opportunity set because the rule permits him to either execute his planned trade and hold his planned allocation $\bar{S}_i$ or cancel his planned trade and hold his initial endowment

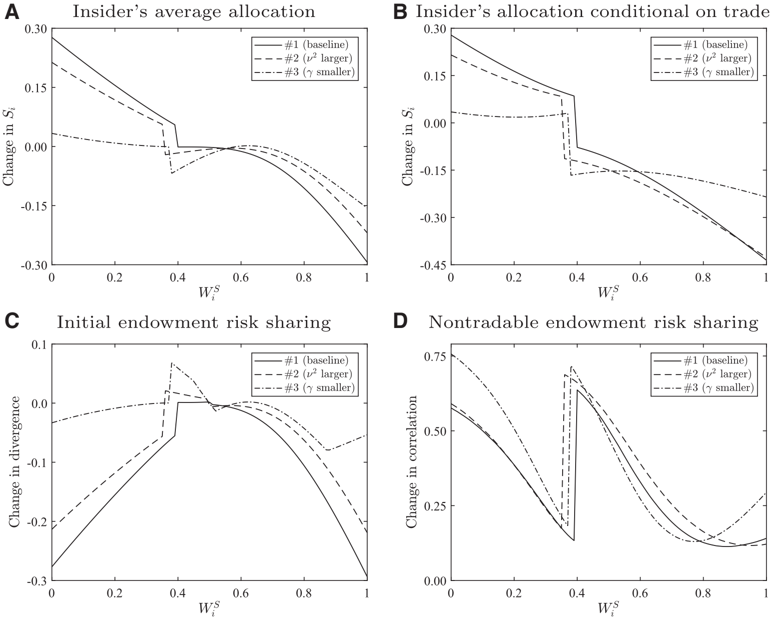

Figure 3
Stock allocations and risk sharing
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panel A plots the difference between the insider's average realized allocation S_i when he trades pursuant to a predetermined plan and his average allocation when he trades without restrictions, panel B plots the difference between the insider's allocation conditional on trade occurring when he trades pursuant to a predetermined plan and his average allocation when he trades without restrictions, panel C plots the difference between the magnitude of divergence from perfect risk sharing when the insider trades pursuant to a predetermined plan and the magnitude of divergence when he trades without restrictions, and panel D plots the difference between the Spearman rank correlation of the insider's equilibrium allocation S_i and his nontradable endowment w when he trades pursuant to a predetermined plan and the correlation when he trades without restrictions.

W_i^S. In this section, I examine how this portfolio constraint affects equilibrium allocations, risk sharing, and adverse selection.

Figure 3A plots the difference between the insider's average allocation under Rule 10b5-1, which is given by $\Pr[S_i=\bar{S}_i]\bar{S}_i+\Pr[S_i=W_i^S]W_i^S$, and his average allocation when he trades without restrictions, which is determined by integrating (38) over $\tilde{w}$ and $\tilde{y}$. Figure 3B plots the difference in allocations conditional on trade occurring. These figures indicate that the insider tends to trade a larger quantity of shares when he trades pursuant to a predetermined plan, holding more stock on average when he buys (i.e., small W_i^S) but less stock on average when he sells (i.e., large W_i^S).

The effect of Rule 10b5-1 on equilibrium allocations is driven by a reduction in adverse selection. I measure the degree of adverse selection as the Spearman rank correlation between the insider's allocation S_i and the value of his information y.[17] Because the insider's allocation under Rule 10b5-1 may take one of only two possible values (either W_i^S or $\bar{S}_i$), the conventional way of measuring adverse selection as the aggressiveness with which the insider trades on his private information, $\partial S_i/\partial y$, is infeasible in this setting. The rank correlation, which captures the ordinal relation between the insider's private information and equilibrium allocation, reflects his ability to trade on the basis of such information. A larger positive coefficient indicates that the insider tends to hold more (less) stock when his information is more positive (negative) and is, thus, better able to exploit his information advantage. Figure 4A, which plots the difference between the degree of adverse selection under Rule 10b5-1 and the degree of adverse selection when the insider trades without a plan, shows that outsiders face less adverse selection under the rule. Adverse selection falls because the rule constrains the insider's portfolio opportunity set, hindering his ability to exploit his information advantage.

By mitigating adverse selection and, as a consequence, enabling investors to trade a larger quantity of stock, Rule 10b5-1 can improve the investors' ability to share the risk associated with their initial endowments, W_i^S and W_o^S. I measure this risk-sharing ability using the magnitude of divergence between the insider's average equilibrium allocation and his average allocation in an alternative economy with perfect risk sharing.[18] Less divergence indicates greater risk sharing. Figure 3C shows that the insider's average equilibrium allocation under Rule 10b5-1 is closer to the perfect risk-sharing allocation that would be achieved in the absence of adverse selection if there is a sufficient difference between his initial endowment and perfect risk-sharing allocation; if this difference is small, then the low probability of trade may result in slightly greater divergence. Thus, Rule 10b5-1 enhances the investors' ability to diversify their portfolios and share the risk associated with their initial endowments when those endowments are sufficiently different from perfect risk-sharing allocations.

In contrast, the rule impedes the investors' ability to share the risk associated with the insider's nontradable endowment because the portfolio constraint imposed by the rule limits the insider's trading flexibility. Similar to the metric for adverse selection, I measure the insider's ability to hedge his endowment shock using the Spearman rank correlation between his allocation S_i and nontradable endowment w (the conventional way of measuring the insider's hedging ability, $\partial S_i/\partial w$, is infeasible under the rule). A larger negative coefficient indicates that the insider tends to hold more (less) stock when his

[17] Other measures of rank correlation generate similar results. To determine the Spearman rank correlation, I compute S_i for 1 million simulated realizations of $\tilde{y}$ and $\tilde{w}$. The simulated realizations are also used to evaluate Rule 10b5-1's effects on risk sharing and market depth, which are discussed below.

[18] Perfect risk sharing arises when there is no asymmetric information and, hence, no adverse selection. Taking the limit of $\hat{S}_i$ and $\hat{S}_o$ in Theorem 3 as $\gamma \to 0$, the insider's and outsiders' respective equilibrium allocations are $\frac{1}{3}(1+W_i^S-w)$ and $\frac{1}{3}(2-W_i^S+w)$ when information sets are symmetric.

endowment shock is more negative (positive) and is, therefore, better able to hedge his nontradable endowment. Figure 3D, which plots the difference between the correlations with and without Rule 10b5-1, shows that the rule, by constraining the insider's portfolio opportunity set, hampers the investors' ability to share the risk associated with the insider's nontradable endowment.

The rule has a bigger effect on allocations and adverse selection when the insider possesses a greater amount of private information simply because there is more adverse selection for the rule to mitigate in this case. The influence of the insider's endowment-shock volatility is more nuanced. Because Rule 10b5-1 hinders the insider's ability to hedge his nontradable endowment, the rule, *ceteris paribus*, effectively increases his risk exposure. To (partially) offset the greater risk exposure, which is increasing in the volatility of his endowment shock, the insider tends to hold less stock. Hence, when ν^2 is larger, the insider's stock allocation increases to a lesser extent when he executes a planned purchase (i.e., for small W_i^S) but decreases to a greater extent when he executes a planned sale (i.e., for large W_i^S).

3.3 Prices, market efficiency, and market depth

The constraint imposed on the insider's portfolio opportunity set by Rule 10b5-1 also affects the information environment and equilibrium stock price. By forcing the insider to choose between only two possible allocations ($\bar{S}_i$ or W_i^S), the rule effectively censors the insider's demand. As a result, the rule lowers the precision of the signal embedded in the equilibrium price (because multiple values of k give rise to the same outcome) and, thereby, decreases the quality of information conveyed to less-informed outsiders through trade.

Following standard practice in the literature (e.g., Spiegel and Subrahmanyam 1992), I measure the informational efficiency of the market as the inverse of the variance of the insider's private information conditional on the trading outcome. The following corollary provides analytic expressions for market efficiency, denoted by Σ.

Corollary 1. When the insider may trade only pursuant to a predetermined trading plan, average market efficiency is

$$\Sigma = \Phi\left(\tfrac{\Delta}{\sigma}\right)\left[\gamma\varepsilon^2 - \frac{\gamma\varepsilon^2\Delta}{\sigma^2}\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\Phi\left(\frac{\Delta}{\sigma}\right)} - \left(\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\Phi\left(\frac{\Delta}{\sigma}\right)}\right)^2\right]^{-1}$$
$$+\left(1-\Phi\left(\tfrac{\Delta}{\sigma}\right)\right)\left[\gamma\varepsilon^2 + \frac{\gamma\varepsilon^2\Delta}{\sigma^2}\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{\Delta}{\sigma}\right)\right)} - \left(\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{\Delta}{\sigma}\right)\right)}\right)^2\right]^{-1}, \quad (45)$$

where

$$\Delta \equiv P(\bar{S}_i) + \tfrac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S + \bar{S}_i). \quad (46)$$

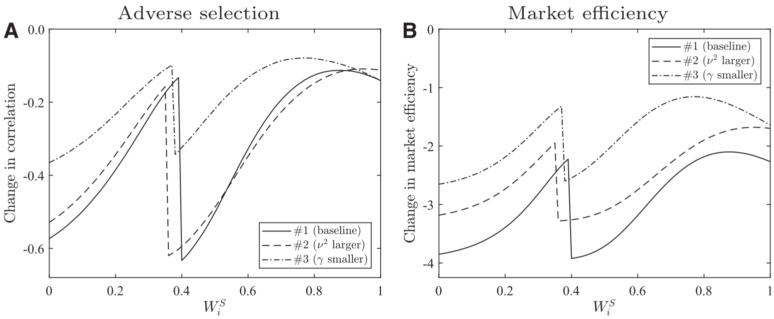

Figure 4
Adverse selection and market efficiency
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panel A plots the difference between the Spearman rank correlation of the insider's equilibrium allocation S_i and his private information y when he trades pursuant to a predetermined plan and the correlation when he trades without restrictions, and panel B plots the average difference between market efficiency when the insider trades pursuant to a predetermined plan and market efficiency when he trades without restrictions.

When the insider may trade without a predetermined trading plan, market efficiency is

$$\hat{\Sigma} = \frac{1}{\gamma \varepsilon^2} + \frac{1}{(1-\gamma)\varepsilon^2 \beta}. \tag{47}$$

Figure 4B, which plots the difference between average market efficiency under Rule 10b5-1 and market efficiency when the insider trades without any restrictions, shows that the market is less efficient under the rule. The rule decreases efficiency to a greater extent when the insider possesses more private information because more information is censored by the rule when γ is larger. Efficiency also declines to a greater extent when the insider's endowment shock is less volatile because censoring his demand, which reveals more information in the absence of the rule when ν^2 is smaller, is more detrimental in this case.

The decline in market efficiency and changes to the risk-sharing environment discussed in Section 3.2 affect the equilibrium stock price under Rule 10b5-1. Figure 5A plots the difference between the transaction price under Rule 10b5-1, which is a constant (conditional on $\bar{S}_i$) characterized by Theorem 1, and the average transaction price without Rule 10b5-1, which is obtained by integrating (37) over $\tilde{w}$ and $\tilde{y}$. Conditional on trade occurring, the price tends to be higher under Rule 10b5-1 when the insider buys but lower when he sells. As Figure 3B shows, conditional on trade occurring, the insider holds more (less) stock on average under the rule when he buys (sells), which decreases (increases) the residual stock supply that must be absorbed by outsiders. Because outsiders bear less (more) risk on average when the insider executes a planned purchase (sale), they are willing to pay a higher (lower) price for the stock. Furthermore, although the rule reduces market efficiency, the nature of the information inferred by outsiders tends to be more positive (negative)

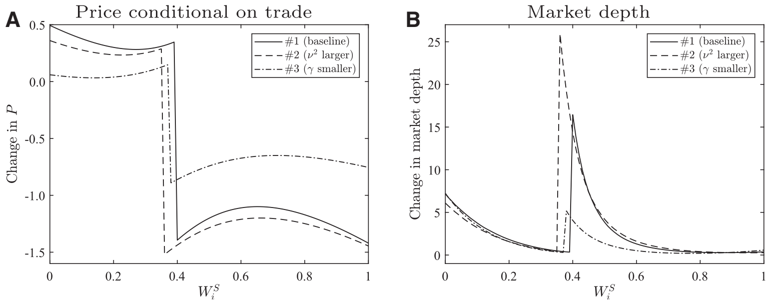

Figure 5
Stock price and market depth
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panel A plots the difference between the transaction price $P(\bar{S}_i)$ when the insider trades pursuant to a predetermined plan and the average price $\hat{P}(\hat{S}_i)$ when he trades without restrictions, and panel B plots the difference between the magnitude of the inverse of the Spearman rank correlation of the stock price P and the insider's nontradable endowment w when he trades pursuant to a predetermined plan and the magnitude of the inverse of the correlation when he trades without restrictions.

when the insider makes a bigger purchase (sale), so outsiders are willing to pay a higher (lower) price for the stock on average when the insider executes a planned purchase (sale). However, the outsiders' increased uncertainty caused by the drop in market efficiency, *ceteris paribus*, decreases their demand for the stock regardless of whether the insider buys or sells. Thus, the extent to which the rule increases the average stock price when the insider buys is smaller than the extent to which it decreases the average price when he sells. The effects of ν^2 and γ on the average price are similar to their effects on allocations, which are described in Section 3.2.

In addition to affecting the average price level, the rule also affects market depth. I measure market depth as the magnitude of the inverse of the Spearman rank correlation between the stock price P and the insider's nontradable endowment w (the conventional way of measuring depth, $|\partial P/\partial w|^{-1}$, is infeasible under the rule). This measure reflects the impact of an exogenous demand shock on the price, with a larger coefficient indicating a smaller impact and, hence, greater depth. Figure 3D, which plots the difference between market depth under Rule 10b5-1 and market depth when the insider trades without a plan, shows that the market is deeper under the rule. Market depth increases because the rule prevents the insider from freely adjusting his demand in response to his endowment shock, making the equilibrium price less sensitive to his nontradable endowment.

3.4 Welfare

Rule 10b5-1 affects the investors' welfare through a few channels. As discussed above, the rule reduces adverse selection and, thereby, enhances the investors' ability to share the risk associated with their initial endowments. At the same time, however, because the rule severely limits the insider's trading flexibility, the rule diminishes his capacity to capitalize on his information advantage and hinders the investors' ability to share the risk associated with the insider's nontradable endowment. Depending on the relative strengths of these effects, Rule 10b5-1 may either raise or lower the investors' welfare.

I assess the rule's effect on welfare by computing certainty equivalents for the investors. An investor's certainty equivalent is the amount of additional wealth with which he must be endowed in the benchmark economy where the insider trades without any restrictions for that investor to be indifferent between a regulatory regime in which the insider may trade only pursuant to a predetermined plan and a regime without such a rule. A positive (negative) certainty equivalent indicates that an investor is better (worse) off under Rule 10b5-1.

Figures 6A and 6B, which plot the investors' certainty equivalents, indicate that the rule largely improves ex ante welfare for both the insider and outsiders. Provided there is a sufficient degree of information asymmetry, the reduction in adverse selection and corresponding benefit the insider enjoys from being better able to share the risk associated with his initial endowment dominates the restriction on his portfolio opportunity set and corresponding detriments he suffers from being less able to capitalize on his information advantage and hedge his nontradable endowment. Similarly, the reduction in adverse selection improves the outsiders' ability to share the risk associated with their initial endowments and allows them to trade more shares on average at a more favorable price (i.e., sell more shares at a higher price and buy more shares at a lower price; see Figures 3B and 5A).[19]

Although Rule 10b5-1 mostly has a positive impact on the insider's welfare, it reduces his welfare when he receives a smaller initial stock endowment and has little private information (parameterization #3). In this case, the loss of trading flexibility, which prevents the insider from hedging his endowment shock, outweighs the modest benefit arising from better initial endowment risk sharing. This suggests that the adoption of a trading plan is detrimental to the insider if reducing adverse selection does not sufficiently improve the insider's ability to share the risk associated with his initial endowment.[20] The adoption of a trading plan may also negatively affect the outsiders' welfare in a narrow set of circumstances, namely, when the insider's hedging motive for trade is sufficiently strong relative to his information-based motive and the initial stock

[19] Although the rule increases market depth, outsiders are nevertheless able to trade at a relatively more favorable price because the insider's information-based motive for trade decreases to a greater extent than his hedging motive. Specifically, the percentage decrease in the correlation between the insider's private information y and his equilibrium stock allocation S_i, weighted by the variance of his private information, $\gamma\varepsilon^2$, is greater than the percentage increase in the correlation between the insider's nontradable endowment w and his equilibrium stock allocation S_i, weighted by the variance of the his endowment shock, ν^2.

[20] Of course, if adopting a trading plan is voluntary, then the insider will not adopt one unless it improves his welfare. In Section 4.1, I analyze the impact of the rule when adopting a trading plan is voluntary.

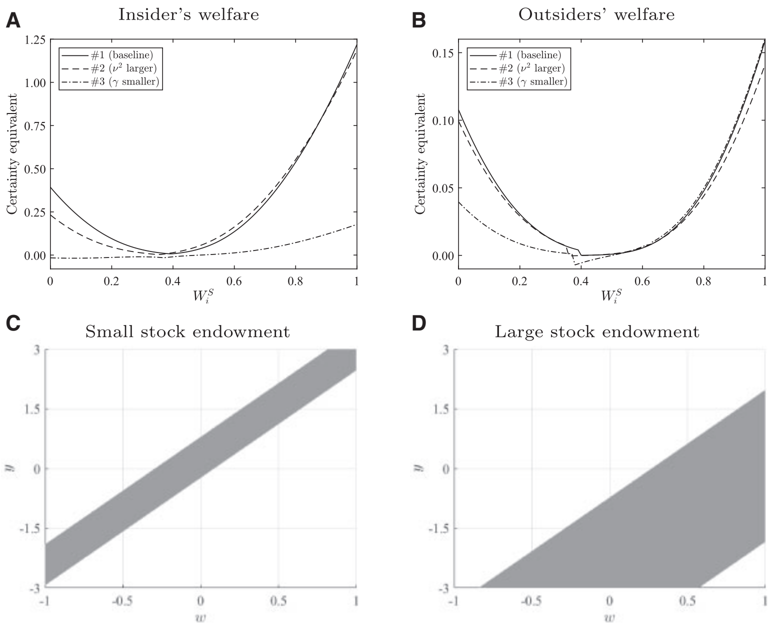

Figure 6
Ex ante and ex post welfare
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panels A and B, respectively, plot the insider's and outsiders' certainty equivalents of the insider adopting a cancellable predetermined trading plan. The shaded regions in panels C and D indicate the realizations of the insider's endowment shock w and private information y for which a predetermined trading plan increases his ex post welfare when his initial stock endowment is small ($W_i^S = 0.25$) and large ($W_i^S = 0.75$), respectively, for parameterization #3.

endowments are such that trade rarely occurs under the rule. In this scenario, the rule prevents outsiders from capitalizing on the insider's hedging demand.

The welfare effects tend to be stronger when there is a bigger improvement in initial endowment risk sharing and a smaller decline in nontradable endowment risk sharing (i.e., when ν^2 is smaller or γ is larger). Additionally, the rule has a bigger impact on welfare for more extreme levels of initial endowments (i.e., W_i^S close to either 0 or 1) because the investors are more motivated to engage in trade to diversify their portfolios in these cases.

Examining the insider's ex post welfare in different regions of the state space (defined by the realizations of $\tilde{w}$ and $\tilde{y}$) further highlights the channels through which Rule 10b5-1 affects ex ante welfare. Figures 6C and 6D depict how the rule affects the insider's ex post welfare for various realizations of $\tilde{w}$ and $\tilde{y}$ when he possesses little private information (parameterization #3).[21] When the insider's initial stock endowment W_i^S is relatively small ($W_i^S = 0.25$; Figure 6C),

[21] I focus on parameterization #3 because, as Figure 6A shows, the insider's ex ante welfare may either rise or fall under this parameterization, depending on W_i^S.

he values ex post trading flexibility over better ex ante diversification because his endowed stock allocation already reflects his risk preferences reasonably well. Consequently, he receives little benefit from the improvement in initial endowment risk sharing, and there is only a narrow region of the state space where he is better off ex post under the rule, which explains why his ex ante welfare declines (see Figure 6A).[22]

Conversely, when W_i^S is relatively large ($W_i^S\!=\!0.75$; Figure 6D), ex ante diversification is more valuable than ex post trading flexibility. Thus, the rule increases the insider's ex ante welfare, but the reason is not simply because he is better off ex post under a larger set of realizations of w and y, as his ex post welfare still declines for a vast majority of outcomes. Rather, the rule increases the insider's ex ante welfare because it serves as insurance against poor outcomes, enabling him to make better trades and, thereby, dramatically raise his welfare in states where his marginal utility is high (e.g., w is high and y is low) while restricting his ability to trade in states where his marginal utility is low (e.g., w is low or y is high).[23]

3.5 Summary

The numerical analysis generates several economic insights that hold over a wide range of parameterizations (see footnote 14). Although the specific magnitudes of Rule 10b5-1's effects depend on parameters, several general conclusions can be drawn from the analysis.

Figure 2 definitively shows that the insider plans to buy (sell) stock when his initial endowment is small (large) and that he often exploits the rule's selective termination option when he receives information and/or an endowment shock that is adverse to his planned trade. Additionally, Figures 4 and 5 conclusively show that the constraint on the insider's portfolio imposed by the rule reduces both adverse selection and market efficiency but increases market depth. As Figure 3 shows, this portfolio constraint hinders the sharing of risk associated with the insider's nontradable endowment, whereas the reduction in adverse selection allows the investors to trade a greater quantity of stock on average (conditional on trade occurring). The latter effect facilitates the sharing of risk associated with the investors' initial endowments, but the insider's ability to cancel his planned trade may hinder such risk sharing when initial endowments do not differ much from perfect risk-sharing allocations. Provided that the insider's informational motive for trade is sufficiently large relative to his hedging motive, the improvement in initial endowment risk sharing outweighs

22 Within the shaded region, the insider is better off even though the ex ante diversification benefits are relatively small because the realizations of $\tilde{w}$ and $\tilde{y}$ are such that he would not substantially alter his planned trade if he had ex post trading flexibility. Above the shaded region, the insider is worse off because he would purchase additional shares of stock if he could trade without any restrictions. Below the shaded region, he would either buy fewer shares or sell the stock if he were not subject to the rule.

23 The insider's average ex post certainty equivalent in the shaded region where the rule improves his welfare is roughly six times higher when $W_i^S\!=\!0.75$ as compared to when $W_i^S\!=\!0.25$.

the deterioration in nontradable endowment risk sharing, which increases the investors' welfare (Figure 6).

4. Extensions

I analyze three extensions of the model. In Section 4.1, I discuss how the voluntary adoption of a trading plan affects the results. I then assess the effects of the rule's selective termination option in Section 4.2. Next, I analyze the impact of the rule relative to an autarkic benchmark in Section 4.3. These extensions are relied upon to explain the robustness of the results to plan termination costs and litigation risk in Section 4.4. Finally, I discuss policy implications of my analysis in Section 4.5.

4.1 Voluntary adoption of trading plan

The analysis heretofore is predicated on the insider's enrollment in a Rule 10b5-1 plan being specified exogenously: either he must trade pursuant to a predetermined trading plan or he cannot. In practice, however, insiders may voluntarily choose whether to adopt a plan. In this section, I endogenize the insider's decision about whether to adopt a trading plan and discuss the implications for the investors' welfare.

The insider will choose to adopt a plan if and only if doing so results in greater expected utility than not adopting one. Importantly, the insider's voluntary adoption of a plan provides no signal to the market because he has no private information at the time of adoption (recall Rule 10b5-1 does not permit an insider to adopt a plan if he is aware of material nonpublic information). Figure 7 plots the investors' certainty equivalents of Rule 10b5-1 when the insider's adoption of a trading plan is voluntary. Because the insider adopts a trading plan only if it increases his welfare, he is weakly better off under the rule. Outsiders also are weakly better off under the rule. For the insider to adopt a plan, the reduction in adverse selection must sufficiently enhance his ability to diversify his portfolio to compensate for his weakened ability to hedge his endowment shock and capitalize on his information advantage. Because outsiders are not directly exposed to the insider's nontradable endowment risk but benefit from both better diversification and the insider's diminished ability to exploit his information advantage, if adverse selection costs are sufficiently large for the insider to benefit from the rule, then they are sufficiently large for outsiders to benefit from the rule, too.

Notably, the insider elects to adopt a plan if and only if the benefits arising from lower adverse selection costs outweigh the detriments associated with less trading flexibility, that is, when there is a sufficient degree of information asymmetry. This result is consistent with empirical evidence that insiders with greater opportunity for strategic trade are more likely to adopt Rule 10b5-1 plans, as such plans are more common for senior management and officers (Sen 2008; Hugon and Lee 2016), for insiders at firms in R&D-intensive industries

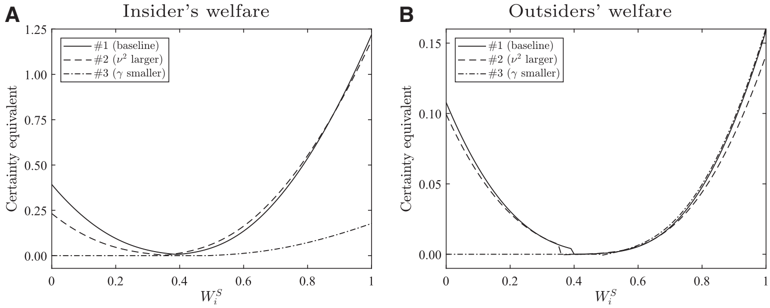

Figure 7
Welfare with voluntary adoption of trading plan
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panels A and B, respectively, plot the insider's and outsiders' certainty equivalents of Rule 10b5-1 when adopting a cancellable predetermined trading plan is voluntary.

(Milian 2016; Hugon and Lee 2016), and for insiders at firms with greater stock price volatility (Henderson et al. 2012). Moreover, the finding that the insider is more prone to adopt a trading plan when W_i^S is large is consistent with Jagolinzer (2009), who documents that sales made pursuant to Rule 10b5-1 plans are much more common than purchases.

4.2 Selective termination option value

The insider's ability to cancel his planned trade creates a selective termination option that he may exercise by abstaining from trade whenever doing so results in greater welfare than trading according to his plan. Although this selective termination option is valuable to the insider, *ceteris paribus*, because it gives him the flexibility to forgo trade, it can be detrimental to him in equilibrium because having the ability to cancel his trade prevents the complete elimination of adverse selection and, thus, inhibits efficient risk sharing. In this section, I examine the value of the selective termination option by comparing the investors' welfare in the economy wherein the insider may cancel his planned trade after observing his private information and endowment shock (as in Section 2.1) to their welfare in an alternative setting wherein the insider may not terminate his plan.[24] Adverse selection exists in the former environment, but not in the latter. An asterisk (*) is added to the variables to distinguish them from the economy in which the insider's trading plan is cancellable.

With a noncancellable plan, the insider must execute his planned trade, so time-1 allocations are determined at $t=0$ before his private information y and endowment shock w are realized (i.e., $S_i^* = \bar{S}_i^*$). I conjecture (and verify) a price

[24] The alternative setting in which the insider may not terminate his trading plan differs from the advance disclosure environments studied by Huddart et al. (2010) and Lenkey (2014), because the insider must determine his planned trade *before* he acquires his private information under Rule 10b5-1, whereas he may determine his trade *after* acquiring information under an advance disclosure requirement.

that is linear in the insider's stock allocation. Hence, the equilibrium derivation, which is contained in Appendix C, is similar to the derivation in the unregulated benchmark economy (Section 2.2). The following theorem characterizes the equilibrium when the insider must trade pursuant to a noncancellable plan.

Theorem 4. When the insider is obligated to execute his predetermined trading plan, there exists a unique (linear) equilibrium in which the stock price and allocations are given by

$$P^* = -\frac{\delta\varepsilon^2[2-\delta^2\varepsilon^2\nu^2-(1-\delta^2\varepsilon^2\nu^2)W_i^S]}{3-2\delta^2\varepsilon^2\nu^2}, \tag{48}$$

$$S_i^* = \frac{(1-\delta^2\varepsilon^2\nu^2)(1+W_i^S)}{3-2\delta^2\varepsilon^2\nu^2}, \tag{49}$$

$$S_o^* = \frac{1+(1-\delta^2\varepsilon^2\nu^2)(1-W_i^S)}{3-2\delta^2\varepsilon^2\nu^2}. \tag{50}$$

Without a selective termination option, the insider faces more risk, *ceteris paribus*, because he is obligated to trade a predetermined quantity of stock, regardless of the realizations of his endowment shock and private information; consequently, he holds less stock on average to reduce his aggregate risk exposure. Hence, providing the insider with a selective termination option leads him to buy more shares when his initial stock endowment W_i^S is small and sell fewer shares when his initial endowment is large, as Figure 8A shows. However, the adverse selection that exists when the insider possesses a selective termination option, *ceteris paribus*, limits his ability to make larger trades, so his average allocation increases to a greater extent when he plans to sell. Additionally, because the insider's decision to execute his planned transaction reveals some information to outsiders, the insider pays a higher price when he buys (i.e., for small W_i^S) but receives a lower price when he sells (i.e., for large W_i^S) with a selective termination option, as shown in Figure 8B. In contrast, no information is revealed through trade when the insider is obligated to execute his plan.

The impact of the selective termination option on the equilibrium price and allocations affects the investors' ex ante welfare (derived in Appendix C). Comparing the investors' welfare in the current setting wherein the insider must execute his planned trade to their welfare in the economy wherein the insider may terminate his plan yields certainty equivalents of the selective termination option. An investor's certainty equivalent corresponds to the value of the option to that investor. Figure 8C and 8D show that both the insider and outsiders benefit from the option when W_i^S is small but suffer a detriment when W_i^S is large.

Similar to Rule 10b5-1's effect on the insider's welfare discussed in Section 3.4, the value of the selective termination option depends on whether

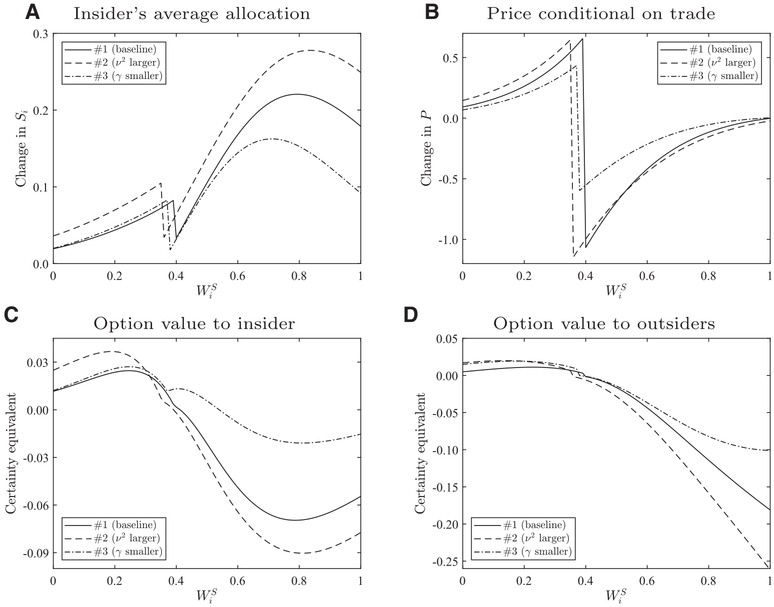

Figure 8
Selective termination option
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panel A plots the difference between the insider's average allocation when he may terminate his planned trade and his allocation when he cannot, panel B plots the difference between the transaction price when he may terminate his planned trade and the transaction price when he cannot, panel C plots the ex ante value of the selective termination option to the insider, and panel D plots the ex ante value of the selective termination option to outsiders.

the benefits arising from greater trading flexibility outweigh the detriments stemming from adverse selection. On the one hand, the option affords the insider greater flexibility because he may choose to forgo trade after observing his endowment shock and private information. On the other hand, adverse selection exists when the insider possesses a selective termination option, but not when he must execute his planned trade. For large stock endowments, the adverse selection costs outweigh the benefits from having greater trading flexibility because such costs limit the insider's ability to reduce the high risk exposure (in the form of more stock) with which he is endowed; when the insider possesses a selective termination option, he tends to sell fewer shares at a lower price (Figures 8A and 8B), which results in lower wealth and greater risk exposure. Conversely, for small endowment levels, the benefits from increased trading flexibility outweigh the costs arising from adverse selection because he is endowed with less risk.

The selective termination option creates a slightly different trade-off for outsiders. While outsiders are directly harmed by adverse selection, they are indirectly affected by the option's impact on the insider's aggregate risk exposure. When the insider's initial stock endowment is small, outsiders benefit from the option because they are able to sell more shares to the insider at a higher price, leading to a wealth transfer from the insider to outsiders. Conversely, when the insider's initial endowment is large, outsiders tend to buy fewer shares, which leaves them with a less-diversified portfolio on average. Hence, the selective termination option increases (decreases) the outsiders' welfare when W_i^S is small (large).

Figures 9A and 9B depict the regions of the state space where the selective termination option increases the insider's ex post welfare. The option provides value ex post two ways. First, it allows the insider to cancel his planned transaction when the realizations of $\tilde{w}$ and $\tilde{y}$ are such that he obtains greater utility by not trading. This is captured by the lower shaded region in Figure 9A, where the insider forgoes a planned purchase (w high, y low) and by the shaded region in Figure 9B, where he forgoes a planned sale (w low, y high). Second, the option reduces the insider's risk exposure, so he plans to purchase more shares when W_i^S is small, as discussed above. This perhaps more subtle effect benefits the insider ex post in the upper shaded region of Figure 9A (w low, y high).

4.3 Autarky

I now evaluate the impact of Rule 10b5-1 relative to an autarkic economy in which the investors do not engage in trade but instead hold their initial endowments. This setting reflects the reality that insiders may be prohibited from trading while in possession of private information (e.g., SEC Rule 10b-5), though there is abundant empirical evidence that many insiders earn abnormal trading profit (see, e.g., Lakonishok and Lee 2001; Jeng et al. 2003; Marin and Olivier 2008; Cohen et al. 2012). The setting can be interpreted as an economy in which the insider faces high litigation risk for insider trading. Because there is no trade in this alternative benchmark economy, I focus solely on the welfare implications of the rule.

Expressions for the investors' ex ante expected utility are easily obtained when there is no trade, as described in Appendix D. Figure 10 plots the certainty equivalents of permitting the insider to trade pursuant to a predetermined plan rather than requiring the investors to hold their initial endowments. Consistent with Dow and Rahi (2003), Spiegel and Subrahmanyam (1992), and other studies, allowing the insider to trade increases welfare for both the insider and outsiders because the improvement in risk sharing outweighs the adverse selection costs. Thus, viewed strictly as a mechanism to encourage trade in an economy with (prohibitively) high litigation risk, Rule 10b5-1 makes investors better off.

4.4 Termination costs and litigation risk

Under current law, insiders do not incur legal liability for canceling a planned trade because such liability may arise only "in connection with the purchase or sale of any security" (§10 of the Securities Exchange Act of 1934). However,

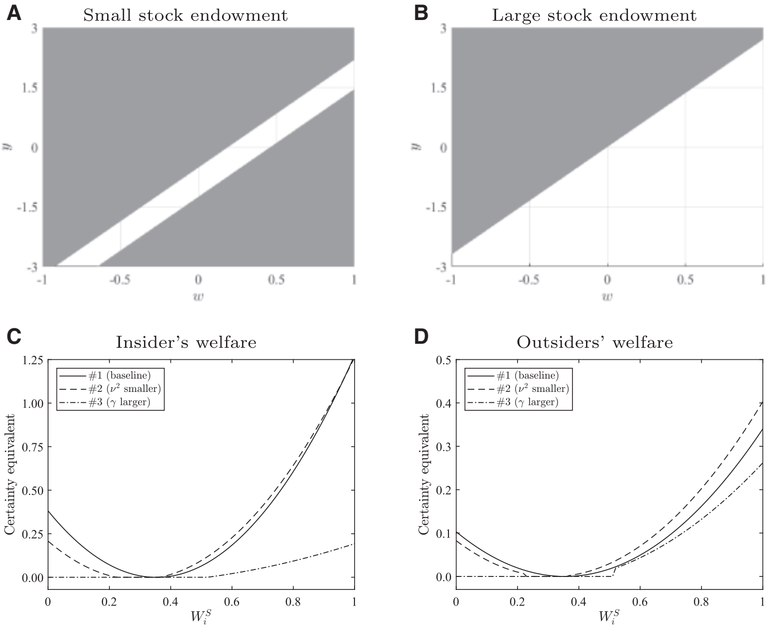

Figure 9
Ex post selective termination option value and welfare with voluntary adoption of a noncancellable trading plan
The shaded regions in panels A and B indicate the realizations of the insider's endowment shock w and private information y for which the selective termination option increases his ex post welfare when his initial stock endowment is small ($W_i^S = 0.25$) and large ($W_i^S = 0.75$), respectively, for parameterization #3. For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panels C and D, respectively, plot the insider's and outsiders' certainty equivalents of a noncancellable plan when adoption is voluntary.

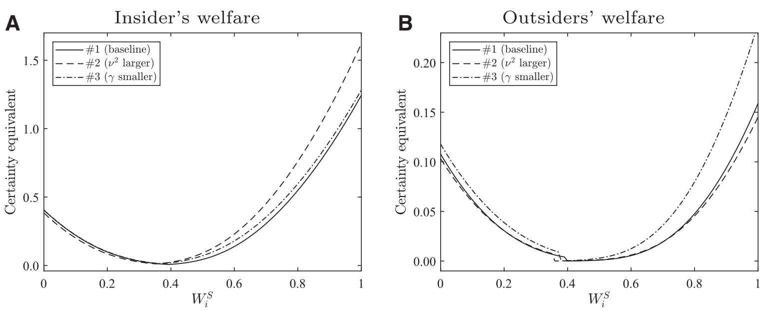

Figure 10
Welfare relative to autarkic benchmark
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panels A and B, respectively, plot the insider's and outsiders' certainty equivalents of the insider adopting a cancellable predetermined trading plan relative to autarky.

terminating a planned transaction is not necessarily costless. Rule 10b5-1 stipulates that a plan must be “entered into in good faith and not as part of a plan or scheme to evade” insider trading laws and regulations. Accordingly, the cancellation of a planned trade could affect the availability of the defense for prior transactions conducted pursuant to that plan and would make the defense unavailable for future transactions unless a new plan were adopted. Although the extent to which these consequences would dissuade insiders from terminating a planned trade is unclear, as Milian (2016) reports that the median trading plan consists of only four transactions, repeatedly adopting and terminating trading plans could raise doubts about an insider’s good faith.

Nonetheless, the qualitative implications of Rule 10b5-1 should largely be unaffected by termination costs. Because the rule would still limit the insider’s ability to adjust his demand to reflect his private information and endowment shock, the rule would still facilitate the sharing of risk associated with the investors’ initial stock endowments but inhibit the sharing of risk associated with the insider’s nontradable endowment. Hence, the basic economic trade-offs would still exist if the insider incurred a cost to cancel his planned trade.

Interpreting the benchmark economy wherein the insider must execute his plan as a market with a sufficiently high termination cost to dissuade the insider from ever canceling his planned trade can provide insights into how a more moderate termination cost might affect welfare. Figures 9C and 9D plot the investors’ certainty equivalents of the insider adopting a noncancellable trading plan relative to trading without a plan when the adoption of a plan is voluntary. The figures show that investors are weakly better off with adoption, suggesting that the rule’s effects on welfare are qualitatively unaffected by termination costs.

While insiders may incur implicit plan termination costs in practice, they may also face litigation risk. Although I do not explicitly model litigation risk, the various economic environments can be interpreted as markets with different degrees and types of such risk. The economy where the insider may trade only pursuant to a cancellable plan (Section 2.1) can be interpreted as a market with no litigation risk for canceling a planned transaction, the economy where the insider must execute his planned trade (Section 4.2) can be interpreted as a market with high litigation risk for canceling a planned transaction, the unregulated economy where the insider may trade without restrictions (Section 2.2) can be interpreted as a market with no litigation risk for insider trading, and the autarkic economy (Section 4.3) can be interpreted as a market with high litigation risk for insider trading. Because permitting the insider to adopt a Rule 10b5-1 plan raises the investors’ welfare relative to autarky and permitting the insider to voluntarily adopt a noncancellable plan raises the investors’ welfare relative to when he may voluntarily adopt a cancellable plan, the welfare-enhancing effects of the rule would still hold if the insider were subject to litigation risk for either trading without a plan or canceling a planned transaction.

4.5 Policy implications

As currently constituted, Rule 10b5-1 permits the voluntary adoption of a cancellable trading plan. Although this regulatory framework weakly improves the investors' welfare relative to the unregulated benchmark economy wherein the insider trades without restrictions (Section 4.1) and strictly improves welfare relative to autarky (Section 4.3), the investors could potentially attain greater welfare if the insider were able to adopt a noncancellable plan (Section 4.2). As Figures 7 and 8 show, the conditions under which the insider voluntarily adopts a trading plan often coincide with the conditions under which the selective termination option decreases both his and the outsiders' welfare; under such conditions, the insider would prefer to adopt a noncancellable plan. Rule 10b5-1 does not enable an investor to adopt a noncancellable plan, however, because there is no way for him to credibly commit to execute his planned trade. Thus, a modified rule that gave the insider the choice to adopt a cancellable or noncancellable plan could increase welfare.

Figure 11A depicts the levels of the insider's initial stock endowment for which he prefers to adopt a cancellable trading plan (shaded region), adopt a noncancellable trading plan (dashed region), or trade without a plan (nonshaded region) for each of the parameterizations. The insider prefers a noncancellable plan when his initial stock endowment W_i^S is large but a cancellable plan when W_i^S is small and he possesses a sufficient amount of private information.[25] If he possesses little private information and is endowed with a small amount of stock, then he prefers to trade without a plan. These preferred courses of action stem from the trade-offs between adverse selection and trading flexibility discussed above.

A modified rule that authorized noncancellable trading plans could also improve utilitarian welfare, which I measure as the sum of the insider's and outsiders' certainty equivalents. Figure 11B depicts the levels of the insider's initial stock endowment for which utilitarian welfare is maximized by the insider adopting a cancellable trading plan, adopting a noncancellable plan, or trading without a plan. The figure indicates that authorizing the insider to trade pursuant to a noncancellable plan would improve utilitarian welfare when he is endowed with a large amount of stock. Although the insider's choice of plan coincides with the socially efficient (i.e., utilitarian welfare-maximizing) type of plan under a majority of conditions, utilitarian welfare could be improved by incentivizing the insider to trade pursuant to a cancellable plan (rather than without a plan) when his initial stock endowment is small and he possesses little private information and to trade pursuant to a noncancellable plan (rather than a cancellable plan) for some moderate levels of his initial endowment.

[25] Comparing Figures 7A and 11A indicates that the insider prefers to adopt a cancellable plan rather than to trade without a plan (which are the only two options currently permitted by Rule 10b5-1) in cases in which he would choose to adopt a noncancellable plan.

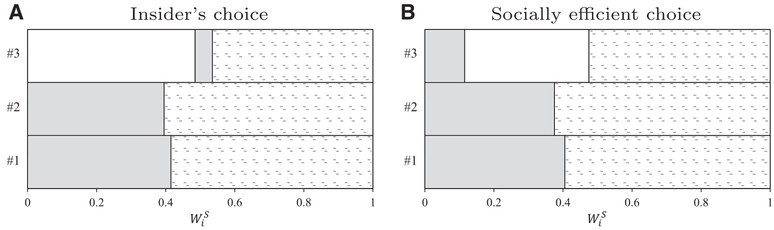

Figure 11
Optimal plan type
For various levels of the insider's initial stock endowment W_i^S and multiple parameterizations, panels A and B, respectively, depict the insider's and the socially efficient plan adoption choice. The shaded regions represent the adoption of a cancellable trading plan; the dashed regions represent the adoption of a noncancellable trading plan; and the nonshaded regions represent no plan adoption.

Table 2
Summary of Rule 10b5-1's effects.
The qualitative effects of the insider adopting a cancellable trading plan relative to the various benchmarks are reported. A "+" indicates that a metric increases, a "−" indicates that a metric decreases, and a "±" indicates that a metric may either increase or decrease (depending on parameters) with a cancellable trading plan

Benchmark	Insider's welfare	Outsiders' welfare	Total welfare	Adverse selection	Market efficiency	Market depth
No restrictions	±	±	±	−	−	+
No termination option	±	±	±	+	+	−
Autarky	+	+	+	+	+	−

Utilitarian welfare may not be improved by incentivizing the insider to trade without a plan.

A modified rule that authorized the insider to trade pursuant to a noncancellable plan would also affect other market attributes in addition to welfare. Specifically, adverse selection and market efficiency would decrease whereas market depth would increase if the insider were to trade pursuant to a noncancellable (instead of a cancellable) plan because the trading outcome is independent of the insider's private information and endowment shock in the absence of a selective termination option. Table 2 summarizes these effects. Overall, creating a mechanism by which insiders could adopt noncancellable trading plans could potentially improve welfare for both insiders and ordinary investors because such a mechanism could further reduce adverse selection and enhance risk sharing.

5. Conclusion

Within a strategic rational expectations equilibrium framework, I show that permitting an informed insider to trade only pursuant to a predetermined trading plan increases welfare for both the insider and uninformed outsiders over a wide set of parametric conditions. While such a rule is generally welfare improving (provided there is a sufficient degree of information asymmetry), an alternative rule under which the insider was prohibited from terminating his planned trade would, in many circumstances, raise welfare to an even greater extent.

The model considered in this article abstracts from certain features of reality that may present opportunities for future research. For example, Muth (2009) and Veliotis (2010) argue that Rule 10b5-1 may incentivize insiders to manipulate the timing and/or content of firm disclosures so that planned trades can be executed at more favorable prices, and Shon and Veliotis (2013) find that firms with 10b5-1 sales executed shortly after earnings announcements are more likely to meet or beat earnings forecasts. While its good faith provision could potentially void the rule's protection against insider trading liability under such circumstances, an analysis of an insider's jointly determined disclosure policy and trading plan could be a worthwhile extension. Alternatively, examining an insider's optimal trading plan in a dynamic setting could be interesting, though Milian (2016) finds that in practice most Rule 10b5-1 plans are implemented over short horizons with only a handful of trades. Modeling the rule's impact on the incentive to acquire socially valuable information as in Leland (1992), for instance, is another possible extension.

Appendix A: Text of Rule 10b5-1

The relevant text of Rule 10b5-1, which is codified by 17 CFR 240.10b5-1, states:

(i) [A] person's purchase or sale is not "on the basis of" material nonpublic information if the person making the purchase or sale demonstrates that:

- (A) Before becoming aware of the information, the person had:
  - (1) Entered into a binding contract to purchase or sell the security,
  - (2) Instructed another person to purchase or sell the security for the instructing person's account, or
  - (3) Adopted a written plan for trading securities;
- (B) The contract, instruction, or plan ... :
  - (1) Specified the amount of securities to be purchased or sold and the price at which and the date on which the securities were to be purchased or sold;
  - (2) Included a written formula or algorithm, or computer program, for determining the amount of securities to be purchased or sold and the price at which and the date on which the securities were to be purchased or sold; or
  - (3) Did not permit the person to exercise any subsequent influence over how, when, or whether to effect purchases or sales; provided, in addition, that any other person who, pursuant to the contract, instruction, or plan, did exercise such influence must not have been aware of the material nonpublic information when doing so; and
- (C) The purchase or sale that occurred was pursuant to the contract, instruction, or plan. A purchase or sale is not "pursuant to a contract, instruction, or plan" if, among other things, the person who entered into the contract, instruction, or plan altered or deviated from the contract, instruction, or plan to purchase or sell securities (whether by changing the amount, price, or timing of the purchase or sale), or entered into or altered a corresponding or hedging transaction or position with respect to those securities.

(ii) [The affirmative defense] is applicable only when the contract, instruction, or plan to purchase or sell securities was given or entered into in good faith and not as part of a plan or scheme to evade the prohibitions of this section.

(iii) [Definitions]

(A) Amount. "Amount" means either a specified number of shares or other securities or a specified dollar value of securities.

(B) Price. "Price" means the market price on a particular date or a limit price, or a particular dollar price.

(C) Date. "Date" means, in the case of a market order, the specific day of the year on which the order is to be executed (or as soon thereafter as is practicable under ordinary principles of best execution). "Date" means, in the case of a limit order, a day of the year on which the limit order is in force.

Appendix B: Proofs and Expected Utilities

B.1 Outsiders' Time-1 Expected Utility under Rule 10b5-1

The outsiders' expected utility as given by (13) can be rewritten as

$$-\frac{\begin{array}{c}\dfrac{e^{-\delta\left(W_o^B+(W_o^S-S_o)P(S_i)-\frac{1}{2}(1-\gamma)\delta\varepsilon^2 S_o^2\right)}}{\sqrt{2\pi\gamma\varepsilon^2}\sqrt{2\pi(1-\gamma)\varepsilon^2\beta}}\displaystyle\int_{\underline{k}}^{\overline{k}}\int_{-\infty}^{\infty}\exp\left[-\delta S_o\tilde{y}\right]\\ \times\exp\left[-\dfrac{\tilde{y}^2}{2\gamma\varepsilon^2}\right]\exp\left[-\dfrac{\left(\frac{\tilde{y}-\tilde{k}}{(1-\gamma)\delta\varepsilon^2}\right)^2}{2\nu^2}\right]\mathrm{d}\tilde{y}\,\mathrm{d}\tilde{k}\end{array}}{\dfrac{1}{\sqrt{2\pi[\gamma+(1-\gamma)\beta]\varepsilon^2}}\displaystyle\int_{\underline{k}}^{\overline{k}}\exp\left[-\dfrac{\tilde{k}^2}{2[\gamma+(1-\gamma)\beta]\varepsilon^2}\right]\mathrm{d}\tilde{k}},$$

where the last exponential in the numerator follows from the convolution of $\tilde{w}$ and $\tilde{k}$ (see (7)). The denominator is a normalizing constant. Integrating this expression yields (14).

Proof of Theorem 1

I first derive (16) and (17). Differentiating (14) with respect to S_o yields the first-order condition that characterizes the outsiders' stock demand,

$$P(S_i)=-\delta\varepsilon^2 S_o-\frac{\gamma\varepsilon^2\left(\phi\left(\frac{\overline{k}+\gamma\delta\varepsilon^2 S_o}{\sigma}\right)-\phi\left(\frac{\underline{k}+\gamma\delta\varepsilon^2 S_o}{\sigma}\right)\right)}{\sigma\left(\Phi\left(\frac{\overline{k}+\gamma\delta\varepsilon^2 S_o}{\sigma}\right)-\Phi\left(\frac{\underline{k}+\gamma\delta\varepsilon^2 S_o}{\sigma}\right)\right)}. \tag{B1}$$

If $\bar{S}_i<W_i^S$, then, conditional on trade occurring, (6) implies that $\underline{k}=\infty$ and $\overline{k}=\frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\bar{S}_i)+P(\bar{S}_i)$. Substituting these expressions and $S_o=1-\bar{S}_i$ into (B1) gives (16). Conversely, if $\bar{S}_i>W_i^S$, then (6) implies that $\underline{k}=\frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\bar{S}_i)+P(\bar{S}_i)$ and $\overline{k}=\infty$, and substituting these expressions and $S_o=1-\bar{S}_i$ into (B1) gives (17). Next, I show that (16) and (17) each characterize a unique fixed point. Suppose $\bar{S}_i<W_i^S$. Define $\Psi\equiv\frac{\phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)}{\sigma\Phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)}$. Well-known properties of the normal distribution hazard ratio imply[26]

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[26] It is a well-known fact that $\frac{\phi(\zeta)}{1-\Phi(\zeta)}$ is an increasing convex function of ζ, $\lim_{\zeta\to-\infty}\frac{\phi(\zeta)}{1-\Phi(\zeta)}=0$, $\lim_{\zeta\to\infty}\frac{\phi(\zeta)}{1-\Phi(\zeta)}=\zeta$, and $\lim_{\zeta\to\infty}\partial\left[\frac{\phi(\zeta)}{1-\Phi(\zeta)}\right]/\partial\zeta=1$. Equivalently, $\frac{\phi(\zeta)}{\Phi(\zeta)}$ is a decreasing convex function of ζ, $\lim_{\zeta\to-\infty}\frac{\phi(\zeta)}{\Phi(\zeta)}=-\zeta$, $\lim_{\zeta\to\infty}\frac{\phi(\zeta)}{\Phi(\zeta)}=0$, and $\lim_{\zeta\to-\infty}\partial\left[\frac{\phi(\zeta)}{\Phi(\zeta)}\right]/\partial\zeta=-1$. Analogous properties apply to nonstandard normal distributions.

(i) $-\gamma\varepsilon^2\Psi$ is monotonically increasing and concave in $P(\bar{S}_i)$;

(ii) $\lim_{P(\bar{S}_i)\to-\infty} -\gamma\varepsilon^2\Psi = \frac{\gamma\varepsilon^2(P(\bar{S}_i)-\mu)}{\sigma^2}$;

(iii) $\lim_{P(\bar{S}_i)\to\infty} -\gamma\varepsilon^2\Psi = 0$; and

(iv) $\lim_{P(\bar{S}_i)\to-\infty} \frac{\partial[-\gamma\varepsilon^2\Psi]}{\partial P(\bar{S}_i)} = \frac{\gamma\varepsilon^2}{\sigma^2}$.

Then (ii) implies that the left-hand-side (LHS) of (16) is strictly less than the right-hand-side (RHS) for sufficiently low $P(\bar{S}_i)$ because $\frac{\gamma\varepsilon^2(P(\bar{S}_i)-\mu)}{\sigma^2} = \frac{\gamma(P(\bar{S}_i)+[\frac{1}{2}(1-\gamma)(W_i^S+\bar{S}_i)+\gamma(1-\bar{S}_i)]\delta\varepsilon^2)}{\gamma+(1-\gamma)^2\delta^2\varepsilon^2\nu^2} > P(\bar{S}_i)$ for sufficiently low $P(\bar{S}_i)$. Additionally, (iii) implies that the LHS of (16) is strictly greater than the RHS for sufficiently high $P(\bar{S}_i)$. Thus, there exists a fixed point characterized by (16). Furthermore, (i) and (iv) imply that the fixed point is unique because the slope of the LHS, 1, is strictly greater than the maximum slope of the RHS, $\frac{\gamma\varepsilon^2}{\sigma^2} = \frac{\gamma}{\gamma+(1-\gamma)^2\delta^2\varepsilon^2\nu^2} < 1$. Alternatively, suppose $\bar{S}_i > W_i^S$. Define $\Psi' \equiv \frac{\phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{P(\bar{S}_i)-\mu}{\sigma}\right)\right)}$. Similar to above, well-known properties of the normal distribution hazard ratio imply

(a) $\gamma\varepsilon^2\Psi'$ is monotonically increasing and convex in $P(\bar{S}_i)$;

(b) $\lim_{P(\bar{S}_i)\to-\infty} \gamma\varepsilon^2\Psi' = 0$;

(c) $\lim_{P(\bar{S}_i)\to\infty} \gamma\varepsilon^2\Psi' = \frac{\gamma\varepsilon^2(P(\bar{S}_i)-\mu)}{\sigma^2}$; and

(d) $\lim_{P(\bar{S}_i)\to\infty} \frac{\partial[\gamma\varepsilon^2\Psi']}{\partial P(\bar{S}_i)} = \frac{\gamma\varepsilon^2}{\sigma^2}$.

Then (b) implies that the LHS of (17) is strictly less than the RHS for sufficiently low $P(\bar{S}_i)$ while (c) implies that the LHS is strictly greater than the RHS for sufficiently high $P(\bar{S}_i)$, so there exists a fixed point characterized by (17). Moreover, (a) and (d) imply that the fixed point is unique for reasons analogous to those described above, where $\bar{S}_i < W_i^S$. Last, I demonstrate that $P(\bar{S}_i)$ is monotonically increasing and concave in $\bar{S}_i$ if $\bar{S}_i < W_i^S$ but that $P(\bar{S}_i)$ is monotonically increasing and convex in $\bar{S}_i$ if $\bar{S}_i > W_i^S$. Suppose $\bar{S}_i < W_i^S$. Differentiating the RHS of (16) with respect to $\bar{S}_i$ yields $\delta\varepsilon^2 + \frac{\partial[-\gamma\varepsilon^2\Psi]}{\partial\mu}\frac{\partial\mu}{\partial\bar{S}_i}$. Because $\frac{\partial[-\gamma\varepsilon^2\Psi]}{\partial\mu} < 0$ (see footnote 26), if $\frac{\partial\mu}{\partial\bar{S}_i} = \delta\varepsilon^2[\gamma - \frac{1}{2}(1-\gamma)] \le 0$ (i.e., if $\gamma \le \frac{1}{3}$), then the RHS of (16) is obviously increasing in $\bar{S}_i$. Conversely, if $\frac{\partial\mu}{\partial\bar{S}_i} > 0$, then the RHS of (16) is increasing in $\bar{S}_i$ because $-\frac{\gamma\varepsilon^2}{\sigma^2} < \frac{\partial[-\gamma\varepsilon^2\Psi]}{\partial\mu} < 0$, which implies $0 > \frac{\partial[-\gamma\varepsilon^2\Psi]}{\partial\bar{S}_i} > -\frac{\gamma\varepsilon^2}{\sigma^2}\frac{\partial\mu}{\partial\bar{S}_i} = -\frac{\gamma[\gamma-\frac{1}{2}(1-\gamma)]\delta\varepsilon^2}{\gamma+(1-\gamma)^2\delta^2\varepsilon^2\nu^2} > -\delta\varepsilon^2$ because $\frac{\gamma[\gamma-\frac{1}{2}(1-\gamma)]}{\gamma+(1-\gamma)^2\delta^2\varepsilon^2\nu^2} < 1 \Longleftrightarrow (1-\gamma)^2\delta^2\varepsilon^2\nu^2 > -\frac{3}{2}\gamma(1-\gamma)$, which is obviously satisfied. In either case, $P(\bar{S}_i)$ is increasing in $\bar{S}_i$ because the derivative of the LHS, $\frac{\partial P(\bar{S}_i)}{\partial P(\bar{S}_i)} = 1$, is greater than the derivative of the RHS, $\frac{\partial[-\delta\varepsilon^2(1-\bar{S}_i)-\gamma\varepsilon^2\Psi]}{\partial P(\bar{S}_i)} < \frac{\gamma\varepsilon^2}{\sigma^2} < 1$. Furthermore, the concavity of $-\gamma\varepsilon^2\Psi$ implies that $P(\bar{S}_i)$ must increase by a smaller amount to maintain the fixed point when $\bar{S}_i$ is larger; hence, $P(\bar{S}_i)$ is concave in $\bar{S}_i$. Alternatively, suppose $\bar{S}_i > W_i^S$. Differentiating the RHS of (17) with respect to $\bar{S}_i$ yields $\delta\varepsilon^2 + \frac{\partial[\gamma\varepsilon^2\Psi']}{\partial\mu}\frac{\partial\mu}{\partial\bar{S}_i}$. Because $-\frac{\gamma\varepsilon^2}{\sigma^2} < \frac{\partial[\gamma\varepsilon^2\Psi']}{\partial\mu} < 0$, the RHS of (17) is increasing in $\bar{S}_i$ for reasons analogous to those discussed above, where $\bar{S}_i < W_i^S$. Similarly, $P(\bar{S}_i)$ is convex in $\bar{S}_i$ due to the convexity of $\gamma\varepsilon^2\Psi'$. ■

B.2 Insider's Time-0 Expected Utility under Rule 10b5-1

The insider's expected utility at $t=0$ depends on whether he plans to sell or purchase stock at $t=1$. If the insider executes his planned trade, then his expected utility is given by

$$-\frac{\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)\bar{k}+\delta\varepsilon^2(\gamma+\beta)\bar{S}_i}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)-\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)\underline{k}+\delta\varepsilon^2(\gamma+\beta)\bar{S}_i}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)}{\sqrt{1-\delta^2\varepsilon^2\nu^2}\left(\Phi\left(\frac{\bar{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)-\Phi\left(\frac{\underline{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)\right)}$$
$$\times\exp\left[-\delta\left(W_i^B+(W_i^S-\bar{S}_i)P(\bar{S}_i)-\frac{\delta\varepsilon^2\bar{S}_i^2}{2(1-\delta^2\varepsilon^2\nu^2)}\right)\right], \tag{B2}$$

which is obtained by substituting $S_i=\bar{S}_i$ and (21) into (5) and integrating over $\tilde{k}$ and $\tilde{w}$ (recall $\underline{k}$ and $\bar{k}$ denote the respective lower and upper bounds on k as determined by (6)). If the insider does not execute his planned trade, then his expected utility is given by

$$-\frac{\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)\bar{k}+\delta\varepsilon^2(\gamma+\beta)W_i^S}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)-\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)\underline{k}+\delta\varepsilon^2(\gamma+\beta)W_i^S}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)}{\sqrt{1-\delta^2\varepsilon^2\nu^2}\left(\Phi\left(\frac{\bar{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)-\Phi\left(\frac{\underline{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)\right)}\exp\left[-\delta\left(W_i^B-\frac{\delta\varepsilon^2(W_i^S)^2}{2(1-\delta^2\varepsilon^2\nu^2)}\right)\right], \tag{B3}$$

which is obtained by substituting $S_i=W_i^S$ and (21) into (5) and integrating over $\tilde{k}$ and $\tilde{w}$. The insider's time-0 expected utility is then obtained by substituting the appropriate values for $\underline{k}$ and $\bar{k}$, which depend on whether $\bar{S}_i$ is less than or greater than W_i^S, into (B2) and (B3) and weighting the utility functions by the probability of trade occurring or not occurring. This yields

$$-\frac{\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)[P(\bar{S}_i)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2W_i^S]+\frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta)\bar{S}_i}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)}{\sqrt{1-\delta^2\varepsilon^2\nu^2}}$$
$$\times\exp\left[-\delta\left(W_i^B+(W_i^S-\bar{S}_i)P(\bar{S}_i)-\frac{\delta\varepsilon^2\bar{S}_i^2}{2(1-\delta^2\varepsilon^2\nu^2)}\right)\right]$$
$$-\frac{\left(1-\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)[P(\bar{S}_i)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2\bar{S}_i]+\frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta)W_i^S}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)\right)}{\sqrt{1-\delta^2\varepsilon^2\nu^2}}$$
$$\times\exp\left[-\delta\left(W_i^B-\frac{\delta\varepsilon^2(W_i^S)^2}{2(1-\delta^2\varepsilon^2\nu^2)}\right)\right] \tag{B4}$$

if $\bar{S}_i<W_i^S$ and

$$-\frac{\left(1-\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)[P(\bar{S}_i)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2W_i^S]+\frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta)\bar{S}_i}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)\right)}{\sqrt{1-\delta^2\varepsilon^2\nu^2}}$$
$$\times\exp\left[-\delta\left(W_i^B+(W_i^S-\bar{S}_i)P(\bar{S}_i)-\frac{\delta\varepsilon^2\bar{S}_i^2}{2(1-\delta^2\varepsilon^2\nu^2)}\right)\right]$$
$$-\frac{\Phi\left(\frac{(1-\delta^2\varepsilon^2\nu^2)[P(\bar{S}_i)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2\bar{S}_i]+\frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta)W_i^S}{\sqrt{(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\varepsilon^2}}\right)}{\sqrt{1-\delta^2\varepsilon^2\nu^2}}$$
$$\times\exp\left[-\delta\left(W_i^B-\frac{\delta\varepsilon^2(W_i^S)^2}{2(1-\delta^2\varepsilon^2\nu^2)}\right)\right] \tag{B5}$$

if $\bar{S}_i>W_i^S$.

B.3 Outsiders' Time-0 Expected Utility under Rule 10b5-1

Similar to the insider, the outsiders' expected utility at $t=0$ depends on whether the insider plans to sell or purchase stock at $t=1$. The outsiders' expected utility is given by

$$-\frac{\Phi\left(\frac{\overline{k}+\gamma\delta\varepsilon^2(1-\bar{S}_i)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)-\Phi\left(\frac{\underline{k}+\gamma\delta\varepsilon^2(1-\bar{S}_i)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)}{\Phi\left(\frac{\overline{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)-\Phi\left(\frac{\underline{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)}\exp\left[-\delta\left(W_o^B+(\bar{S}_i-W_i^S)P(\bar{S}_i)-\tfrac{1}{2}\delta\varepsilon^2(1-\bar{S}_i)^2\right)\right] \tag{B6}$$

if the insider executes his planned trade. This expression is obtained by substituting $S_o=1-\bar{S}_i$, $W_o^S=1-W_i^S$, and (21) into (13) and integrating over $\tilde{k}$ and $\tilde{w}$. If the insider does not execute his planned trade, then the outsiders' expected utility is obtained by substituting $S_o=1-W_i^S$, $W_o^S=1-W_i^S$, and (21) into (13) and integrating over $\tilde{k}$ and $\tilde{w}$, which gives

$$-\frac{\Phi\left(\frac{\overline{k}+\gamma\delta\varepsilon^2(1-W_i^S)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)-\Phi\left(\frac{\underline{k}+\gamma\delta\varepsilon^2(1-W_i^S)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)}{\Phi\left(\frac{\overline{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)-\Phi\left(\frac{\underline{k}}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)}\exp\left[-\delta\left(W_o^B-\tfrac{1}{2}\delta\varepsilon^2(1-W_i^S)^2\right)\right]. \tag{B7}$$

Then the outsiders' time-0 expected utility is obtained by substituting the appropriate values for $\underline{k}$ and $\overline{k}$ into (B6) and (B7) and weighting the utility functions by the probability of trade occurring or not occurring, which yields

$$\begin{aligned}
&-\Phi\left(\frac{P(\bar{S}_i)+\gamma\delta\varepsilon^2(1-\bar{S}_i)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\bar{S}_i)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)\\
&\quad\times\exp\left[-\delta\left(W_o^B+(\bar{S}_i-W_i^S)P(\bar{S}_i)-\tfrac{1}{2}\delta\varepsilon^2(1-\bar{S}_i)^2\right)\right]\\
&-\left(1-\Phi\left(\frac{P(\bar{S}_i)+\gamma\delta\varepsilon^2(1-W_i^S)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\bar{S}_i)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)\right)\\
&\quad\times\exp\left[-\delta\left(W_o^B-\tfrac{1}{2}\delta\varepsilon^2(1-W_i^S)^2\right)\right]
\end{aligned} \tag{B8}$$

if $\bar{S}_i<W_i^S$ and

$$\begin{aligned}
&-\left(1-\Phi\left(\frac{P(\bar{S}_i)+\gamma\delta\varepsilon^2(1-\bar{S}_i)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\bar{S}_i)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)\right)\\
&\quad\times\exp\left[-\delta\left(W_o^B+(\bar{S}_i-W_i^S)P(\bar{S}_i)-\tfrac{1}{2}\delta\varepsilon^2(1-\bar{S}_i)^2\right)\right]\\
&-\Phi\left(\frac{P(\bar{S}_i)+\gamma\delta\varepsilon^2(1-W_i^S)+\frac{1}{2}(1-\gamma)\delta\varepsilon^2(W_i^S+\bar{S}_i)}{\sqrt{[\gamma+(1-\gamma)\beta]\varepsilon^2}}\right)\\
&\quad\times\exp\left[-\delta\left(W_o^B-\tfrac{1}{2}\delta\varepsilon^2(1-W_i^S)^2\right)\right]
\end{aligned} \tag{B9}$$

if $\bar{S}_i>W_i^S$.

Proof of Theorem 2

Differentiating (B4) and (B5) with respect to $\bar{S}_i$ yields first-order conditions that characterize the insider's optimal trading plan, conditional on either planning to sell or planning to buy. These conditions are given by (23) and (24), respectively. Suppose $\bar{S}_i<W_i^S$. Define $\bar{\Psi}\equiv\frac{2\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)}{\bar{\sigma}\Phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)}$. Because $\bar{\mu}$ is increasing in $\bar{S}_i$, it follows that (see footnote 26):

(i) $-\bar{\Psi}$ is monotonically increasing and concave in $\bar{S}_i$;

(ii) $\lim_{\bar{S}_i \to -\infty} -\bar{\Psi} = \frac{1}{2}\delta\varepsilon^2[(1+\gamma+\beta)\bar{S}_i + (1-\gamma)(1-\delta^2\varepsilon^2\nu^2)W_i^S] + (1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)$;

(iii) $\lim_{\bar{S}_i \to \infty} -\bar{\Psi} = 0$; and

(iv) $\lim_{\bar{S}_i \to -\infty} \frac{\partial[-\bar{\Psi}]}{\partial \bar{S}_i} = \frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta) + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}$.

Then (ii) implies

$$\lim_{\bar{S}_i \to -\infty} \frac{(1-\delta^2\varepsilon^2\nu^2)(W_i^S \frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} - P(\bar{S}_i)) - \bar{\Psi}}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}} = \frac{(1-\delta^2\varepsilon^2\nu^2)[\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} + \frac{1}{2}\delta\varepsilon^2(1-\gamma)]W_i^S + \frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta)\bar{S}_i}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}} > \bar{S}_i$$

as $\bar{S}_i \to -\infty$ because $\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} > 0$ (Theorem 1) and $\frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta) < \delta^2\varepsilon^2$ given $\nu^2 < \frac{1}{\delta^2\varepsilon^2}$, so the LHS of (23) is strictly less than the RHS for sufficiently small $\bar{S}_i$. Moreover, the LHS is strictly greater than the RHS for $\bar{S}_i = W_i^S$ (note that $\bar{S}_i$ is bounded from above by W_i^S if the insider plans to sell), as substituting $\bar{S}_i = W_i^S$ allows the RHS of (23) to be rewritten

$$\begin{aligned}
&\frac{(1-\delta^2\varepsilon^2\nu^2)\left(W_i^S \frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} - P(\bar{S}_i)\right)}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}} \\
&\quad - \frac{2\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\phi\left(\frac{2[\delta\varepsilon^2 W_i^S + (1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)]}{\sqrt{4\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)}}\right)}{\left[\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}\right]\sqrt{4\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)}\,\Phi\left(\frac{2[\delta\varepsilon^2 W_i^S + (1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)]}{\sqrt{4\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)}}\right)} \\
&\quad < \frac{(1-\delta^2\varepsilon^2\nu^2)\left(W_i^S \frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} - P(\bar{S}_i)\right)}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}} + \frac{\delta\varepsilon^2 W_i^S + (1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}} \\
&\quad = W_i^S,
\end{aligned}$$

where the inequality follows from the fact that $-\frac{\phi(\zeta)}{\Phi(\zeta)} < \zeta$ for finite ζ and the equality follows from algebra. Hence, there exists a fixed point characterized by (23). The fixed point is unique because the slope of the LHS, 1, is greater than the maximum slope of the RHS, $\frac{\delta\varepsilon^2[1+\gamma+(1-\gamma)\delta^2\varepsilon^2\nu^2]}{2\left[\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}\right]}\left(1 + \frac{(W_i^S - \bar{S}_i)(1-\delta^2\varepsilon^2\nu^2)\frac{\partial^2 P(\bar{S}_i)}{\partial \bar{S}_i^2}}{\delta\varepsilon^2 + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}}\right) < 1$, given that $\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i} > 0$, $\frac{\partial^2 P(\bar{S}_i)}{\partial \bar{S}_i^2} < 0$ (Theorem 1), and $\nu^2 < \frac{1}{\delta^2\varepsilon^2}$.

Alternatively, suppose $\bar{S}_i > W_i^S$. Define $\bar{\Psi}' \equiv \frac{2\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)}{\bar{\sigma}\left(1-\Phi\left(\frac{\bar{\mu}}{\bar{\sigma}}\right)\right)}$. Similar to above, because $\bar{\mu}$ is increasing in $\bar{S}_i$, it follows that

(a) $\bar{\Psi}'$ is monotonically increasing and convex in $\bar{S}_i$;

(b) $\lim_{\bar{S}_i \to -\infty} \bar{\Psi}' = 0$;

(c) $\lim_{\bar{S}_i \to \infty} \bar{\Psi}' = \frac{1}{2}\delta\varepsilon^2[(1+\gamma+\beta)\bar{S}_i + (1-\gamma)(1-\delta^2\varepsilon^2\nu^2)W_i^S] + (1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)$; and

(d) $\lim_{\bar{S}_i \to \infty} \frac{\partial \bar{\Psi}'}{\partial \bar{S}_i} = \frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta) + (1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}$.

Then (c) implies

$$\lim_{\bar{S}_i\to\infty}\frac{(1-\delta^2\varepsilon^2\nu^2)(W_i^S\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}-P(\bar{S}_i))+\bar{\Psi}'}{\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}}=\frac{(1-\delta^2\varepsilon^2\nu^2)[\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}+\frac{1}{2}\delta\varepsilon^2(1-\gamma)]W_i^S+\frac{1}{2}\delta\varepsilon^2(1+\gamma+\beta)\bar{S}_i}{\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}}<\bar{S}_i$$

as $\bar{S}_i\to\infty$, so the LHS of (24) is strictly greater than the RHS for sufficiently large $\bar{S}_i$. Additionally, the LHS is strictly less than the RHS for $\bar{S}_i=W_i^S$ (note that $\bar{S}_i$ is bounded from below by W_i^S if the insider plans to buy), as substituting $\bar{S}_i=W_i^S$ allows the RHS of (24) to be rewritten

$$\frac{(1-\delta^2\varepsilon^2\nu^2)\big(W_i^S\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}-P(\bar{S}_i)\big)}{\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}}$$

$$+\frac{2\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\phi\Big(\frac{2[\delta\varepsilon^2W_i^S+(1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)]}{\sqrt{4\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)}}\Big)}{\big[\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}\big]\sqrt{4\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)}\Big(1-\Phi\Big(\frac{2[\delta\varepsilon^2W_i^S+(1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)]}{\sqrt{4\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)}}\Big)\Big)}$$

$$>\frac{(1-\delta^2\varepsilon^2\nu^2)\big(W_i^S\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}-P(\bar{S}_i)\big)}{\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}}+\frac{\delta\varepsilon^2W_i^S+(1-\delta^2\varepsilon^2\nu^2)P(\bar{S}_i)}{\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}}$$

$$=W_i^S,$$

where the inequality follows from the fact that $\frac{\phi(\zeta)}{1-\Phi(\zeta)}>\zeta$ for finite ζ and the equality follows from algebra. Thus, there exists a fixed point characterized by (24), and the fixed point is unique because the slope of the LHS, 1, is greater than the maximum slope of the RHS, $\frac{\delta\varepsilon^2[1+\gamma+(1-\gamma)\delta^2\varepsilon^2\nu^2]}{2\big[\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}\big]}\Bigg(1-\frac{(\bar{S}_i-W_i^S)(1-\delta^2\varepsilon^2\nu^2)\frac{\partial^2 P(\bar{S}_i)}{\partial \bar{S}_i^2}}{\delta\varepsilon^2+(1-\delta^2\varepsilon^2\nu^2)\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}}\Bigg)<1$, given that $\frac{\partial P(\bar{S}_i)}{\partial \bar{S}_i}>0$, $\frac{\partial^2 P(\bar{S}_i)}{\partial \bar{S}_i^2}>0$ (Theorem 1) and $\nu^2<\frac{1}{\delta^2\varepsilon^2}$. ■

B.4 Expressions for Equilibrium Constants without Rule 10b5-1

$$\eta_1=-\frac{\gamma+\beta}{(1-\gamma)\delta\nu^2}-\frac{\gamma(2\gamma+\beta)W_i^S}{(1-\gamma)\delta\nu^2[(1-\gamma)\beta-\gamma]}\tag{B10}$$

$$\eta_2=\frac{(1-\gamma)\delta\varepsilon^2(2\gamma+\beta)}{(1-\gamma)\beta-\gamma}\tag{B11}$$

$$\psi_1=\frac{\eta_2W_i^S-\eta_1}{(1-\gamma)\delta\varepsilon^2+2\eta_2}\tag{B12}$$

$$\psi_2=\frac{1}{(1-\gamma)\delta\varepsilon^2+2\eta_2}\tag{B13}$$

$$\alpha_1=\frac{(1-\gamma)\delta\varepsilon^2\eta_1+(\eta_1+\eta_2W_i^S)\eta_2}{(1-\gamma)\delta\varepsilon^2+2\eta_2}\tag{B14}$$

$$\alpha_2=\frac{\eta_2}{(1-\gamma)\delta\varepsilon^2+2\eta_2}\tag{B15}$$

$$\alpha_1' = -\frac{(1-\gamma)\delta\varepsilon^2(\gamma+\beta)[\eta_1+(2-W_i^S)\eta_2+(1-\gamma)\delta\varepsilon^2]}{[\gamma+(1-\gamma)\beta][(1-\gamma)\delta\varepsilon^2+2\eta_2]} \tag{B16}$$

$$\alpha_2' = \frac{(1-\gamma)\delta\varepsilon^2(2\gamma+\beta)+2\gamma\eta_2}{[\gamma+(1-\gamma)\beta][(1-\gamma)\delta\varepsilon^2+2\eta_2]}. \tag{B17}$$

B.5 Insider's Time-0 Expected Utility without Rule 10b5-1

The insider's time-0 expected utility is derived by substituting (1), (28), (29), (37), and (38) into (27) and integrating over $\tilde{w}$, $\tilde{y}$, and $\tilde{z}$, which yields

$$\begin{aligned} &-\sqrt{\frac{(1-\gamma)[(3-\gamma)\beta+3\gamma]^2}{(2\beta-3+4\gamma)(\gamma+\beta)+\gamma\beta}}\exp\Bigg[-\delta W_i^B \\ &\quad+\frac{[\gamma-(1-\gamma)\beta](\gamma+\beta)\big[2[(2-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)-\gamma\delta^2\varepsilon^2\nu^2]W_i^S-(1-\delta^2\varepsilon^2\nu^2)(\gamma+\beta)\big]}{2\beta(1-\gamma)\nu^2[(2\beta-3+4\gamma)(\gamma+\beta)+\gamma\beta]} \\ &\quad+\frac{\big([4\gamma(\gamma-\gamma^2\delta^2\varepsilon^2\nu^2+\beta^2)-\beta^2](\gamma+\beta)-(\gamma^2\delta^2\varepsilon^2\nu^2-\beta^2)\beta^2\big)(W_i^S)^2}{2\beta(1-\gamma)\nu^2[(2\beta-3+4\gamma)(\gamma+\beta)+\gamma\beta]}\Bigg]. \end{aligned} \tag{B18}$$

B.6 Outsiders' Time-0 Expected Utility without Rule 10b5-1

The outsiders' time-0 expected utility is derived by substituting (1), (33), (34), (37), and (39) into (32) and integrating over $\tilde{w}$, $\tilde{y}$, and $\tilde{z}$, which yields

$$\begin{aligned} &-\sqrt{\frac{(1-\gamma)[(3-\gamma)\beta+3\gamma]^2}{[\gamma+(1-\gamma)\beta][9(1-\gamma)(\gamma+\beta)+(\gamma+\beta)^2-\gamma\beta(1+\beta)]}} \\ &\quad\times\exp\Bigg[-\delta W_o^B-\frac{(\gamma+\beta)[(1-\gamma)\beta-\gamma]^2(1-4W_o^S)}{2(1-\gamma)\nu^2\beta[9(1-\gamma)(\gamma+\beta)+(\gamma+\beta)^2-\gamma\beta(1+\beta)]} \\ &\quad+\frac{\big[4\gamma^2[\gamma-\beta(1-2\gamma)+(2+\gamma)\beta^2+\beta^3]-5\beta^3-13\gamma\beta^2-(1-\gamma)\beta^4\big](W_o^S)^2}{2(1-\gamma)\nu^2\beta[9(1-\gamma)(\gamma+\beta)+(\gamma+\beta)^2-\gamma\beta(1+\beta)]}\Bigg]. \end{aligned} \tag{B19}$$

Proof of Corollary 1

When the insider may trade without a predetermined trading plan, simply inverting the variance in (8) yields (47). The remainder of the proof focuses on the case in which the insider may trade only pursuant to a predetermined plan. Outsiders may observe one of two possible signals under Rule 10b5-1: either $k<\Delta$ or $k>\Delta$. Outsiders observe the former signal if the insider either executes a planned sale or cancels a planned purchase; they observe the latter signal if he either executes a planned purchase or cancels a planned sale. Suppose $k<\Delta$. Then

$$\mathbb{E}[\tilde{y}|k<\Delta]=\frac{1}{\sigma\Phi\left(\frac{\Delta}{\sigma}\right)}\int_{-\infty}^{\Delta}\frac{\gamma\tilde{k}\phi\left(\frac{\tilde{k}}{\sigma}\right)}{\gamma+(1-\gamma)\beta}\,\mathrm{d}\tilde{k}=-\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\Phi\left(\frac{\Delta}{\sigma}\right)}$$

and

$$\begin{aligned} \mathbb{V}[\tilde{y}|k<\Delta]&=\frac{1}{\sqrt{\gamma}\varepsilon\nu}\int_{-\infty}^{\Delta}\int_{-\infty}^{\infty}\left(\tilde{k}+(1-\gamma)\delta\varepsilon^2\tilde{w}+\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\Phi\left(\frac{\Delta}{\sigma}\right)}\right)^2\phi\left(\frac{\tilde{k}+(1-\gamma)\delta\varepsilon^2\tilde{w}}{\sqrt{\gamma}\varepsilon}\right)\phi\left(\frac{\tilde{w}}{\nu}\right)\mathrm{d}\tilde{w}\,\mathrm{d}\tilde{k} \\ &=\gamma\varepsilon^2-\frac{\gamma\varepsilon^2\Delta}{\sigma^2}\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\Phi\left(\frac{\Delta}{\sigma}\right)}-\left(\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\Phi\left(\frac{\Delta}{\sigma}\right)}\right)^2. \end{aligned} \tag{B20}$$

Alternatively, suppose $k>\Delta$. Then

$$\mathbb{E}[\tilde{y}|k>\Delta]=\frac{1}{\sigma\left(1-\Phi\left(\frac{\Delta}{\sigma}\right)\right)}\int_{-\infty}^{\Delta}\frac{\gamma\tilde{k}\phi\left(\frac{\tilde{k}}{\sigma}\right)}{\gamma+(1-\gamma)\beta}\,\mathrm{d}\tilde{k}=\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{\Delta}{\sigma}\right)\right)}$$

and

$$\mathbb{V}[\tilde{y}|k>\Delta]=\frac{1}{\sqrt{\gamma}\varepsilon\nu}\int_{-\infty}^{\Delta}\int_{-\infty}^{\infty}\left(\tilde{k}+(1-\gamma)\delta\varepsilon^2\tilde{w}-\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{\Delta}{\sigma}\right)\right)}\right)^2\phi\left(\frac{\tilde{k}+(1-\gamma)\delta\varepsilon^2\tilde{w}}{\sqrt{\gamma}\varepsilon}\right)\phi\left(\frac{\tilde{w}}{\nu}\right)\mathrm{d}\tilde{w}\,\mathrm{d}\tilde{k}$$

$$=\gamma\varepsilon^2+\frac{\gamma\varepsilon^2\Delta}{\sigma^2}\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{\Delta}{\sigma}\right)\right)}-\left(\frac{\gamma\varepsilon^2\phi\left(\frac{\Delta}{\sigma}\right)}{\sigma\left(1-\Phi\left(\frac{\Delta}{\sigma}\right)\right)}\right)^2. \tag{B21}$$

Weighting the inverses of (B20) and (B21) by $\Phi\left(\frac{\Delta}{\sigma}\right)$ and $1-\Phi\left(\frac{\Delta}{\sigma}\right)$, respectively, yields (45). ■

Appendix C: Noncancellable Trading Plan

I conjecture (and verify) a stock price that is a linear function of the insider's stock allocation,

$$P^*(\bar{S}_i^*)=\eta_1^*+\eta_2^*\bar{S}_i^*, \tag{C1}$$

where η_1^* and η_2^* are constants. The insider's objective is to select a trading plan $\bar{S}^*\in\mathbb{R}$ to maximize his expected utility from consumption C_i^* subject to a budget constraint:

$$\max_{\bar{S}_i^*\in\mathbb{R}}\quad \mathbb{E}\left[-\exp[-\delta\tilde{C}_i^*]\right] \tag{C2}$$

$$\text{s.t.}\quad \tilde{C}_i^*=B_i^*+(\bar{S}_i^*+\tilde{w})\tilde{x} \tag{C3}$$

$$B_i^*=W_i^B+(W_i^S-\bar{S}_i^*)P^*(\bar{S}_i^*). \tag{C4}$$

Substituting (1), (C1), (C3), and (C4) into (C2), integrating over $\tilde{w}$, $\tilde{y}$, and $\tilde{z}$, differentiating with respect to S_i^*, and solving the first-order condition gives the insider's stock demand,

$$\bar{S}_i^*=\frac{(1-\delta^2\varepsilon^2\nu^2)(\eta_2^*W_i^S-\eta_1^*)}{\delta\varepsilon^2+2(1-\delta^2\varepsilon^2\nu^2)\eta_2^*}. \tag{C5}$$

Then substituting (C5) into (C1) provides an expression for the stock price,

$$P^*=\eta_1^*-\frac{(1-\delta^2\varepsilon^2\nu^2)\eta_1^*\eta_2^*}{\delta\varepsilon^2+2(1-\delta^2\varepsilon^2\nu^2)\eta_2^*}+\frac{(1-\delta^2\varepsilon^2\nu^2)(\eta_2^*)^2W_i^S}{\delta\varepsilon^2+2(1-\delta^2\varepsilon^2\nu^2)\eta_2^*}. \tag{C6}$$

Outsiders need not make any inferences when the insider trades pursuant to a noncancellable trading plan. The outsiders' objective is to maximize their expected utility from consumption C_o^* by choosing a stock allocation $S_o^*\in\mathbb{R}$ subject to a budget constraint:

$$\max_{S_o^*\in\mathbb{R}}\quad \mathbb{E}\left[-\exp[-\delta\tilde{C}_o^*]\right] \tag{C7}$$

$$\text{s.t.}\quad \tilde{C}_o^*=B_o^*+S_o^*\tilde{x} \tag{C8}$$

$$B_o^*=W_o^B+(W_o^S-S_o^*)P^*. \tag{C9}$$

Substituting (1), (C8), and (C9) into (C7), integrating over $\tilde{y}$ and $\tilde{z}$, differentiating with respect to S_o^*, and solving the first-order condition yields the outsiders' stock demand,

$$S_o^*=-\frac{P^*}{\delta\varepsilon^2}. \tag{C10}$$

Imposing the market-clearing condition generates another expression for the stock price,

$$P^*=-\delta\varepsilon^2-\frac{\delta\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)\eta_1^*}{\delta\varepsilon^2+2(1-\delta^2\varepsilon^2\nu^2)\eta_2^*}+\frac{\delta\varepsilon^2(1-\delta^2\varepsilon^2\nu^2)\eta_2^*W_i^S}{\delta\varepsilon^2+2(1-\delta^2\varepsilon^2\nu^2)\eta_2^*}. \tag{C11}$$

Next, setting the coefficients in (C6) and (C11) equal to one another and solving the system of equations yields expressions for the stock price and allocations in terms of the underlying parameters. These expressions are reported by (48), (49), and (50) in Theorem 4. The insider's and outsiders' time-0 expected utilities, which are given by

$$-\frac{1}{\sqrt{1-\delta^2\varepsilon^2\nu^2}}\exp\left[-\delta\left(W_i^B+\frac{\delta\varepsilon^2[(1-\delta^2\varepsilon^2\nu^2)(1+(W_i^S)^2)-2(2-\delta^2\varepsilon^2\nu^2)W_i^S}{2[3-2\delta^2\varepsilon^2\nu^2]}\right)\right] \tag{C12}$$

and

$$-\exp\left[-\delta\left(W_o^B+\frac{\delta\varepsilon^2[1-2(2-\delta^2\varepsilon^2\nu^2)W_o^S-(1-\delta^2\varepsilon^2\nu^2)(5-3\delta^2\varepsilon^2\nu^2)(W_o^S)^2]}{2[3-2\delta^2\varepsilon^2\nu^2]^2}\right)\right], \tag{C13}$$

respectively, are obtained by substituting (48), (49), and (50) into the appropriate objective functions and integrating over $\tilde{w}$, $\tilde{y}$, and $\tilde{z}$.

Appendix D: Autarky

The insider and outsiders do not trade but hold their initial stock and bond endowments instead. Substituting (1), (3), (4), and $S_i = W_i^S$ into (2) and integrating over $\tilde{w}$, $\tilde{x}$, and $\tilde{y}$ gives the insider's ex ante expected utility:

$$-\frac{1}{\sqrt{1-\delta^2\varepsilon^2\nu^2}}\exp\left[-\delta\left(W_i^B-\frac{\delta\varepsilon^2(W_i^S)^2}{2(1-\delta^2\varepsilon^2\nu^2)}\right)\right]. \tag{D1}$$

Similarly, substituting (1), (11), (12), and $S_o = W_o^S$ into (10) and integrating over $\tilde{x}$ and $\tilde{y}$ gives the outsiders' ex ante expected utility:

$$-\exp\left[-\delta\left(W_o^B-\tfrac{1}{2}\delta\varepsilon^2(W_o^S)^2\right)\right]. \tag{D2}$$

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