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Abstract

We develop a model of government intervention with information disclosure in which the government with two private signals trades against other market participants to stabilize the financial markets. The government trades optimally based more on the price target than the noisy signal about the fundamentals. Information disclosure harms financial stability by deteriorating the information advantages of the government. Releasing the price target diminishes noises in financial markets and decreases market liquidity, while releasing the fundamental signal reduces private information in financial markets and improves market liquidity; and the tradeoffs of releasing both signals depend on its policy weights. Releasing the fundamental signal raises price efficiency effectively, while releasing the price target has subtle effects on price efficiency. Under different scenarios of information disclosure, there exist tradeoffs between financial stability and price efficiency.

Keywords: government intervention; information disclosure; financial stability; price efficiency; market liquidity

JEL Classifications: D8, G1

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1 Introduction

Government intervention through direct trading is becoming a common way to stabilize the financial markets, especially during a financial crisis or a stock-market meltdown. For example, in August 1998, at the peak of Asian economic crisis, the Hong Kong government spent HK$118 billion and purchased shares of 33 constituent stocks of Hang Seng index (HS) to stabilize the stock market; during China's stock market turmoil in 2015-2016, the Chinese government organized a "national team" of securities firms to intervene the stock market directly; to combat the financial crisis of 2008-2009 and COVID-19 pandemic in 2020 and their aftermath, the Federal Reserve of America (FR), European Central Bank (ECB), Bank of Japan (BOJ) and other central banks purchased large quantities of government securities, mortgage-backed securies, corporate bonds and equities; from 2002 through 2018, the Bank of Japan constantly purchased Japanese stocks through the purchases of Exchange-Traded Funds (ETFs) to stabilize the financial markets and stimulate the economy.[1] Even though the motives and consequences of these trades continue to be intensely debated, how information disclosure affects the effectiveness of government intervention has received much less attention.

In this article, we develop a market microstructure model of government intervention where a large player, the government, has two types of information: the price target signal and a noisy signal about the fundamentals. The government owning two private signals are identified as the important features of direct government intervention in financial markets in the literature.[2] Should the government reveal its own information publicly? This issue had been hotly debated in relation to regulatory stress tests of financial institutions. In particular, there are different views on whether the results of such stress tests should be publicly disclosed (see Goldstein and Sapra (2013) for a survey). Our model discusses this debate by addressing the following

[1] Cheng, Fung, and Chan (2000) and Su, Yip and Wong (2002) study the Hong Kong government intervention during the 1998 Asian financial crisis. Huang, Miao and Wang (2019) and Allen et al. (2020) examine the Chinese government intervention in the 2015-2016 stock market turmoil. Yang and Zhu (2021) and Caballero and Simsek (2021) review briefly the large asset purchases conducted by major central banks during the 2008-2009 financial crisis and COVID-19 pandemic, respectively. Shirai (2018a, 2018b), Barbon and Gianinazzi (2019), and Charoenwong et al. (2021) review the stock purchases through exhange-traded funds (ETF) conducted by the Bank of Japan.

[2] The literature identifies several recurring features of direct government intervention in financial markets (e.g., Edison, 1993; Vitale, 1999; Sarno and Taylor, 2001; Neely, 2005; Engel, 2014; Pasquariello (2017); Pasquariello, Roush and Vega, 2020): (1) governments tend to pursue nonpublic price targets in those markets; (2) governments often intervene in secret in the targeted markets; (3) governments are likely to have an information advantage over most market participants about the fundamentals of the traded assets; (4) the observed ex post effectiveness of government intervention is often attibuted to that information advantage; (5) those price targets may be related to governments' fundamental information; (6) governments are sensitive to the potential costs of their interventions.

question: Is disclosure of information to the market desirable when the government is trying to stabilize the financial markets? For this purpose, we formulate four scenarios of information disclosure and examine how each of them affects the effectiveness of government intervention, especially for financial stability and market quality.

In the baseline model without information disclosure, we introduce a stylized government with private information into the standard Kyle (1985) setting. The insider trades on his precise information about the fundamental to maximize his profits. The government cares about both financial stability and cost of intervention and trades against the insider based on its private signals. The noise traders have no private information and provide exogenous randomness to the financial markets. The market maker clears the market and prices the risky asset using the weak rule of market efficiency. In equilibrium, we find that: (i) The government trades based more on the price target signal than on the fundamental signal and the trading intensity in the price target (the fundamental signal) increases (decreases) in its policy weight. The insider always buys on his precise information about the fundamental and earns profits in financial markets. (ii) The government's direct trading injects new noises in financial markets and improves market liquidity unambiguously. (iii) Whenever the government cares about its policy goals, government intervention stabilizes the financial markets effectively. (iv) Government's direct trading affects price efficiency positively through its fundamental signal and negatively through the price target signal, and the net effects hinge on two important parameters: ρ and ϕ. Furthermore, if the government's two signals are weakly correlated, then there exist potential tradeoffs between financial stability and price efficiency.

In the extended models, we formulate three scenarios of information disclosure: releasing the price target, releasing the fundamental signal and releasing both signals, and explore how information disclosure affects the effectiveness of government intervention. By comparing market performances of government intervention under these different scenarios about information disclosure, we find that different policies on information disclosure have diverse effects on financial stability and market quality. First of all, information disclosure deteriorates the government's information advantage and harms financial stability unambiguously. For financial stability, releasing both signals is the worst one while no information release is the best one. Releasing the price target is worse than releasing the fundamental signal for most cases, since the price target is more related to price stability. Secondly, releasing the price target diminishes the noises in financial markets and hence decreases market liquidity, while releasing the nosiy signal about the fundamentals reduces private information in financial markets and hence raises market liquidity. Releasing the fundamental signal is the best policy for market liquidity and releasing the price target is the worst one. The comparisons between releasing both signals and no disclosure hinge on the policy weight of the government: if the government puts an equal weight on its policy goal and the cost of intervention, then the positive effect of releasing the fundamental signal dominates and releasing both signals is the better policy; conversely, if the government cares more about its policy goal, then the negative effect of releasing the price target dominates and no information disclosure is better. Thirdly, releasing the fundamental signal raises price efficiency effectively, while releasing the price target has complex and ambiguous effects on price efficiency and its net effects may be small. Once the fundamental information is released, the marginal effect of releasing the price target is trivial. Finally, under different scenarios of government intervention with information disclosure, there exist potential tradeoffs between financial stability and price efficiency.

Our paper contributes to the literature on the financial market implications of government intervention. Three theoretical papers are closest to ours. Pasquariello, Roush, and Vega (2020) find that government intervention improves market liquidity of the financial markets in a static Kyle setting. Brunnermeier et al. (2022) develop a noisy rational expectations model and show that by leaning against noise traders, government intervention improves financial stability but does harm to price efficiency. Huang et al. (2022) construct a two-period Kyle model with an informed government and show that the government trades against the insider trading and improves financial stability and price efficiency simultanuously. The common feature of these three papers is that the government intervenes the financial markets through direct trading. However, they do not discuss how information disclosure affects the effectiveness of government intervention. In our model, we formulate three different scenarios of information disclosure and investigate how the disclosure of information affects financial stability and market quality in the financial markets.

Some theorists examine the real effects of government intervention through other policy tools. For examples, Subrahmanyam (1994) and Chen, Petukhov, and Wang (2018) show that circuit breakers increase price volatility and exacerbate price movements. Bond and Goldstein (2015) study how government intervention through cash injections or other interventions affect information aggregation by prices; Cong, Grenadier, and Hu (2020) explore information externalities of government intervention through direct liquidity injections in money market issues;

Yang and Zhu (2021) illustrate that predictable central bank interventions by adjusting the interest rates or purchasing assets interact with strategic trading and produce a V-shaped price pattern around central bank interventions.

Some empirical papers examine the effects of government intervention on the financial markets. Cheng, Fung, and Chan (2000) and Su, Yip and Wong (2002) study the implications of the intervention of the Hong Kong government during the 1998 Asian financial crisis. Pasquariello (2007) explores the impact of Central Bank interventions on the process of price formation in the U.S. foreign exchange market. Veronesi and Zingles (2010) analyze the costs and benefits of Paulson's plan in the United States. Pasquariello (2017) show that direct government intervention in a market may induce violations of the law of one price in other arbitrage-related markets. Shirai (2018b), Barbon and Gianinazzi (2019), and Katagiri, Shino, and Takahashi (2022) study the effects on domestic equity prices of the ETF purchase programme undertaken by the Bank of Japan. Charoenwong et al. (2021) find that the ETF purchases conducted by the Bank of Japan from January 2011 through March 2018 boosted share valuations of the affected firms, encouraged those firms to issue equity, but did not increase their capital investment. Allen et al. (2020) and Huang et al. (2019) show that government trading in China's stock market in 2015 both created value and improved liquidity. Bian et al. (2021) show that China's price limit rule led to unintended contagion across stocks during the 2015 market turmoil in China.

Our paper also contributes to the literature on multiple dimensions of information disclosure[3]. Two recent papers, by Bond and Goldstein (2015) and Goldstein and Yang (2019), point out that in the presence of multiple dimensions of information, the real-efficiency implications of disclolsure might be different depending on what dimension of information is disclosed. Bond and Goldstein (2015) establish that if the government discloses information about a variable about which speculators have some additional information, then the government learns less from prices and harms itself because the disclosed information reduces the incentives of speculators to trade on their information; if instead the government discloses information about a variable about which speculators know less than the government, then the government learns more from prices and helps itself because the disclosed information reduces the risk that speculators face and trade more. Goldstein and Yang (2019) show that if disclosure concerns a variable that the real decision maker cares to learn about, disclosure negatively affects price informativeness; if disclosure concerns a variable that real decision maker already knows much about, disclo-

[3]Goldstein and Yang (2017) offer an analytical review of information disclosure in financial markets.

sure always improves price informativeness and real efficiency. These two papers examine how disclosing different types of information affects price informativeness. Our paper complements this literature by investigating how releasing different information affects financial stability and market quality of the financial markets.

The rest of the paper is organized as follows. Section 2 provides the baseline model of government intervention without information disclosure and presents the equilibrium results. Section 3 formulates three scenarios of information disclosure and analyzes their equilibrium results. Section 4 compares market performances of government intervention under different scenarios of information disclosure and develops main results. Section 5 concludes.

2 The baseline model without information disclosure

In this section, we present a baseline model with government intervention by introducing a stylized government with private information in the static Kyle setting and examine how government intervention through informed trading affects the financial markets.

2.1 The Kyle model with government intervention

We consider an economy with one trading period. There is a single risky asset traded in the financial market. The final payoff of the risky asset v, which we refer to as the economic fundamental, follows a normal distribution with mean p_0 and variance σ_v^2.

The economy is populated by four types of traders: a risk-neutral insider (i.e., informed trader), a representative risk-neutral competitive market maker, a large government player ("national team") and noise traders. As usual, the insider submits market orders to maximize profit, noise traders provide randomness to hide the insider's private information, and the market maker sets the price. The new player is the government, and its behavior serves regulation purposes.

Specifically, the government submits a market order g to minimize the expected value of the following loss function:

$$\phi(\triangle p)^2 + c, \tag{1}$$

where the parameter $\phi \in [0, \infty)$ stands for the relative weight placed by the government on its policy motives. The first term $(\triangle p)^2$ captures the government's policy motive, "price stability". Formally, $(\triangle p)^2 \equiv (p - p_T)^2$, where p is the equilibrium price and p_T is the price target. The second component in (1), c, is the cost of intervention, which comes from the trading loss (negative of trading revenue). Specifically, we have $c = (p - v)g$, where g is the government's order flow, and $(p - v)g$ is its trading loss. The specification of the loss function (1) is similar in spirit to Stein (1989), Bhattacharya and Weller (1997), Vitale (1999), Pasquariello (2017), and Pasquariello, Roush and Vega (2020). If $\phi = 0$, the government trades just as another insider who maximizes the expected profit from trading. When $\phi > 0$, the government cares about its policy goal. The greater ϕ is, the more important is the government's policy goal (financial stability).

Similar to Kyle (1985), the insider learns the liquidity value v at the beginning of trading and places market order x. Noise traders do not receive any information, and their net demand u is normally distributed with mean zero and variance σ_u^2. The government has two private signals: a price target, $p_T \sim N\left(\bar{p}_T, \sigma_T^2\right)$ and a noisy signal about the fundamental $s = v + \varepsilon$, where $\varepsilon \sim N(0, \sigma_\varepsilon^2)$. In January 2013, the Bank of Japan (BOJ) put forward its 2% price stability target and then adopted Quantitiative and Qualitative Monetary Easing (QQE) including purchases of Japannes stocks as the main part to achieve the target. Besides, on July 5, 2015, the China Securities Regulatory Commission (CSRC) announced that the People's Bank of China (PBC) would help the China Securities Finance Corporation Limited (CSF) stabilize the stock market by providing liquidity supports through multiple ways. The two facts motivate us to introduce the price target signal in the model. On the other hand, the government usually has the first-hand economic data. In the digital age, the government can exploit low-latency economic data that are already available on Big Tech platforms, such as Amazon, Google, and the Alibaba Group. The government would use real-time economic data to assess economic fundamentals. Hence endowing the government with a fundamental signal is also suitable. We assume that the liquidation value v and the price target p_T follow a bivariate normal distribution, namely, $(v, p_T) \sim N(p_0, \bar{p}_T, \sigma_v^2, \sigma_T^2, \rho)$, and that both u and ε are independent of other random variables. Thus the government's two private signals also follow a bivariate normal random distribution, namely, $(s, p_T) \sim N(p_0, \bar{p}_T, \sigma_v^2 + \sigma_\varepsilon^2, \sigma_T^2, \rho)$.

The market maker determines the price p at which she trades the quantity to clear the market. The market maker observes the aggregate order flow $y = x + g + u$. The weak-form-efficiency pricing rule of the market maker implies that the market maker sets the price equal to the posterior expectation of v given public information as follows:

$$p = E(v|y). \tag{2}$$

2.2 Equilibrium

We characterize the equilibrium of the model economy in this subsection. We firstly define the equilibrium. A perfect Bayesian equilibrium is a collection of functions $\{x(v), g(s, p_T), p(y)\}$, that satisfies: (1) Optimization:

$$\begin{aligned} x^* &\in \arg\max_{\{x\}} E\left[(v-p)x|v\right], & (3) \\ g^* &\in \arg\min_{\{g\}} E\left[\phi(p-p_T)^2 + (p-v)g|s, p_T\right]. & (4) \end{aligned}$$

(2) Market efficiency: p is determined according to equation (2).

We are interested in a linear equilibrium in which the trading strategies and the pricing function are all linear. Formally, a linear equilibrium is defined as a perfect Bayesian equilibrium in which there exist five constants: $(\beta, \gamma, \alpha, \eta, \lambda) \in \mathbb{R}^5$, such that

$$\begin{aligned} x &= \beta(v - p_0), & (5) \\ g &= \gamma(s - p_0) + \alpha(p_T - \bar{p}_T) + \eta, & (6) \\ p &= p_0 + \lambda(y - \eta), \text{with } y = x + g + u. & (7) \end{aligned}$$

Equations (5) and (6) indicate that the insider and the government trade based on their private information, respectively.[4] The pricing equation (7) states that the price is equal to the expected value of v before trading, adjusted by the information carried by the arriving aggregated order flow. We solve a linear equilibrium of the model in Appendix A and summarize the solution in the following

Proposition 1 *A linear pure strategy equilibrium is defined by five unknowns β, γ, α, η and λ, which are characterized by five equations (26), (29)-(32), together with one SOC (25). The equation system can be changed as a polynomial of λ. To be specific, λ solves the*

[4] The linear forms are motivated by Bernhardt and Miao (2004) and Yang and Zhu (2020), who specify that the trading strategy of an informed agent is a linear function of each piece of private information.

following polynomial:

$$a_6\lambda^6 + a_5\lambda^5 + a_4\lambda^4 + a_3\lambda^3 + a_2\lambda^2 + a_1\lambda + a_0 = 0, \tag{8}$$

where the coefficients a_i's are listed in (36)-(42). All the other variables can be solved as expressions of λ as follows:

$$\begin{aligned}
\beta &= \frac{2\phi\lambda + 2 - [\delta + (1-\delta)\rho^2] - 2\phi\lambda\frac{\rho\sigma_T}{\sigma_v}}{4\phi\lambda^2 + 4\lambda - [\delta + (1-\delta)\rho^2](\lambda + 2\phi\lambda^2)}, \\
\gamma &= \frac{1 - 2\phi\lambda + (\lambda + 2\phi\lambda^2)\frac{\rho\sigma_T}{\sigma_v}\frac{\phi}{1+\phi\lambda}}{4\phi\lambda^2 + 4\lambda - [\delta + (1-\delta)\rho^2](\lambda + 2\phi\lambda^2)}\delta, \\
\alpha &= \frac{1 - 2\phi\lambda + (\lambda + 2\phi\lambda^2)\frac{\rho\sigma_T}{\sigma_v}\frac{\phi}{1+\phi\lambda}}{4\phi\lambda^2 + 4\lambda - [\delta + (1-\delta)\rho^2](\lambda + 2\phi\lambda^2)}(1-\delta)\frac{\rho\sigma_v}{\sigma_T} + \frac{\phi}{1+\phi\lambda}, \\
\eta &= 2\phi(\bar{p}_T - p_0),
\end{aligned}$$

where $\delta \equiv \frac{cov(v,s|p_T)}{var(s|p_T)} = \frac{(1-\rho^2)\sigma_v^2}{(1-\rho^2)\sigma_v^2 + \sigma_\varepsilon^2}$. Then the expected price volatility is

$$E[(p - p_T)^2] = \lambda(\beta + \gamma)\sigma_v^2 + (1 - 2\lambda\alpha)\sigma_T^2 + \lambda[\alpha - 2(\beta + \gamma)]\rho\sigma_v\sigma_T + (p_0 - \bar{p}_T)^2.$$

The measure for price discovery/efficiency is

$$var(v|p) = var(v|y) = [1 - \lambda(\beta + \gamma)]\sigma_v^2 - \lambda\alpha\rho\sigma_v\sigma_T.$$

The expected profit of the insider and expected cost of the government are, respectively,

$$\begin{aligned}
E(\pi) &= [1 - \lambda(\beta + \gamma)]\beta\sigma_v^2 - \lambda\alpha\beta\rho\sigma_v\sigma_T, \\
E(c) &= [\lambda(\beta + \gamma) - 1]\gamma\sigma_v^2 + \lambda\gamma^2\sigma_\varepsilon^2 + \lambda\alpha^2\sigma_T^2 + (\lambda\beta + 2\lambda\gamma - 1)\alpha\rho\sigma_v\sigma_T.
\end{aligned}$$

2.3 Numerical results

In this subsection we simulate the equilibrium of the benchmark model and examine how government intervention without informationn disclosure affects the financial markets. Figures 1, 2 and 3 display the numerical results.

Trading behavior. The trading intensity of the insider (β) increases in the amount of noisy trading per unit of private information (θ), for any given values of ρ and ϕ. Since the insider's objective is profit-maximization, the larger trading intensities lead to higher levels of expected profits. Thus the expected profits of the insider also increase in the amount of noisy trading per unit of private information. Since the insider has precise information about the fundamentals and cares only about profits, he always buys and earns profits in financial markets. If the government cares more about its policy goals (i.e., ϕ is larger), the insider will trade more intensively on his precise information and hence earn more profits.

The trading position of the government depends on its two private signals. As long as the government cares about its policy goals (i.e., $\phi > 0$), it will trade more on the price target signal than on the fundamental signal (i.e., $\alpha > \gamma$). Furthermore, if the government cares more about the policy goal (i.e., ϕ is larger), then its trading intensity in the price target (α) will be larger while the trading intensity in the fundamental signal (γ) will be smaller. Thus price volatility will be smaller while the government's expected costs will be larger. The intuition is that: when making intervention decisions, the government relates financial stability more with the price target signal and cost minimization more with the fundamental signal.

Market liquidity. Market liquidity is measured by the inverse of Kyle's lambda ($1/\lambda$), and a lower λ means that market is deeper and more liquid. Relative to the standard Kyle setting, government intervention increases market liquidity definitely, for any given values of ρ, ϕ and θ. Furthermore, market liquidity increases in the policy weight of the government. Intuitively, government trading injects new noises (through σ_T^2 and σ_ε^2) in financial markets and these noises play the similar roles to the noisy trading in financial markets. Thus government trading improves market liquidity unambiguously. If the government cares more about its policy goal, it will trade more aggressively on the price target and hence make the financial markets deeper.[5] The theoretical results on improved market liquidity induced by government intervention match the empirical findings of Huang, Miao and Wang (2019) and Pasquariello, Roush and Vega (2020) very well.

Price stability. If the government cares about its policy goals ($\phi > 0$), government intervention improves price stability substantially. Furthermore, price stability increases in the policy weight of the government. That is, if the government attaches more importance to its policy goals, it will achieve it more effectively by trading on its own private information. However, if the government has no policy concerns ($\phi = 0$) and its two signals have very weak correlations ($\rho = 0, 0.1$), then price will be more volatile than the standard Kyle setting. In this case, the government trades like another informed trader and makes money in financial markets. With

[5] Numerically, keeping other exogenous parameters fixed, increasing σ_T^2 raises $1/\lambda$.

less precise information than the insider, the government trades less aggressively on the noisy signal about the fundamental and makes less money than the insider. Besides, if the government has no policy concerns while its two signals have strong correlations ($\rho = 0.5$), then government intervention also stabilizes the financial markets effectively.

Price efficiency. Price aggregates all information and noises in financial markets. Government's direct trading affects price efficiency positively through its noisy signal about the fundamentals and negatively through the price target signal. Its final effects hinge on two important parameters: ρ and ϕ. Suppose that the government's two signals are uncorrelated ($\rho = 0$). Then, if the government cares more about its policy goals ($\phi = 3$), then the negative effect through the price target dominates and government intervention impairs price efficiency; however, if the government puts an equal weight on both goals or does not care about its policy goal ($\phi = 0$ or 1), then the positive effect through its fundamental signal dominates and government intervention improves price efficiency. When the government's two signals are correlated ($\rho = 0.1, 0.5$), the positive effect through the price target always dominates and government intervention improves price efficiency definitely.

On the other hand, the correlation between two signals of the government determines how price efficiency changes in the policy weight of the government. If the two signals of the government have weak correlations ($\rho = 0, 0.1$), then price efficiency decreases in the policy weight of the government; conversely, if the two signals have strong correlations ($\rho = 0.5$), then price efficiency increases in the policy weight of the government.

Besides, there exist potential tradeoffs between financial stability and price efficiency. If the government's two signals are highly correlated ($\rho = 0.5$), both price stability and price efficiency increase in the policy weight of the government. In other words, if two signals of the government correlate highly, government intervention improves both price stability and price efficiency simultaneously, similar to the results of Huang et al. (2022). However, if the two signals are weakly correlated ($\rho = 0$ or 0.1), price stability increases while price efficiency decreases in the policy weight of the government, which displays that there are tradeoffs between price stability and price efficiency. Brunnermeier, Sockin and Xiong (2022) derive the tradeoffs between financial stability and price efficiency in a different theoretical framework.

[Insert Figure 1, 2, and 3 here.]

3 Government intervention with information disclosure

Now we begin to examine whether information disclosure is helpful for government intervention or not. Since the government has two private signals, we investigate three special cases: releasing the price target $\{p_T\}$, releasing the noisy signal about the fundamentals $\{s\}$ and releasing both signals $\{p_T, s\}$, respectively. Information disclosure changes the information structure of the financial markets and hence affects the performance of government intervention. In this section we formulate three different disclosure scenarios, present their equilibrium results and bring forward basic features of each scenario. We simulate these three cases and compare their different performances in the next section. We summarize the information structures of three scenarios in the following Table 1:

	Insider's information	MM's information	government's information
Benchmark	$\{v\}$	$\{y\}$	$\{p_T, s\}$
Release p_T	$\{v, p_T\}$	$\{y, p_T\}$	$\{p_T, s\}$
Release s	$\{v, s\}$	$\{y, s\}$	$\{p_T, s\}$
Release p_T, s	$\{v, p_T, s\}$	$\{y, p_T, s\}$	$\{p_T, s\}$

3.1 Releasing the price target $\{p_T\}$

In this case we assume that the government releases the realizations of the price target signal before trading. With the enlarged information set $\{v, p_T\}$, the insider's maximization problem is changed as

$$\max_{\{x\}} E[(v-p)x|v, p_T]. \tag{9}$$

Meanwhile, the market maker also sees the signal released by the government, $\{p_T\}$, and uses her new information set $\{y, p_T\}$ to update the conditional expectations about the fundamentals. Thus the pricing rule of market efficiency is transformed into

$$p = E(v|y, p_T). \tag{10}$$

Conjecture the decision rules for the insider and the government and the pricing rule for the market maker as follows

$$x = \beta_T(v-p_0) + \xi_T(p_T - \bar{p}_T), \tag{11}$$

$$g = \gamma_T(s-p_0) + \alpha_T(p_T - \bar{p}_T) + \eta_T, \tag{12}$$

$$p = p_0 + \frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + \lambda_T[y - E(y|p_T)], \text{ with } y = x+g+u, \tag{13}$$

where

$$E(y|p_T) = [(\beta_T + \gamma_T)\frac{\rho\sigma_v}{\sigma_T} + \xi_T + \alpha_T](p_T - \bar{p}_T) + \eta_T.$$

We solve the model in Appendix B and summarize the equilibrium in the following

Proposition 2 *If the government releases the price target signal* $\{p_T\}$*, then a linear equilibrium is defined by six unknowns* $(\beta_T, \xi_T, \gamma_T, \alpha_T, \eta_T, \lambda_T) \in R^6$*, which are characterized by six equations (44)-(49), together with the SOC,* $\lambda_T > 0$*. The equation system can be solved as the following fourth-order polynomial of* λ_T*:*

$$\left(\begin{array}{c} \phi^2(4-2\delta)^2\sigma_u^2\lambda_T^4 + 4\phi(2-\delta)(4-\delta)\sigma_u^2\lambda_T^3 + \\ [(4-\delta)^2\sigma_u^2 + 4\phi^2\delta^2\sigma_\varepsilon^2 - 4\phi^2(1-\delta)(1-\rho^2)\sigma_v^2]\lambda_T^2 - \\ [4\phi\delta^2\sigma_\varepsilon^2 + (8+2\delta^2-6\delta)\phi(1-\rho^2)\sigma_v^2]\lambda_T + \delta^2\sigma_\varepsilon^2 + 2(\delta-2)(1-\rho^2)\sigma_v^2 \end{array}\right) = 0.$$

All other endogenous parameters can be solved as expressions of λ_T *as follows:*

$$\begin{aligned}
\beta_T &= \frac{2\phi\lambda_T + 2 - \delta}{4\phi\lambda_T^2 + 4\lambda_T - (\lambda_T + 2\phi\lambda_T^2)\delta}, \\
\xi_T &= \frac{-2\phi\lambda_T - 2 + \delta}{4\phi\lambda_T^2 + 4\lambda_T - (\lambda_T + 2\phi\lambda_T^2)\delta}\frac{\rho\sigma_v}{\sigma_T}, \\
\gamma_T &= \frac{(1-2\phi\lambda_T)\delta}{4\phi\lambda_T^2 + 4\lambda_T - (\lambda_T + 2\phi\lambda_T^2)\delta}, \\
\alpha_T &= \frac{(1+2\phi\lambda_T)(-2\phi\lambda_T - 2 + \delta) + (2+2\phi\lambda_T)(1-2\phi\lambda_T)(1-\delta)}{4\phi\lambda_T^2 + 4\lambda_T - (\lambda_T + 2\phi\lambda_T^2)\delta}\frac{\rho\sigma_v}{\sigma_T} + 2\phi, \\
\eta_T &= 2\phi(\bar{p}_T - p_0),
\end{aligned}$$

where $\delta \equiv \frac{cov(v,s|p_T)}{var(s|p_T)} = \frac{(1-\rho^2)\sigma_v^2}{(1-\rho^2)\sigma_v^2 + \sigma_\varepsilon^2}$*. The expected price volatility is then*

$$E[(p-p_T)^2] = \lambda_T(\beta_T + \gamma_T)(1-\rho^2)\sigma_v^2 + \rho^2\sigma_v^2 + \sigma_T^2 - 2\rho\sigma_v\sigma_T + (p_0 - \bar{p}_T)^2.$$

The measure for price discovery/efficiency is

$$var(v|p) = [1 - \lambda_T(\beta_T + \gamma_T)](1 - \rho^2)\sigma_v^2.$$

The expected profits of the insider and the expected costs of the government are,

$$\begin{aligned} E(\pi) &= [1 - \lambda_T(\beta_T + \gamma_T)]\beta_T(1 - \rho^2)\sigma_v^2, \\ E(c) &= [\lambda_T(\beta_T + \gamma_T) - 1]\gamma_T(1 - \rho^2)\sigma_v^2 + \lambda_T\gamma_T^2\sigma_\varepsilon^2. \end{aligned}$$

Compared to the benchmark model, the government now releases the price target signal before trading. In order to achieve its policy goal, the government will trade more intensively on the price target. Knowing the government's policy goal and the price target, the insider will trade less intensively on his precise information on the fundamental in general and trade against the price target. However, if the two signals are uncorrelated ($\rho = 0$), the insider will ignore the released price target.

The effects on market liquidity of releasing the price target relate to the correlations between these two signals. If these two signals have zero correlations, releasing the price target shuts down the noise-addition channel of the price target in the baseline model and thus reduces market liquidity. However, if these two signals are correlated, there are two opposite effects: releasing the price target gets rid of the stochastic noise driven by the price target and reduces market liquidity; meanwhile, releasing the price target reduces private information of the financial market and creates a channel to increase market liquidity. Thus the net effects of releasing the price target on market liquidity hinge on the tradeoffs between these two opposite effects.

Releasing the price target signal has ambiguous effects on price efficiency, relative to the benchmark model. On one hand, knowing the price target, the market maker learns more information of the fundamentals from seeing the total trading volumes and this may improve price efficiency. On the other hand, releasing the price target signal changes the trading behaviors of the insider and the government greatly and may do good (or harm) to price efficiency. Therefore, the total effects of releasing the price target on price efficiency are ambiguous. Furthermore, the correlations between these two signals may also play important roles. In particular, if the correlations between the fundamentals and the price target are strong, releasing the price target will reveal more information about the fundamentals and improve price efficiency effectively;

conversely, if the correlations are weak, releasing the price target will have little net effects on price discovery.

3.2 Releasing the noisy signal about the fundamental

Now suppose that the government releases its noisy signal about the fundamental before trading. With the enlarged information set $\{v, s\}$, the insider's maximization problem is changed as

$$\max_{\{x\}} E[(v-p)x|v,s]. \tag{14}$$

Meanwhile, observing the signal released by the government, $\{s\}$, the market maker uses the information set $\{y, s\}$ to update her conditional expectations about the fundamentals. Thus the pricing rule of market efficiency is transformed into

$$p = E(v|y,s). \tag{15}$$

Conjecture instead the decision rules and the pricing rule as follows:

$$x = \beta_s(v-p_0) + \xi_s(s-p_0), \tag{16}$$

$$g = \gamma_s(s-p_0) + \alpha_s(p_T - \bar{p}_T) + \eta_s, \tag{17}$$

$$p = p_0 + \delta_1(s-p_0) + \lambda_s[y - E(y|s)], \text{ with } y = x+g+u, \tag{18}$$

where

$$\begin{aligned} E(y|s) &= \beta_s E(v-p_0|s) + (\xi_s+\gamma_s)(s-p_0) + \alpha_s E(p_T-\bar{p}_T|s) + \eta_s \\ &= (\beta_s\delta_1 + \xi_s + \gamma_s + \alpha_s\delta_2)(s-p_0) + \eta_s. \end{aligned}$$

We solve the model in Appendix C and summarize the equilibrium results in the following

Proposition 3 *If the government releases the noisy signal about the fundamental* $\{s\}$*, a linear equilibrium is defined by six unknowns* $(\beta_s, \xi_s, \gamma_s, \alpha_s, \eta_s, \lambda_s) \in R^6$*, which are characterized by six equations (51)-(56), together with one SOC,* $\lambda_s > 0$*. The equation system degenerates to the following fourth-order polynomial of* λ_s*:*

$$a_4\lambda_s^4 + a_3\lambda_s^3 + a_2\lambda_s^2 + a_1\lambda_s + a_0 = 0,$$

where the coefficients $a_i's$ are listed in Appendix C. All the other variables can be solved as expressions of λ_s as follows:

$$
\begin{aligned}
\beta_s &= \frac{2\phi\lambda_s(1-\frac{\rho\sigma_T}{\sigma_v})+2-(1-\delta)\rho^2}{4\phi\lambda_s^2+4\lambda_s-(\lambda_s+2\phi\lambda_s^2)(1-\delta)\rho^2}, \\
\xi_s &= -\frac{2\phi\lambda_s[1-(1-\delta)\rho^2+\frac{\rho\sigma_T}{\sigma_v}]+2}{4\phi\lambda_s^2+4\lambda_s-(\lambda_s+2\phi\lambda_s^2)(1-\delta)\rho^2}\delta_1+\frac{(1-2\phi\lambda_s)(1-\delta)\frac{\rho\sigma_v}{\sigma_T}+4\phi\lambda_s}{4\phi\lambda_s^2+4\lambda_s-(\lambda_s+2\phi\lambda_s^2)(1-\delta)\rho^2}\delta_2, \\
\gamma_s &= (1+2\phi\lambda_s)\begin{pmatrix} -\frac{2\phi\lambda_s[1-(1-\delta)\rho^2+\frac{\rho\sigma_T}{\sigma_v}]+2}{4\phi\lambda_s^2+4\lambda_s-(\lambda_s+2\phi\lambda_s^2)(1-\delta)\rho^2}\delta_1 \\ +\frac{(1-2\phi\lambda_s)(1-\delta)\frac{\rho\sigma_v}{\sigma_T}+4\phi\lambda_s}{4\phi\lambda_s^2+4\lambda_s-(\lambda_s+2\phi\lambda_s^2)(1-\delta)\rho^2}\delta_2 \end{pmatrix}+\frac{\left[(-2\phi\lambda_s-4\phi^2\lambda_s^2)(1-\frac{\rho\sigma_T}{\sigma_v})+2\right]\delta}{4\phi\lambda_s^2+4\lambda_s-(\lambda_s+2\phi\lambda_s^2)(1-\delta)\rho^2}, \\
\alpha_s &= \frac{(1-2\phi\lambda_s)(1-\delta)\frac{\rho\sigma_v}{\sigma_T}+4\phi\lambda_s}{4\phi\lambda_s^2+4\lambda_s-(\lambda_s+2\phi\lambda_s^2)(1-\delta)\rho^2}, \\
\eta_s &= 2\phi(\bar{p}_T-p_0),
\end{aligned}
$$

where $\delta_1 \equiv \frac{cov(v,s)}{var(s)} = \frac{\sigma_v^2}{\sigma_v^2+\sigma_\varepsilon^2}$, $\delta_2 \equiv \frac{cov(p_T,s)}{var(s)} = \frac{\rho\sigma_v\sigma_T}{\sigma_v^2+\sigma_\varepsilon^2}$, and $\delta \equiv \frac{cov(v,s|p_T)}{var(s|p_T)} = \frac{(1-\rho^2)\sigma_v^2}{(1-\rho^2)\sigma_v^2+\sigma_\varepsilon^2}$.
The expected price volatility is then

$$
E[(p-p_T)^2]=\begin{pmatrix} [\delta_1^2+\lambda_s(1+\delta_1)(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)]\sigma_v^2+(1-2\lambda_s\alpha_s)\sigma_T^2 \\ +[\lambda_s\alpha_s(1+\delta_1)-2\delta_1-2\lambda_s(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)]\rho\sigma_v\sigma_T \\ +[\delta_1^2-\lambda_s\delta_1(\beta_s\delta_1+\alpha_s\delta_2)]\sigma_\varepsilon^2+(p_0-\bar{p}_T)^2 \end{pmatrix}.
$$

The measure for price discovery/efficiency is

$$
var(v|p)=\frac{\begin{pmatrix} \lambda_s(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)[1-\delta_1-\lambda_s(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)]\sigma_v^2+[\delta_1^2-\lambda_s\delta_1(\beta_s\delta_1 \\ +\alpha_s\delta_2)]\sigma_\varepsilon^2+\lambda_s[1-\delta_1-2\lambda_s(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)]\alpha_s\rho\sigma_v\sigma_T-\lambda_s^2\alpha_s^2\rho^2\sigma_T^2 \end{pmatrix}}{\begin{pmatrix} [\delta_1^2+\lambda_s(1+\delta_1)(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)]\sigma_v^2+[\delta_1^2-\lambda_s\delta_1(\beta_s\delta_1+\alpha_s\delta_2)]\sigma_\varepsilon^2 \\ +\lambda_s(1+\delta_1)\alpha_s\rho\sigma_v\sigma_T \end{pmatrix}}\sigma_v^2.
$$

The expected profit of the insider and expected cost of the government are, respectively,

$$
E(\pi)=\begin{pmatrix} [1-\delta_1-\lambda_s(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)](\beta_s+\xi_s)\sigma_v^2+ \\ [\lambda_s(\beta_s\delta_1+\alpha_s\delta_2)-\delta_1]\xi_s\sigma_\varepsilon^2-\lambda_s\alpha_s(\beta_s+\xi_s)\rho\sigma_v\sigma_T \end{pmatrix},
$$

$$
E(c)=\begin{pmatrix} [\lambda_s(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)+\delta_1-1](\gamma_s\sigma_v^2+\alpha_s\rho\sigma_v\sigma_T)+ \\ [\delta_1-\lambda_s(\beta_s\delta_1+\alpha_s\delta_2)]\gamma_s\sigma_\varepsilon^2+\lambda_s\alpha_s\gamma_s\rho\sigma_v\sigma_T+\lambda_s\alpha_s^2\sigma_T^2 \end{pmatrix}.
$$

Compared to the baseline model, the government now releases releases its noisy signal about the fundamentals. Knowing that its released fundamental signal is noisy and the insider's fundamental signal is precise, the government will trade against its fundamental signal and trade more intensively on the price target signal. Observing that the government's signal about the fundamental is noisy, the insider will trade more intensively on his own precise information and trade against the government's fundamental signal. That said, since the released fundamental signal (s) weakens his information advantage, the insider earns less profits than the standard Kyle setting.

The effects on market liquidity of releasing the fundamental signal also relate to the correlations between these two signals. If these two signals have zero correlations, releasing the noisy signal about the fundamental reduces private information in the financial markets and hence improves market liquidity unambiguously. Given the amount of noisy trading, less private information implies less adverse selection and hence leads to deeper financial markets. However, if these two signals are correlated, there are two opposite effects: releasing the fundamental signal reduces private information and improves market liquidity; meanwhile, releasing the fundamental signal decreases some noises driven by the price target and reduces market liquidity. The net effects hinge on the tradeoffs between these two opposite effects.

Releasing the fundamental signal makes the insider trade more intensively on his precise information and the market market learn more information about the fundamental by observing the total trading position. Therefore, price will reveal more information about the fundamentals.

3.3 Releasing two private signals $\{p_T, s\}$

Suppose that the government releases its price target and its noisy signal about the fundamental before trading. With the enlarged information set $\{v, p_T, s\}$, the insider's maximization problem is changed as

$$\max_{\{x\}} E[(v-p)x|v, p_T, s]. \tag{19}$$

In this case, the market maker sees both signals released by the government, and uses her new information set $\{y, p_T, s\}$ to update her conditional expectations about the fundamentals. Then the pricing rule of market efficiency is transformed into

$$p = E(v|y, p_T, s). \tag{20}$$

Conjecture the decision rules and the pricing rule of the economy:

$$x = \beta_{s,T}(v - p_0) + \xi_{s,T}^{(1)}(s - p_0) + \xi_{s,T}^{(2)}(p_T - \bar{p}_T), \tag{21}$$

$$g = \gamma_{s,T}(s - p_0) + \alpha_{s,T}(p_T - \bar{p}_T) + \eta_{s,T}, \tag{22}$$

$$p = p_0 + (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + \delta(s - p_0) + \lambda_{s,T}[y - E(y|s, p_T)], \text{ with } y = x + g + u \tag{23}$$

where

$$\begin{aligned} E(y|s,p_T) &= \beta_{s,T}E(v - p_0|s,p_T) + (\xi_{s,T}^{(1)} + \gamma_{s,T})(s - p_0) + (\xi_{s,T}^{(2)} + \alpha_{s,T})(p_T - \bar{p}_T) + \eta_{s,T} \\ &= \left(\begin{array}{c} \beta_{s,T}\left[(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + \delta(s - p_0)\right] \\ +(\xi_{s,T}^{(1)} + \gamma_{s,T})(s - p_0) + (\xi_{s,T}^{(2)} + \alpha_{s,T})(p_T - \bar{p}_T) + \eta_{s,T} \end{array} \right), \end{aligned}$$

$$\delta \equiv \frac{cov(v,s|p_T)}{var(s|p_T)} = \frac{(1-\rho^2)\,\sigma_v^2}{(1-\rho^2)\,\sigma_v^2 + \sigma_\varepsilon^2}.$$

In Appendix D, we derive the equilibrium of the model and summarize it in the following

Proposition 4 *If the government releases two private signals $\{p_T, s\}$, a linear equilibrium is defined by seven unknowns $(\beta_{s,T}, \xi_{s,T}^{(1)}, \xi_{s,T}^{(2)}, \gamma_{s,T}, \alpha_{s,T}, \eta_{s,T}, \lambda_{s,T}) \in R^7$, which are characterized by seven equations (58)-(64), together with one SOC, $\lambda_{s,T} > 0$. The equation system can be solved as follows:*

$$\begin{aligned} \beta_{s,T} &= \frac{\sigma_u}{\sqrt{(1-\rho^2)\,(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2}}, \\ \xi_{s,T}^{(1)} &= -\frac{\delta\sigma_u}{\sqrt{(1-\rho^2)\,(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2}}, \\ \xi_{s,T}^{(2)} &= -\frac{(1-\delta)\sigma_u}{\sqrt{(1-\rho^2)\,(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2}}\frac{\rho\sigma_v}{\sigma_T}, \\ \gamma_{s,T} &= -2\phi\delta, \\ \alpha_{s,T} &= 2\phi\left[1 - (1-\delta)\frac{\rho\sigma_v}{\sigma_T}\right], \\ \eta_{s,T} &= 2\phi(\bar{p}_T - p_0), \\ \lambda_{s,T} &= \frac{\sqrt{(1-\rho^2)\,(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2}}{2\sigma_u}. \end{aligned}$$

The expected price volatility is then

$$E[(p-p_T)^2] = \left[\frac{1}{2}(1-\delta)(1+\rho^2)+\delta\right]\sigma_v^2+\sigma_T^2-2\rho\sigma_v\sigma_T+(p_0-\bar{p}_T)^2.$$

The measure for price discovery/efficiency is

$$var(v|p) = \frac{(1-\rho^4)(1-\delta)^2\sigma_v^2+2\delta^2\sigma_\varepsilon^2}{2\left(1-\rho^2\right)\delta^2\sigma_v^2+2\left(1+\rho^2\right)\sigma_v^2+2\delta^2\sigma_\varepsilon^2}\sigma_v^2.$$

The expected profit of the insider and expected cost of the government are, respectively,

$$E(\pi) = \frac{\sigma_u\sqrt{\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2+\delta^2\sigma_\varepsilon^2}}{2},$$

$$E(c) = 0.$$

Relative to the benchmark model without information release, the government now releases both signals. Since releasing either signal increases the government's trading intensity in the price target, the government will trade more intensively on the price target than either case. However, the government trades against its fundamental signal because it knows that its fundamental signal is noisy while the insider's fundamental signal is precise. As shown in above two subsections, releasing the price target decreases the insider's trading intensity on his precise fundamental information while releasing the noisy signal about the fundamental increases his trading intensity on his fundamental information. The net effects of releasing both signals on the insider's trading intensity in his fundamental information depend on the tradeoffs of the two opposite effects, which may relate to other parameter values. Meanwhile, the insider trades against both released signals, because he has precise information about the fundamentals and know the government's problem very well.

Releasing the price target gets rid of some noises in financial markets and decreases market liquidity, while releasing the fundamental signal reduces price information in financial markets and improves market liquidity. The final effects on market liquidity of releasing both signals may relate to the policy weight of the government, rather than the correlations between the two signals. Releasing the noisy signal about the fundamentals raises price efficiency largely while releasing the price target signal has ambiguous and relatively small effects on price efficiency. Their final effects on price efficiency may be positive.

4 Comparisons: release or not and release which

In this section, we compare market performances of government intervention under four different scenarios about information disclosure: the baseline model without information disclosure, releasing the price target signal, releasing the noisy signal about the fundamentals, and releasing both the price target and the noisy signal about the fundamentals. We discuss how government intervention and information disclosure affects financial stability and market quality. We report the numerical results of two important cases: $\phi = 1$ (the government puts an equal weight on its policy goal and profit maximization) in Figures 4, 5, and 6, and $\phi = 3$ (the government cares more about its policy goals) in Figures 7, 8, and 9 and also summarize them in Tables 2 and 3.

Table 2 ($\phi = 1$)

	$\rho = 0$	$\rho = 0.1$	$\rho = 0.5$
$\frac{1}{E(p-p_T)^2}$	$\emptyset \succ \{s\}^r \succ \{p_T\}^r \succ \{s, p_T\}^r$	$\emptyset \succ \{s\}^r \succ \{p_T\}^r \succ \{s, p_T\}^r$	$\emptyset \succ \{s\}^r ? \{p_T\}^r \succ \{s, p_T\}^r$
$\frac{1}{\lambda}$	$\{s\}^r \succ \{s, p_T\}^r \succ \emptyset \succ \{p_T\}^r$	$\{s\}^r \succ \{s, p_T\}^r \succ \emptyset \succ \{p_T\}^r$	$\{s\}^r \succ \{s, p_T\}^r \succ \emptyset \succ \{p_T\}^r$
$\frac{1}{var(v\|y)}$	$\{s, p_T\}^r \sim \{s\}^r \succ \emptyset \succ \{p_T\}^r$	$\{s, p_T\}^r \sim \{s\}^r \succ \emptyset \succ \{p_T\}^r$	$\{s, p_T\}^r \sim \{s\}^r \succ \{p_T\}^r \succ \emptyset$

Table 3 ($\phi = 3$)

	$\rho = 0$	$\rho = 0.1$	$\rho = 0.5$
$\frac{1}{E(p-p_T)^2}$	$\emptyset \succ \{s\}^r \succ \{p_T\}^r \succ \{s, p_T\}^r$	$\emptyset \succ \{s\}^r \succ \{p_T\}^r \succ \{s, p_T\}^r$	$\emptyset \succ \{s\}^r \succ \{p_T\}^r \succ \{s, p_T\}^r$
$\frac{1}{\lambda}$	$\{s\}^r \succ \emptyset \succ \{s, p_T\}^r \succ \{p_T\}^r$	$\{s\}^r \succ \emptyset \succ \{s, p_T\}^r \succ \{p_T\}^r$	$\{s\}^r \succ \emptyset \succ \{s, p_T\}^r \succ \{p_T\}^r$
$\frac{1}{var(v\|y)}$	$\{s, p_T\}^r \sim \{s\}^r \succ \emptyset \succ \{p_T\}^r$	$\{s, p_T\}^r \sim \{s\}^r \succ \emptyset \succ \{p_T\}^r$	$\{s, p_T\}^r \sim \{s\}^r \succ \emptyset \succ \{p_T\}^r$

Market liquidity. We have shown in Section 3 that relative to the baseline model without information disclosure, releasing the price target diminishes the noises in financial markets and hence decreases market liquidity, while releasing the nosiy signal about the fundamentals reduces private information in financial markets and hence raises market liquidity. Thus the ranks for market liquidity among these four cases are as follow: $\{s\}^r \succ \emptyset, \{s, p_T\}^r \succ \{p_T\}^r$, as shown in Figures 4-9. The rank between $\emptyset$ and $\{s, p_T\}^r$ hinges on the policy weights of the government. Specifically, if the government puts an equal wight on policy goals and profit maximization ($\phi = 1$), the measure for market liquidity of releasing both signals is larger than that of the benchmark model without information disclosure, which establishes that the positive effect on market liquidity of releasing the fundamental signal dominates the negative effect of releasing the price target. However, if the government places larger weights on its policy goals ($\phi = 3$), then the negative effect of releasing the price target dominates the positive effect of releasing the fundamental signal and hence the financial markets are deeper in the benchmark model without information disclosure. Except for some quantitative implications, the correlations between these two signals play little roles in the ranks among the four cases.

Price stability. For any parameter values of θ, ρ, and ϕ, price volatility for the case of releasing two signals is larger than price volatility for either case of releasing one signal, while price volatility of releasing either signal is larger than the one for the case without information disclosure, as shown in Figures 4-9. That is to say, information disclosure does harm to financial stability unambiguously: no information disclosure is better than releasing either one of two signals, and releasing either signal is better than releasing both signals. The intuition is that: in this model, when intervening the financial markets through direct trading, the government plays games with the insider based on its own private information. Releasing one signal implies reducing its information advantages, and releasing both signals turns out to abandon its information advantages. Altogether, information disclosure reduces the government's information advantages, deteriorates its intervention ability through direct trading and hence harms financial stability.

Besides, releasing the price target is worse than releasing the noisy signal about the fundamentals, for most cases displayed in Figures 4-9. In this model, the price target signal is more related to financial stability and the fundamental signal is more related to profit maximization. Hence, releasing the price target is more harmful for financial stability than releasing the fundamental signal. However, if the government puts an equal weight on its policy goals ($\phi = 1$) and profit maximization and its two signals have strong correlations ($\rho = 0.5$), their rank may hinge on the amount of noisy trading per unit of private information (θ).

Price efficiency. Figures 4-9 display that the ranks for price efficiency among the four cases are as follows: $\{s, p_T\}^r \sim \{s\}^r \succ \emptyset, \{p_T\}^r$. As discussed in the above sections, releasing the fundamental signal with high quality raises price efficiency effectively, while releasing the price target has opposite effects on price efficiency and its net effects may be small. Then we conclude that $\{s, p_T\}^r, \{s\}^r \succ \emptyset, \{p_T\}^r$. The equivalence between releasing both signals and releasing the fundamental signal shows that once the fundamental information is released, the marginal effect of releasing the price target is trivial.

Compared to the benchmark setting without information disclosure, releasing the price target has opposite effects on price efficiency: the negative effect is by injecting more noises and the positive effect is due to providing more information to the market maker. For most cases, the negative effect dominates the positive effect, namely, $\emptyset \succ \{p_T\}^r$. However, if the government puts an equal weight on policy goals and profit maximization ($\phi = 1$) and its two signals are highly correlated ($\rho = 0.5$), then the positive effect dominates its negative effect, leading to $\{p_T\}^r \succ \emptyset$.

In a closely related model where the government only has the fundamental signal, Huang et al. (2022) show that government intervention improves both financial stability and price efficiency simultaneously. In our model, the government has two private signals and alternative policies about information disclosure, there exist potential tradeoffs between financial stability and price efficiency, as shown in Figures 4-9. Specifically, releasing both signals is the worst one for price stability while it is also the best one for price efficiency; releasing nothing is the best one for financial stability while it is not advantage for price efficiency; relative to releasing the price target signal, releasing the noisy signal does good to both financial stability and price efficiency. Under a noisy rational expectations equilibrium model of government intervention, Brunnermeier et al. (2022) derive the similar tradeoffs between price efficiency and financial stability.

5 Concluding remarks

We develop a theoretical model of government intervention with information disclosure in which the government with two private signals trades against other market participants in financial markets. The price target signal is more related to financial stability and the government with policy concerns trades optimally based more on the price target signal than on the fundamental signal. Information disclosure harms financial stability unambiguously by deteriorating the information advantage of the government. Releasing the price target diminishes noises in financial markets and hence decreases market liquidity, while releasing the nosiy signal about the fundamentals reduces private information in financial markets and hence raises market liquidity, and the tradeoffs between two opposite effects of releasing two signals depend on the policy weights of the government. Releasing the fundamental signal raises price efficiency effectively, while releasing the price target has subtle effects on price efficiency and its net effects may be small. Once the fundamental information is released, the marginal effect of releasing the price target is trivial. Under different scenarios of government intervention with information disclosure, there exist potential tradeoffs between financial stability and price efficiency.

6 Appendix

6.1 Appendix A

Proof of Proposition 1. Firstly, we solve the insider's Problem. Let $\pi = (v - p)x$ denote the insider's profit that is directly attributable to his trade. The insider has information $\{v\}$ and chooses x to solve (3). Using equations (6), (7) and the projection theorem, we can compute

$$E\left[(v-p)x|v\right] = [\left(1 - \lambda\gamma - \lambda\alpha\rho\frac{\sigma_T}{\sigma_v}\right)(v - p_0) - \lambda x]x.$$

Taking the first-order-condition (FOC) results in the solution as follows:

$$x = \frac{1 - \lambda\gamma - \lambda\alpha\rho\frac{\sigma_T}{\sigma_v}}{2\lambda}(v - p_0). \tag{24}$$

The second-order-condition (SOC) is

$$\lambda > 0. \tag{25}$$

Comparing the FOC (24) with the conjectured strategy (5), we have

$$\beta = \frac{1 - \lambda\gamma - \lambda\alpha\rho\frac{\sigma_T}{\sigma_v}}{2\lambda}. \tag{26}$$

Secondly, we solve the government's problem. Endowed with the information set $\{s, p_T\}$, the government chooses g to solve (4). Using equations (5) and (7), we can compute

$$E\left[\phi(p - p_T)^2 + (p - v)g|s, p_T\right] = \left\{\begin{array}{c} 2\phi\lambda\beta(p_0 - p_T - \lambda\eta + \lambda g)E(v - p_0|s, p_T) + \\ \phi(p_0 - p_T - \lambda\eta + \lambda g)^2 + (\lambda\beta - 1)gE(v - p_0|s, p_T) \\ +\phi\lambda^2\sigma_u^2 + \phi\lambda^2\beta^2 E[(v - p_0)^2|s, p_T] + \lambda g^2 - \lambda\eta g \end{array}\right\}, \tag{27}$$

where

$$\begin{aligned} E(v - p_0|s, p_T) &= E(v - p_0|p_T) + \frac{cov(v - p_0, s|p_T)}{var(s|p_T)}[s - E(s|p_T)] \\ &= (1 - \delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + \delta(s - p_0), \end{aligned}$$

$$E[(v-p_0)^2|s,p_T] = [E(v-p_0|s,p_T)]^2 + var(v-p_0|s,p_T)$$
$$= \left\{ \begin{array}{c} \left[(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\delta(s-p_0)\right]^2 \\ +(1-\delta)\left(1-\rho^2\right)\sigma_v^2 \end{array} \right\},$$

$$\delta \equiv \frac{cov(v,s|p_T)}{var(s|p_T)} = \frac{(1-\rho^2)\sigma_v^2}{(1-\rho^2)\sigma_v^2+\sigma_\varepsilon^2}.$$

The first-order-condition (FOC) for g gives

$$g = \frac{1}{2\phi\lambda^2+2\lambda}\left\{ \begin{array}{c} (1-\lambda\beta-2\phi\lambda^2\beta)\delta(s-p_0)+(2\phi\lambda^2+\lambda)\eta+2\phi\lambda(\bar{p}_T-p_0) \\ +[(1-\lambda\beta-2\phi\lambda^2\beta)(1-\delta)\frac{\rho\sigma_v}{\sigma_T}+2\phi\lambda](p_T-\bar{p}_T) \end{array} \right\}. \quad (28)$$

Comparing the FOC (28) with the conjectured trading strategy (6), we have

$$\gamma = \frac{1-\lambda\beta-2\phi\lambda^2\beta}{2\phi\lambda^2+2\lambda}\delta, \quad (29)$$

$$\alpha = \frac{1-\lambda\beta-2\phi\lambda^2\beta}{2\phi\lambda^2+2\lambda}(1-\delta)\frac{\rho\sigma_v}{\sigma_T}+\frac{\phi}{1+\phi\lambda}, \quad (30)$$

$$\eta = 2\phi\left(\bar{p}_T-p_0\right). \quad (31)$$

The SOC for the government $2\phi\lambda^2+2\lambda>0$ holds accordingly, if the SOC for the insider (25) holds.

Thirdly, we examine the market maker's problem. The market maker observes the aggregate order flow y and sets $p=E[v|y]$. Using equations (5), (6), (7), and the projection theorem, we have

$$\lambda = \frac{(\beta+\gamma)\sigma_v^2+\alpha\rho\sigma_v\sigma_T}{(\beta+\gamma)^2\sigma_v^2+\gamma^2\sigma_\varepsilon^2+\alpha^2\sigma_T^2+\sigma_u^2+2(\beta+\gamma)\alpha\rho\sigma_v\sigma_T}. \quad (32)$$

Fourthly, we solve the equation system composed of (26), (29), (30), (31), and (32). Substituting (26) into (29), we can have

$$\gamma = \frac{1-2\phi\lambda+(\lambda+2\phi\lambda^2)\frac{\rho\sigma_T}{\sigma_v}\frac{\phi}{1+\phi\lambda}}{4\phi\lambda^2+4\lambda-[\delta+(1-\delta)\rho^2](\lambda+2\phi\lambda^2)}\delta. \quad (33)$$

Putting equation (33) in (26) gives us

$$\beta = \frac{2\phi\lambda+2-[\delta+(1-\delta)\rho^2]-2\phi\lambda\frac{\rho\sigma_T}{\sigma_v}}{4\phi\lambda^2+4\lambda-[\delta+(1-\delta)\rho^2](\lambda+2\phi\lambda^2)}. \quad (34)$$

Combining (33) and (34) leads to

$$\beta+\gamma=\frac{2+2\phi\lambda-2\phi\lambda\delta-(1-\delta)\rho^2+(\lambda\delta+2\phi\lambda^2\delta-2\phi\lambda^2-2\lambda)\frac{\rho\sigma_T}{\sigma_v}\frac{\phi}{1+\phi\lambda}}{4\phi\lambda^2+4\lambda-[\delta+(1-\delta)\rho^2](\lambda+2\phi\lambda^2)}. \tag{35}$$

Substituting (35) into (32) and rearranging give rise to the polynomial about λ in Proposition 1, (8), with the following coefficients:

$$a_6 = [4-2\delta-2(1-\delta)\rho^2]^2\phi^4\sigma_u^2, \tag{36}$$

$$a_5 = 2(4-2\delta-2(1-\delta)\rho^2)(8-3\delta-3(1-\delta)\rho^2)\phi^3\sigma_u^2, \tag{37}$$

$$a_4 = \begin{pmatrix} \phi^4\sigma_v^2[(8-4\delta)(1-\delta)\rho^2+4\delta-4-4(1-\delta)^2\rho^4]+\phi^4\sigma_T^2[4(\delta-3)(1-\delta)\rho^2+(4-2\delta)^2] \\ +\phi^4\rho\sigma_v\sigma_T[20\delta-8\delta^2-16+(12-20\delta+8\delta^2)\rho^2]+\phi^4\delta^2\sigma_\varepsilon^2(4-8\rho\sigma_T/\sigma_v+4\rho^2\sigma_T^2/\sigma_v^2) \\ +[(8-3\delta-3(1-\delta)\rho^2)^2+2(4-2\delta-2(1-\delta)\rho^2)(4-\delta-(1-\delta)\rho^2)]\phi^2\sigma_u^2 \end{pmatrix}, \tag{38}$$

$$a_3 = \begin{pmatrix} \phi^3\sigma_v^2\left[-16+14\delta-2\delta^2+\left(8\delta^2-26\delta+18\right)\rho^2+\left(-6+12\delta-6\delta^2\right)\rho^4\right]+ \\ \phi^3\sigma_T^2\left[4(2-\delta)(4-\delta)+(-24+24\delta-4\delta^2)\rho^2\right]+\phi^3\delta^2\sigma_\varepsilon^2\left(4-8\rho\sigma_T/\sigma_v+4\rho^2\sigma_T^2/\sigma_v^2\right) \\ +\phi^3\rho\sigma_v\sigma_T\left[26\delta-24-8\delta^2+(18-26\delta+8\delta^2)\rho^2\right] \\ +2\phi\sigma_u^2(4-\delta-(1-\delta)\rho^2)(8-3\delta-3(1-\delta)\rho^2) \end{pmatrix}, \tag{39}$$

$$a_2 = \begin{pmatrix} \phi^2\sigma_v^2[-24+18\delta-4\delta^2+(15-20\delta+5\delta^2)\rho^2-(1-2\delta+\delta^2)\rho^4]+ \\ \phi^2\sigma_T^2[(4-\delta)^2+(-12+8\delta-\delta^2)\rho^2]+\phi^2\rho\sigma_v\sigma_T[(2\delta-2\delta^2)\rho^2+2\delta^2-2\delta] \\ +\phi^2\delta^2\sigma_\varepsilon^2(-3+2\rho\sigma_T/\sigma_v+\rho^2\sigma_T^2/\sigma_v^2)+[4-\delta-(1-\delta)\rho^2]^2\sigma_u^2 \end{pmatrix}, \tag{40}$$

$$a_1 = \begin{pmatrix} \phi\sigma_v^2[-16+10\delta-2\delta^2+(8-10\delta+2\delta^2)\rho^2]+ \\ \phi\delta^2\sigma_\varepsilon^2(-2+2\rho\sigma_T/\sigma_v)+\phi\rho\sigma_v\sigma_T\left[2\delta^2-8\delta+8+(-6+8\delta-2\delta^2)\rho^2\right] \end{pmatrix}, \tag{41}$$

$$a_0 = [2\delta-4+(3-4\delta+\delta^2)\rho^2-(1-2\delta+\delta^2)\rho^4]\sigma_v^2+\delta^2\sigma_\varepsilon^2. \tag{42}$$

Finally, we compute those moments listed in Proposition 1. The expected price volatility can be computed by

$$
\begin{aligned}
E[(p-p_T)^2] &= E\{(p_0+\lambda[\beta(v-p_0)+\gamma(s-p_0)+\alpha(p_T-\bar{p}_T)+u]-p_T)^2\} \\
&= E\{[\lambda(\beta+\gamma)(v-p_0)+\lambda\gamma\varepsilon+(\lambda\alpha-1)(p_T-\bar{p}_T)+\lambda u+p_0-\bar{p}_T]^2\} \\
&= \left(\begin{array}{c} \lambda^2(\beta+\gamma)^2E[(v-p_0)^2]+\lambda^2\gamma^2\sigma_\varepsilon^2+(\lambda\alpha-1)^2E[(p_T-\bar{p}_T)^2]+ \\ \lambda^2\sigma_u^2+2\lambda(\beta+\gamma)(\lambda\alpha-1)E[(v-p_0)(p_T-\bar{p}_T)]+(p_0-\bar{p}_T)^2 \end{array}\right) \\
&= \left(\begin{array}{c} \lambda^2(\beta+\gamma)^2\sigma_v^2+\lambda^2\gamma^2\sigma_\varepsilon^2+(\lambda\alpha-1)^2\sigma_T^2+\lambda^2\sigma_u^2 \\ +2\lambda(\beta+\gamma)(\lambda\alpha-1)\rho\sigma_v\sigma_T+(p_0-\bar{p}_T)^2 \end{array}\right) \\
&= \left(\begin{array}{c} \lambda^2[\sigma_u^2+\alpha^2\sigma_T^2+\gamma^2\sigma_\varepsilon^2+(\beta+\gamma)^2\sigma_v^2+2(\beta+\gamma)\alpha\rho\sigma_v\sigma_T] \\ +(1-2\lambda\alpha)\sigma_T^2-2\lambda(\beta+\gamma)\rho\sigma_v\sigma_T+(p_0-\bar{p}_T)^2 \end{array}\right) \\
&= \lambda(\beta+\gamma)\sigma_v^2+(1-2\lambda\alpha)\sigma_T^2+\lambda[\alpha-2(\beta+\gamma)]\rho\sigma_v\sigma_T+(p_0-\bar{p}_T)^2.
\end{aligned}
$$

where the sixth equality comes from plugging equation (32). Using the projection theorem and equation (35), we have that

$$
\begin{aligned}
var(v|p) &= var(v|y)=var(v)-\frac{[cov(v,y)]^2}{var(y)}=\sigma_v^2-\lambda cov(v,y) \\
&= \sigma_v^2-\lambda cov(v,\beta(v-p_0)+\gamma(s-p_0)+\alpha(p_T-\bar{p}_T)+\eta+u) \\
&= \sigma_v^2-\lambda[(\beta+\gamma)\sigma_v^2+\alpha\rho\sigma_v\sigma_T] \\
&= [1-\lambda(\beta+\gamma)]\sigma_v^2-\lambda\alpha\rho\sigma_v\sigma_T.
\end{aligned}
$$

The expected profit of the insider is

$$
\begin{aligned}
E(\pi) &= E[(v-p)x] \\
&= E\{(v-p_0-\lambda[\beta(v-p_0)+\gamma(v+\varepsilon-p_0)+\alpha(p_T-\bar{p}_T)+u])\beta(v-p_0)\} \\
&= E\{[(1-\lambda\beta-\lambda\gamma)(v-p_0)-\lambda\gamma\varepsilon-\lambda\alpha(p_T-\bar{p}_T)-\lambda u]\beta(v-p_0)\} \\
&= [1-\lambda(\beta+\gamma)]\beta E[(v-p_0)^2]-\lambda\alpha\beta E[(v-p_0)(p_T-\bar{p}_T)] \\
&= [1-\lambda(\beta+\gamma)]\beta\sigma_v^2-\lambda\alpha\beta\rho\sigma_v\sigma_T.
\end{aligned}
$$

The expression for the expected cost of the government is found as follows:

$$\begin{aligned}
E(c) &= E[(p-v)g] \\
&= E\{(p_0+\lambda[\beta(v-p_0)+\gamma(s-p_0)+\alpha(p_T-\bar{p}_T)+u]-v)[\gamma(s-p_0)+\alpha(p_T-\bar{p}_T)+\eta]\} \\
&= E\{[(\lambda\beta+\lambda\gamma-1)(v-p_0)+\lambda\gamma\varepsilon+\lambda\alpha(p_T-\bar{p}_T)+\lambda u][\gamma(s-p_0)+\alpha(p_T-\bar{p}_T)+\eta]\} \\
&= [\lambda(\beta+\gamma)-1]\gamma E[(v-p_0)^2]+\lambda\gamma^2E(\varepsilon^2)+\lambda\alpha^2E[(p_T-\bar{p}_T)^2] \\
&\quad +(\lambda\beta+2\lambda\gamma-1)\alpha E[(v-p_0)(p_T-\bar{p}_T)] \\
&= [\lambda(\beta+\gamma)-1]\gamma\sigma_v^2+\lambda\gamma^2\sigma_\varepsilon^2+\lambda\alpha^2\sigma_T^2+(\lambda\beta+2\lambda\gamma-1)\alpha\rho\sigma_v\sigma_T.
\end{aligned}$$

Design of the numerical analysis. There are eight exogenous variables in the model: the variance of the liquidation value of the risky asset, σ_v^2, the variance of the noisy trading, σ_u^2, the variance of the information noise of the government, σ_ε^2, the variance of the price target, σ_T^2, the mean of the fundamental value, p_0, the mean of the price target, $\bar{p}_T$, the policy weight of the government, ϕ, and the correlation coefficient between the price target and the liquidation value of the fundamental, ρ. For analytical convenience, we make several specifications about parameters. First, we define $\theta \equiv \sigma_u^2/\sigma_v^2$ as the amount of noisy trading per unit of private information and change its values continuously in $[1, 2]$. Second, we set $\sigma_\varepsilon^2 = \sigma_v^2 = \sigma_T^2 = 1$, which are the same as Pasquariello et al.(2020). Third, p_0 and $\bar{p}_T$ enter only the measure for price volatility $E[(p-p_T)^2]$ as their squared difference $(p_0-\bar{p}_T)^2$. We set $(p_0-\bar{p}_T)^2 = 1$. Fourth, we choose three possible values for $\phi : \{0, 1, 3\}$. When $\phi = 0$, the government is another insider. When $\phi = 1$, the government places equal weight on its policy goal and profit maximization. When $\phi = 3$, the government cares more about the policy goal than about profit maximization. Fifth, we choose three possible values for $\rho : \{0, 0.1, 0.5\}$. When $\rho = 0$, two signals of the government are independent. When $\rho = 0.1$, the two signals have low positive correlation. When $\rho = 0.5$, the two signals have high positive correlation. Figure 1, Figure 2 and Figure 3 correspond to $\rho = 0$, $\rho = 0.1$, and $\rho = 0.5$, respectively. These figures display the trading behaviors of the insider and the government, price volatility, and market quality of the model economy.

6.2 Appendix B

Proof of Proposition 2. Given his information set $\{v, p_T\}$, the insider solves the problem (9). For this purpose, using equation (12) and (13), we compute

$$\begin{aligned} & E[(v-p)x|v,p_T] \\ = & E\left(\left\{\begin{array}{c} v-p_0-\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)-\lambda_T[x+\gamma_T(s-p_0)+\alpha_T(p_T-\bar{p}_T) \\ +\eta_T+u-\left[(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}+\xi_T+\alpha_T\right](p_T-\bar{p}_T)-\eta_T \end{array}\right\} x|v,p_T\right) \\ = & \left\{(1-\lambda_T\gamma_T)(v-p_0)-\lambda_T x+\left[\lambda_T\xi_T+(\lambda_T(\beta_T+\gamma_T)-1)\frac{\rho\sigma_v}{\sigma_T}\right](p_T-\bar{p}_T)\right\} x. \end{aligned}$$

The first-order-condition (FOC) for x gives

$$x=\frac{1-\lambda_T\gamma_T}{2\lambda_T}(v-p_0)+\frac{1}{2\lambda_T}[\lambda_T\xi_T+(\lambda_T(\beta_T+\gamma_T)-1)\frac{\rho\sigma_v}{\sigma_T}](p_T-\bar{p}_T). \quad (43)$$

The second-order-condition (SOC) is $\lambda_T>0$. Comparing the FOC (43) with the conjectured strategy (11) leads to

$$\beta_T=\frac{1-\lambda_T\gamma_T}{2\lambda_T}, \quad (44)$$

$$\xi_T=\frac{\lambda_T\xi_T+[\lambda_T(\beta_T+\gamma_T)-1]\frac{\rho\sigma_v}{\sigma_T}}{2\lambda_T}=(\beta_T+\gamma_T-\frac{1}{\lambda_T})\frac{\rho\sigma_v}{\sigma_T}. \quad (45)$$

Using (11) and (13), the loss function of the government is derived as

$$\begin{aligned} & E[\phi(p-p_T)^2+(p-v)g|s,p_T] \\ = & \left(\begin{array}{c} \phi E\left[\left(\begin{array}{c} p_0+\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\lambda_T[\beta_T(v-p_0)+\xi_T(p_T-\bar{p}_T)+g \\ +u-((\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}+\xi_T+\alpha_T)(p_T-\bar{p}_T)-\eta_T]-p_T \end{array}\right)^2|s,p_T\right]+ \\ E\left[p_0+\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\lambda_T\left(\begin{array}{c} \beta_T(v-p_0)+\xi_T(p_T-\bar{p}_T)+g+u- \\ ((\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}+\xi_T+\alpha_T)(p_T-\bar{p}_T)-\eta_T \end{array}\right)-v|s,p_T\right]g \end{array}\right) \\ = & \left(\begin{array}{c} \phi\left[p_0-p_T+(\frac{\rho\sigma_v}{\sigma_T}-\lambda_T(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}-\lambda_T\alpha_T)(p_T-\bar{p}_T)+\lambda_T g-\lambda_T\eta_T\right]^2+\phi\lambda_T^2\beta_T^2E[(v-p_0)^2|s,p_T] \\ +2\phi\lambda_T\beta_T[p_0-p_T+(\frac{\rho\sigma_v}{\sigma_T}-\lambda_T(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}-\lambda_T\alpha_T)(p_T-\bar{p}_T)+\lambda_T g-\lambda_T\eta_T]E(v-p_0|s,p_T)+ \\ \phi\lambda_T^2\sigma_u^2+[(\lambda_T\beta_T-1)E(v-p_0|s,p_T)+\lambda_T g-\lambda_T\eta_T+(\frac{\rho\sigma_v}{\sigma_T}-\lambda_T(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}-\lambda_T\alpha_T)(p_T-\bar{p}_T)]g \end{array}\right) \end{aligned}$$

where

$$E(v-p_0|s,p_T)=(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\delta(s-p_0),$$

$$var(v-p_0|s,p_T) = var\left(v-p_0|p_T\right) - \frac{cov\left(v-p_0, s|p_T\right)^2}{var\left(s|p_T\right)} = \frac{\left(1-\rho^2\right)\sigma_v^2}{(1-\rho^2)\sigma_v^2+\sigma_\varepsilon^2},$$

$$\begin{aligned} E\left[(v-p_0)^2|s,p_T\right] &= \left[E(v-p_0|s,p_T)\right]^2 + var(v-p_0|s,p_T) \\ &= \left[(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\delta(s-p_0)\right]^2 + \frac{\left(1-\rho^2\right)\sigma_v^2}{(1-\rho^2)\sigma_v^2+\sigma_\varepsilon^2}, \end{aligned}$$

$$\delta \equiv \frac{cov(v,s|p_T)}{var(s|p_T)} = \frac{(1-\rho^2)\sigma_v^2}{(1-\rho^2)\sigma_v^2+\sigma_\varepsilon^2}.$$

The first-order-condition (FOC) for g gives

$$g = \frac{1}{2\phi\lambda_T^2+2\lambda_T}\left\{\begin{array}{c} (1-\lambda_T\beta_T-2\phi\lambda_T^2\beta_T)\delta(s-p_0)+(2\phi\lambda_T^2+\lambda_T)\eta_T+2\phi\lambda_T(\bar{p}_T-p_0) \\ +\left[\begin{array}{c} (1+2\phi\lambda_T)(\lambda_T\alpha_T-\frac{\rho\sigma_v}{\sigma_T}+\lambda_T(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}) \\ +2\phi\lambda_T+(1-\lambda_T\beta_T-2\phi\lambda_T^2\beta_T)(1-\delta)\frac{\rho\sigma_v}{\sigma_T} \end{array}\right](p_T-\bar{p}_T) \end{array}\right\}.$$

The SOC is $2\phi\lambda_T^2+2\lambda_T>0$, which holds accordingly if $\lambda_T>0$ holds. Comparing the above FOC of the government with the conjectured trading strategy of the government (12), we have

$$\gamma_T = \frac{1-\lambda_T\beta_T-2\phi\lambda_T^2\beta_T}{2\phi\lambda_T^2+2\lambda_T}\delta, \tag{46}$$

$$\alpha_T = \frac{(1+2\phi\lambda_T)[\lambda_T(\beta_T+\gamma_T)-1]+(1-\lambda_T\beta_T-2\phi\lambda_T^2\beta_T)(1-\delta)}{\lambda_T}\frac{\rho\sigma_v}{\sigma_T}+2\phi, \tag{47}$$

$$\eta_T = \frac{(2\phi\lambda_T^2+\lambda_T)\eta_T+2\phi\lambda_T(\bar{p}_T-p_0)}{2\phi\lambda_T^2+2\lambda_T} = 2\phi(\bar{p}_T-p_0). \tag{48}$$

By the projection theorem, equation (10) gives rise to

$$\begin{aligned} p &= E(v|p_T)+\frac{cov(v,y|p_T)}{var(y|p_T)}[y-E(y|p_T)] \\ &= E(v)+\frac{cov(v,p_T)}{var(p_T)}(p_T-\bar{p}_T)+\frac{cov(v,y|p_T)}{var(y|p_T)}[y-E(y|p_T)] \\ &= p_0+\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\frac{cov(v,y|p_T)}{var(y|p_T)}[y-E(y|p_T)]. \end{aligned}$$

Combining the above equation with (46) gives us

$$\lambda_T = \frac{cov(v,y|p_T)}{var(y|p_T)} = \frac{(\beta_T+\gamma_T)(1-\rho^2)\sigma_v^2}{(\beta_T+\gamma_T)^2(1-\rho^2)\sigma_v^2+\gamma_T^2\sigma_\varepsilon^2+\sigma_u^2}. \tag{49}$$

By the similar procedure to derive the polynomial in Proposition 1, we change the equation system composed of (44)-(49) into the polynomial about λ_T presented in Proposition 2 and solve other endogenous parameters as functions of λ_T.

The expression for expected price volatility in Proposition 2 is derived as follows:

$$
\begin{aligned}
& E[(p-p_T)^2] \\
= \; & E\left[p_0 + \frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) + \lambda_T \begin{pmatrix} \beta_T(v-p_0)+\gamma_T(s-p_0) \\ +u-(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) \end{pmatrix} - p_T\right]^2 \\
= \; & E\left[\begin{array}{c} p_0-\bar{p}_T+\left(\frac{\rho\sigma_v}{\sigma_T}-1-\lambda_T(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}\right)(p_T-\bar{p}_T) \\ +\lambda_T(\beta_T+\gamma_T)(v-p_0)+\lambda_T u+\lambda_T\gamma_T\varepsilon \end{array}\right]^2 \\
= \; & \begin{pmatrix} (p_0-\bar{p}_T)^2+\left[(1-\lambda_T(\beta_T+\gamma_T))\frac{\rho\sigma_v}{\sigma_T}-1\right]^2\sigma_T^2+\lambda_T^2(\beta_T+\gamma_T)^2\sigma_v^2 \\ +\lambda_T^2\sigma_u^2+\lambda_T^2\gamma_T^2\sigma_\varepsilon^2+2\left[(1-\lambda_T(\beta_T+\gamma_T))\frac{\rho\sigma_v}{\sigma_T}-1\right]\lambda_T(\beta_T+\gamma_T)\rho\sigma_v\sigma_T \end{pmatrix} \\
= \; & \lambda_T^2\left[(\beta_T+\gamma_T)^2(1-\rho^2)\sigma_v^2+\gamma_T^2\sigma_\varepsilon^2+\sigma_u^2\right]+\rho^2\sigma_v^2+\sigma_T^2-2\rho\sigma_v\sigma_T+(p_0-\bar{p}_T)^2 \\
= \; & \lambda_T(\beta_T+\gamma_T)(1-\rho^2)\sigma_v^2+\rho^2\sigma_v^2+\sigma_T^2-2\rho\sigma_v\sigma_T+(p_0-\bar{p}_T)^2,
\end{aligned}
$$

where the last equality is obtained by the substitution of equation (49). The measure for price discovery/efficiency is

$$
\begin{aligned}
var(v|p) &= var(v) - \frac{[cov(v,p)]^2}{var(p)} \\
&= var(v) - \frac{\left[cov\begin{pmatrix} v, p_0+\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\lambda_T[\beta_T(v-p_0)+\gamma_T(s-p_0) \\ +u-(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)] \end{pmatrix}\right]^2}{var\begin{pmatrix} p_0+\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+ \\ \lambda_T[\beta_T(v-p_0)+\gamma_T(s-p_0)+u-(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)] \end{pmatrix}} \\
&= \sigma_v^2 - \frac{\left[\lambda_T(\beta_T+\gamma_T)\sigma_v^2+(1-\lambda_T(\beta_T+\gamma_T))\rho^2\sigma_v^2\right]^2}{\lambda_T^2[(\beta_T+\gamma_T)^2(1-\rho^2)\sigma_v^2+\gamma_T^2\sigma_\varepsilon^2+\sigma_u^2]+\rho^2\sigma_v^2} \\
&= \sigma_v^2 - \frac{[\lambda_T(\beta_T+\gamma_T)(1-\rho^2)\sigma_v^2+\rho^2\sigma_v^2]^2}{\lambda_T(\beta_T+\gamma_T)(1-\rho^2)\sigma_v^2+\rho^2\sigma_v^2} = [1-\lambda_T(\beta_T+\gamma_T)](1-\rho^2)\sigma_v^2.
\end{aligned}
$$

The expected profit of the insider is

$$
\begin{aligned}
& E(\pi) \\
= \;& E[(v-p)x] \\
= \;& E\left(\left[v-p_0-\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)-\lambda_T\left(\begin{array}{c}\beta_T(v-p_0)+\gamma_T(s-p_0)\\ +u-(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)\end{array}\right)\right][\beta_T(v-p_0)+\xi_T(p_T-\bar{p}_T)]\right) \\
= \;& [1-\lambda_T(\beta_T+\gamma_T)]\beta_T\sigma_v^2+[1-\lambda_T(\beta_T+\gamma_T)]\xi_T\rho\sigma_v\sigma_T+[\lambda_T(\beta_T+\gamma_T)-1]\frac{\rho\sigma_v}{\sigma_T}(\beta_T\rho\sigma_v\sigma_T+\xi_T\sigma_T^2) \\
= \;& [1-\lambda_T(\beta_T+\gamma_T)]\beta_T(1-\rho^2)\sigma_v^2.
\end{aligned}
$$

The expected cost of the government is

$$
\begin{aligned}
E(c) &= E[(p-v)g] \\
&= E\left(\left[\begin{array}{c} p_0-v+\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+ \\ \lambda_T\left(\begin{array}{c}\beta_T(v-p_0)+\gamma_T(s-p_0)\\ +u-(\beta_T+\gamma_T)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)\end{array}\right)\end{array}\right][\gamma_T(s-p_0)+\alpha_T(p_T-\bar{p}_T)+\eta_T]\right) \\
&= E\{\left[\begin{array}{c}[\lambda_T(\beta_T+\gamma_T)-1](v-p_0)+\lambda_T\gamma_T\varepsilon+\lambda_T u\\ +[1-\lambda_T(\beta_T+\gamma_T)]\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)\end{array}\right][\gamma_T(s-p_0)+\alpha_T(p_T-\bar{p}_T)+\eta_T]\} \\
&= [\lambda_T(\beta_T+\gamma_T)-1](\gamma_T\sigma_v^2+\alpha_T\rho\sigma_v\sigma_T)+[1-\lambda_T(\beta_T+\gamma_T)]\frac{\rho\sigma_v}{\sigma_T}(\gamma_T\rho\sigma_v\sigma_T+\alpha_T\sigma_T^2)+\lambda_T\gamma_T^2\sigma_\varepsilon^2 \\
&= [\lambda_T(\beta_T+\gamma_T)-1]\gamma_T(1-\rho^2)\sigma_v^2+\lambda_T\gamma_T^2\sigma_\varepsilon^2.
\end{aligned}
$$

6.3 Appendix C

Proof of Proposition 3. Given his information set $\{v,s\}$, the insider solves the problem (14). Using equation (17) and (18), we compute

$$
\begin{aligned}
& E[(v-p)x|v,s] \\
= \;& E\{\left\{\left[v-p_0-\delta_1(s-p_0)-\lambda_s\left(\begin{array}{c}x+\gamma_s(s-p_0)+\alpha_s(p_T-\bar{p}_T)+\eta_s+\\ u-(\beta_s\delta_1+\xi_s+\gamma_s+\alpha_s\delta_2)(s-p_0)-\eta_s\end{array}\right)\right]x|v,s\right\} \\
= \;& [v-p_0-\delta_1(s-p_0)-\lambda_s x+\lambda_s(\beta_s\delta_1+\xi_s+\alpha_s\delta_2)(s-p_0)-\lambda_s\alpha_s E(p_T-\bar{p}_T|v,s)]\,x \\
= \;& \left[v-p_0-\lambda_s x-\lambda_s\alpha_s\frac{\rho\sigma_T}{\sigma_v}(v-p_0)+(\lambda_s\beta_s\delta_1+\lambda_s\xi_s+\lambda_s\alpha_s\delta_2-\delta_1)(s-p_0)\right]x,
\end{aligned}
$$

where $E(p_T - \bar{p}_T|v,s) = E(p_T - \bar{p}_T|v) = \frac{\rho\sigma_T}{\sigma_v}(v - p_0)$. The first-order-condition (FOC) for x gives

$$x = \frac{1-\lambda_s\alpha_s\rho\sigma_T/\sigma_v}{2\lambda_s}(v - p_0) + \frac{\lambda_s\beta_s\delta_1 + \lambda_s\xi_s + \lambda_s\alpha_s\delta_2 - \delta_1}{2\lambda_s}(s - p_0). \tag{50}$$

The second-order-condition (SOC) is $\lambda_s > 0$. Comparing equation (50) with the conjectured strategy (16) leads to

$$\beta_s = \frac{1-\lambda_s\alpha_s\frac{\rho\sigma_T}{\sigma_v}}{2\lambda_s} = \frac{1}{2\lambda_s} - \frac{\alpha_s}{2}\frac{\rho\sigma_T}{\sigma_v}, \tag{51}$$

$$\xi_s = \frac{\lambda_s\beta_s\delta_1 + \lambda_s\xi_s + \lambda_s\alpha_s\delta_2 - \delta_1}{2\lambda_s} = -\frac{\delta_1}{2\lambda_s} - \frac{\delta_1\alpha_s}{2}\frac{\rho\sigma_T}{\sigma_v} + \alpha_s\delta_2, \tag{52}$$

Using (16) and (18), the objective function of the government is derived as

$$E[\phi(p - p_T)^2 + (p - v)g|s, p_T]$$
$$= \left(\begin{array}{c} \phi\{p_0 - p_T - \lambda_s\eta_s + \lambda_s g + [\delta_1 - \lambda_s(\beta_s\delta_1 + \gamma_s + \alpha_s\delta_2)](s - p_0)\}^2 + \\ 2\phi\lambda_s\beta_s\{p_0 - p_T - \lambda_s\eta_s + \lambda_s g + [\delta_1 - \lambda_s(\beta_s\delta_1 + \gamma_s + \alpha_s\delta_2)](s - p_0)\}E[v - p_0|s, p_T] \\ +\phi\lambda_s^2\sigma_u^2 + \phi\lambda_s^2\beta_s^2 E[(v - p_0)^2|s, p_T] + \lambda_s g^2 - \lambda_s\eta_s g + \\ [\delta_1 - \lambda_s(\beta_s\delta_1 + \gamma_s + \alpha_s\delta_2)](s - p_0)g + (\lambda_s\beta_s - 1)E[v - p_0|s, p_T]g \end{array} \right),$$

where

$$E[v - p_0|s, p_T] = (1 - \delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + \delta(s - p_0),$$

$$\delta \equiv \frac{cov(v, s|p_T)}{var(s|p_T)} = \frac{(1 - \rho^2)\sigma_v^2}{(1 - \rho^2)\sigma_v^2 + \sigma_\varepsilon^2}.$$

The first-order-condition (FOC) for g gives:

$$g = \frac{1}{2\phi\lambda_s^2 + 2\lambda_s} \left(\begin{array}{c} [(1 - \lambda_s\beta_s - 2\phi\lambda_s^2\beta_s)\delta + (1 + 2\phi\lambda_s)(\lambda_s\beta_s\delta_1 + \lambda_s\gamma_s + \lambda_s\alpha_s\delta_2 - \delta_1)](s - p_0) \\ +[(1 - \lambda_s\beta_s - 2\phi\lambda_s^2\beta_s)(1 - \delta)\frac{\rho\sigma_v}{\sigma_T} + 2\phi\lambda_s](p_T - \bar{p}_T) \\ +(2\phi\lambda_s^2 + \lambda_s)\eta_s + 2\phi\lambda_s(\bar{p}_T - p_0) \end{array} \right),$$

The SOC is $2\phi\lambda_s^2 + 2\lambda_s > 0$, which holds accordingly if $\lambda_s > 0$ holds. Comparing (17) with the FOC w.r.t g, we obtain

$$\gamma_s = \frac{(1 - \lambda_s\beta_s - 2\phi\lambda_s^2\beta_s)\delta + (1 + 2\phi\lambda_s)(\lambda_s\beta_s\delta_1 + \lambda_s\gamma_s + \lambda_s\alpha_s\delta_2 - \delta_1)}{2\phi\lambda_s^2 + 2\lambda_s}, \tag{53}$$

$$\alpha_s = \frac{(1-\lambda_s\beta_s - 2\phi\lambda_s^2\beta_s)(1-\delta)\frac{\rho\sigma_v}{\sigma_T} + 2\phi\lambda_s}{2\phi\lambda_s^2 + 2\lambda_s}, \tag{54}$$

$$\eta_s = \frac{2\phi\lambda_s(\bar{p}_T - p_0) + (2\phi\lambda_s^2 + \lambda_s)\eta_s}{2\phi\lambda_s^2 + 2\lambda_s} = 2\phi(\bar{p}_T - p_0), \tag{55}$$

By the projection theorem, equation (15) gives rise to

$$p = E(v|s) + \frac{cov(v,y|s)}{var(y|s)}[y - E(y|s)] = p_0 + \delta_1(s - p_0) + \frac{cov(v,y|s)}{var(y|s)}[y - E(y|s)],$$

where

$$\begin{aligned}
& \frac{cov(v,y|s)}{var(y|s)} \\
= \; & \frac{cov(v - E(v|s), y - E(y|s))}{var(y - E(y|s))} \\
= \; & \frac{cov(v - p_0 - \delta_1(s-p_0), \beta_s(v-p_0) + \alpha_s(p_T - \bar{p}_T) + u - (\beta_s\delta_1 + \alpha_s\delta_2)(s-p_0))}{var(\beta_s(v-p_0) + \alpha_s(p_T - \bar{p}_T) + u - (\beta_s\delta_1 + \alpha_s\delta_2)(s-p_0))} \\
= \; & \frac{\begin{pmatrix} (1-\delta_1)(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)\sigma_v^2 + \\ (1-\delta_1)\alpha_s\rho\sigma_v\sigma_T + \delta_1(\beta_s\delta_1 + \alpha_s\delta_2)\sigma_\varepsilon^2 \end{pmatrix}}{\begin{pmatrix} (\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)^2\sigma_v^2 + (\beta_s\delta_1 + \alpha_s\delta_2)^2\sigma_\varepsilon^2 \\ +\alpha_s^2\sigma_T^2 + \sigma_u^2 + 2(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)\alpha_s\rho\sigma_v\sigma_T \end{pmatrix}}.
\end{aligned}$$

Combining equations (18) and the above equation gives us

$$\lambda_s = \frac{cov(v,y|s)}{var(y|s)} = \frac{\begin{pmatrix} (1-\delta_1)(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)\sigma_v^2 + \\ (1-\delta_1)\alpha_s\rho\sigma_v\sigma_T + \delta_1(\beta_s\delta_1 + \alpha_s\delta_2)\sigma_\varepsilon^2 \end{pmatrix}}{\begin{pmatrix} (\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)^2\sigma_v^2 + (\beta_s\delta_1 + \alpha_s\delta_2)^2\sigma_\varepsilon^2 \\ +\alpha_s^2\sigma_T^2 + \sigma_u^2 + 2(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)\alpha_s\rho\sigma_v\sigma_T \end{pmatrix}}. \tag{56}$$

We solve the equation system composed of (51)-(56) as a polynomial about λ_s presented in Proposition 3, where the coefficients are as follows:

$$a_4 = 4\phi^2[2-(1-\delta)\rho^2]^2\sigma_u^2, a_3 = 4\phi[2-(1-\delta)\rho^2][4-(1-\delta)\rho^2]\sigma_u^2,$$

$$a_2 = \begin{pmatrix} [4-(1-\delta)\rho^2]^2\sigma_u^2 + 4\phi^2[(1-\delta)\rho^2 - \frac{\rho\sigma_T}{\sigma_v} - 1](1-\frac{\rho\sigma_T}{\sigma_v})[(1-\delta_1)^2\sigma_v^2 + \delta_1^2\sigma_\varepsilon^2] - \\ 4\phi^2[-2\frac{\rho\sigma_T}{\sigma_v} + (1-\delta)\rho^2][2-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}][(1-\delta_1)\delta_2\sigma_v^2 - \delta_1\delta_2\sigma_\varepsilon^2 - (1-\delta_1)\rho\sigma_v\sigma_T] \\ +4\phi^2[2-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}]^2(\delta_2^2\sigma_v^2 + \delta_2^2\sigma_\varepsilon^2 + \sigma_T^2 - 2\delta_2\rho\sigma_v\sigma_T) \end{pmatrix},$$

$$a_1 = \begin{pmatrix} 2\phi\{[(1-\delta)\rho^2 - \frac{\rho\sigma_T}{\sigma_v} - 1][2-(1-\delta)\rho^2] - 2(1-\frac{\rho\sigma_T}{\sigma_v})\}[(1-\delta_1)^2\sigma_v^2 + \delta_1^2\sigma_\varepsilon^2] - \\ 2\phi \begin{bmatrix} \left(-2\frac{\rho\sigma_T}{\sigma_v} + (1-\delta)\rho^2\right)(1-\delta)\frac{\rho\sigma_v}{\sigma_T} \\ -(1-\delta)\rho^2\left(2-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}\right) \end{bmatrix} [(1-\delta_1)\delta_2\sigma_v^2 - \delta_1\delta_2\sigma_\varepsilon^2 - (1-\delta_1)\rho\sigma_v\sigma_T] \\ +4\phi[2-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}](1-\delta)\frac{\rho\sigma_v}{\sigma_T}(\delta_2^2\sigma_v^2 + \delta_2^2\sigma_\varepsilon^2 + \sigma_T^2 - 2\delta_2\rho\sigma_v\sigma_T) \end{pmatrix},$$

$$a_0 = \begin{pmatrix} -2\left[2-(1-\delta)\rho^2\right]\left[(1-\delta_1)^2\sigma_v^2 + \delta_1^2\sigma_\varepsilon^2\right] + \\ (1-\delta)^2\rho^2\frac{\rho\sigma_v}{\sigma_T}\left[(1-\delta_1)\delta_2\sigma_v^2 - \delta_1\delta_2\sigma_\varepsilon^2 - (1-\delta_1)\rho\sigma_v\sigma_T\right] \\ +(1-\delta)^2\frac{\rho^2\sigma_v^2}{\sigma_T^2}(\delta_2^2\sigma_v^2 + \delta_2^2\sigma_\varepsilon^2 + \sigma_T^2 - 2\delta_2\rho\sigma_v\sigma_T) \end{pmatrix}.$$

By substitions, we solve other parameters as functions of λ_s listed in Proposition 3.

The expected price volatility can be computed by

$$\begin{aligned}
& E[(p-p_T)^2] \\
= \; & E\begin{bmatrix} p_0 + \delta_1(s-p_0) + \lambda_s\beta_s(v-p_0) + \lambda_s\alpha_s(p_T - \bar{p}_T) \\ +\lambda_s u - \lambda_s(\beta_s\delta_1 + \alpha_s\delta_2)(s-p_0) - p_T \end{bmatrix}^2 \\
= \; & E\begin{bmatrix} (\lambda_s\beta_s + \delta_1 - \lambda_s\beta_s\delta_1 - \lambda_s\alpha_s\delta_2)(v-p_0) + (\delta_1 - \lambda_s\beta_s\delta_1 - \lambda_s\alpha_s\delta_2)\varepsilon \\ +(p_0 - \bar{p}_T) + (\lambda_s\alpha_s - 1)(p_T - \bar{p}_T) + \lambda_s u \end{bmatrix}^2 \\
= \; & \begin{bmatrix} (\lambda_s\beta_s + \delta_1 - \lambda_s\beta_s\delta_1 - \lambda_s\alpha_s\delta_2)^2\sigma_v^2 + (\delta_1 - \lambda_s\beta_s\delta_1 - \lambda_s\alpha_s\delta_2)^2\sigma_\varepsilon^2 + (\lambda_s\alpha_s - 1)^2\sigma_T^2 \\ +\lambda_s^2\sigma_u^2 + 2(\lambda_s\beta_s + \delta_1 - \lambda_s\beta_s\delta_1 - \lambda_s\alpha_s\delta_2)(\lambda_s\alpha_s - 1)\rho\sigma_v\sigma_T + (p_0 - \bar{p}_T)^2 \end{bmatrix} \\
= \; & \begin{pmatrix} \lambda_s^2 \begin{bmatrix} (\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)^2\sigma_v^2 + (\beta_s\delta_1 + \alpha_s\delta_2)^2\sigma_\varepsilon^2 + \\ 2(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)\alpha_s\rho\sigma_v\sigma_T + \alpha_s^2\sigma_T^2 + \sigma_u^2 \end{bmatrix} + \\ [\delta_1^2 + 2\lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)\delta_1]\sigma_v^2 + [\delta_1^2 - 2\lambda_s(\beta_s\delta_1 + \alpha_s\delta_2)\delta_1]\sigma_\varepsilon^2 + \\ (1-2\lambda_s\alpha_s)\sigma_T^2 + 2[(\lambda_s\alpha_s - 1)\delta_1 - \lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)]\rho\sigma_v\sigma_T + (p_0 - \bar{p}_T)^2 \end{pmatrix} \\
= \; & \begin{pmatrix} \left[\delta_1^2 + \lambda_s(1+\delta_1)(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)\right]\sigma_v^2 + [\delta_1^2 - \lambda_s\delta_1(\beta_s\delta_1 + \alpha_s\delta_2)]\sigma_\varepsilon^2 + \\ [\lambda_s\alpha_s(1+\delta_1) - 2\delta_1 - 2\lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)]\rho\sigma_v\sigma_T + (1-2\lambda_s\alpha_s)\sigma_T^2 + (p_0 - \bar{p}_T)^2 \end{pmatrix}.
\end{aligned}$$

Using the projection theorem, we have that

$$
\begin{aligned}
var(v|p) &= var(v) - \frac{[cov(v,p)]^2}{var(p)} \\
&= var(v) - \frac{\left[cov\begin{pmatrix} v, p_0 + \delta_1(s-p_0) + \lambda_s[\beta_s(v-p_0) + \alpha_s(p_T - \bar{p}_T) \\ +u - (\beta_s\delta_1 + \alpha_s\delta_2)(s-p_0)] \end{pmatrix}\right]^2}{var\begin{pmatrix} p_0 + \delta_1(s-p_0) + \lambda_s[\beta_s(v-p_0) + \alpha_s(p_T - \bar{p}_T) + u \\ -(\beta_s\delta_1 + \alpha_s\delta_2)(s-p_0)] \end{pmatrix}} \\
&= \sigma_v^2 - \frac{\begin{pmatrix} [\delta_1 + \lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)]\sigma_v^2 \\ +\lambda_s\alpha_s\rho\sigma_v\sigma_T \end{pmatrix}^2}{\begin{pmatrix} [\delta_1^2 + \lambda_s(1+\delta_1)(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)]\sigma_v^2 + [\delta_1^2 - \lambda_s\delta_1(\beta_s\delta_1 + \alpha_s\delta_2)]\sigma_\varepsilon^2 \\ +\lambda_s(1+\delta_1)\alpha_s\rho\sigma_v\sigma_T \end{pmatrix}} \\
&= \frac{\begin{pmatrix} \lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)[1 - \delta_1 - \lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)]\sigma_v^2 + [\delta_1^2 - \lambda_s\delta_1(\beta_s\delta_1 \\ +\alpha_s\delta_2)]\sigma_\varepsilon^2 + \lambda_s[1 - \delta_1 - 2\lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)]\alpha_s\rho\sigma_v\sigma_T - \lambda_s^2\alpha_s^2\rho^2\sigma_T^2 \end{pmatrix}}{\begin{pmatrix} [\delta_1^2 + \lambda_s(1+\delta_1)(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)]\sigma_v^2 + [\delta_1^2 - \lambda_s\delta_1(\beta_s\delta_1 + \alpha_s\delta_2)]\sigma_\varepsilon^2 \\ +\lambda_s(1+\delta_1)\alpha_s\rho\sigma_v\sigma_T \end{pmatrix}}\sigma_v^2.
\end{aligned}
$$

The expected profit of the insider with disclosure of the noisy signal is

$$
\begin{aligned}
E(\pi) &= E[(v-p)x] \\
&= E\{(v - p_0 - \delta_1(s-p_0) - \lambda_s[\beta_s(v-p_0) + \alpha_s(p_T - \bar{p}_T) - (\beta_s\delta_1 + \alpha_s\delta_2)(s-p_0) + u]) \\
&\quad [\beta_s(v-p_0) + \xi_s(s-p_0)]\} \\
&= E\{([1 - \delta_1 - \lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)](v-p_0) + [\lambda_s(\beta_s\delta_1 + \alpha_s\delta_2) - \delta_1]\varepsilon - \lambda_s\alpha_s(p_T - \bar{p}_T) \\
&\quad -\lambda_s u)[(\beta_s + \xi_s)(v-p_0) + \xi_s\varepsilon]\} \\
&= [1 - \delta_1 - \lambda_s(\beta_s - \beta_s\delta_1 - \alpha_s\delta_2)](\beta_s + \xi_s)\sigma_v^2 + [\lambda_s(\beta_s\delta_1 + \alpha_s\delta_2) - \delta_1]\xi_s\sigma_\varepsilon^2 \\
&\quad -\lambda_s\alpha_s(\beta_s + \xi_s)\rho\sigma_v\sigma_T.
\end{aligned}
$$

The expression for the expected cost of the government is found as follows:

$$
\begin{aligned}
& E(c) \\
= \; & E[(p-v)g] \\
= \; & E\left[\begin{array}{c} p_0+\delta_1(s-p_0)-v+ \\ \lambda_s\left(\beta_s(v-p_0)+\alpha_s(p_T-\bar{p}_T)-(\beta_s\delta_1+\alpha_s\delta_2)(s-p_0)+u\right) \end{array}\right][\gamma_s(s-p_0)+\alpha_s(p_T-\bar{p}_T)+\eta_s] \\
= \; & \left(\begin{array}{c} [\lambda_s(\beta_s-\beta_s\delta_1-\alpha_s\delta_2)+\delta_1-1](\gamma_s\sigma_v^2+\alpha_s\rho\sigma_v\sigma_T)+ \\ [\delta_1-\lambda_s(\beta_s\delta_1+\alpha_s\delta_2)]\gamma_s\sigma_\varepsilon^2+\lambda_s\alpha_s\gamma_s\rho\sigma_v\sigma_T+\lambda_s\alpha_s^2\sigma_T^2 \end{array}\right).
\end{aligned}
$$

6.4 Appendix D

Proof of Proposition 4. Given his information set $\{v, p_T, s\}$, the insider solves the problem (19). Using equation (22) and (23), we compute

$$
\begin{aligned}
& E[(v-p)x|v,p_T,s] \\
= \; & E\left[\left(\begin{array}{c} v-p_0-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)-\delta(s-p_0) \\ -\lambda_{s,T}\left(\begin{array}{c} x+\gamma_{s,T}(s-p_0)+\alpha_{s,T}(p_T-\bar{p}_T)+\eta_{s,T}+u \\ -\beta_{s,T}[(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\delta(s-p_0)] \\ -(\xi_{s,T}^{(1)}+\gamma_{s,T})(s-p_0)-(\xi_{s,T}^{(2)}+\alpha_{s,T})(p_T-\bar{p}_T)-\eta_{s,T} \end{array}\right) \end{array}\right)x|v,p_T,s\right] \\
= \; & \left(\begin{array}{c} v-p_0-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)-\delta(s-p_0) \\ -\lambda_{s,T}\left[x-\left(\beta_{s,T}(1-\delta)\frac{\rho\sigma_v}{\sigma_T}+\xi_{s,T}^{(2)}\right)(p_T-\bar{p}_T)-(\beta_{s,T}\delta+\xi_{s,T}^{(1)})(s-p_0)\right] \end{array}\right)x.
\end{aligned}
$$

The first-order-condition (FOC) for x gives

$$
x=\frac{1}{2\lambda_{s,T}}\left\{\begin{array}{c} v-p_0+\left[(\lambda_{s,T}\beta_{s,T}-1)(1-\delta)\frac{\rho\sigma_v}{\sigma_T}+\lambda_{s,T}\xi_{s,T}^{(2)}\right](p_T-\bar{p}_T) \\ +\left[(\lambda_{s,T}\beta_{s,T}-1)\delta+\lambda_{s,T}\xi_{s,T}^{(1)}\right](s-p_0) \end{array}\right\}. \qquad (57)
$$

The second-order-condition (SOC) is $\lambda_{s,T}>0$. Comparing equation (57) with the conjectured strategy (21) leads to

$$\beta_{s,T} = \frac{1}{2\lambda_{s,T}}, \tag{58}$$

$$\xi^{(1)}_{s,T} = \frac{(\lambda_{s,T}\beta_{s,T}-1)\delta + \lambda_{s,T}\xi^{(1)}_{s,T}}{2\lambda_{s,T}} = -\frac{\delta}{2\lambda_{s,T}}, \tag{59}$$

$$\xi^{(2)}_{s,T} = \frac{(\lambda_{s,T}\beta_{s,T}-1)(1-\delta)\frac{\rho\sigma_v}{\sigma_T} + \lambda_{s,T}\xi^{(2)}_{s,T}}{2\lambda_{s,T}} = -\frac{1-\delta}{2\lambda_{s,T}}\frac{\rho\sigma_v}{\sigma_T}. \tag{60}$$

Using (21) and (23), the objective function of the government is derived as

$$E[\phi(p-p_T)^2 + (p-v)g|s,p_T]$$
$$= \left(\begin{array}{c} \phi \left(\begin{array}{c} p_0 - p_T - \lambda_{s,T}\eta_{s,T} + \lambda_{s,T} g + \left[(1-\lambda_{s,T}\beta_{s,T})\delta - \lambda_{s,T}\gamma_{s,T}\right](s-p_0) \\ + \left[(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T} - \lambda_{s,T}\alpha_{s,T}\right](p_T - \bar{p}_T) \end{array} \right)^2 \\ +\phi\lambda^2_{s,T}\beta^2_{s,T}E[(v-p_0)^2|s,p_T] + \phi\lambda^2_{s,T}\sigma^2_u \\ +2\phi\lambda_{s,T}\beta_{s,T} \left(\begin{array}{c} p_0 - p_T - \lambda_{s,T}\eta_{s,T} + \left[(1-\lambda_{s,T}\beta_{s,T})\delta - \lambda_{s,T}\gamma_{s,T}\right](s-p_0) \\ + \left[(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T} - \lambda_{s,T}\alpha_{s,T}\right](p_T-\bar{p}_T) + \lambda_{s,T} g \end{array} \right) E[v-p_0|s,p_T] \\ + \left(\begin{array}{c} (\lambda_{s,T}\beta_{s,T}-1)E[v-p_0|s,p_T] + \left[(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T} - \lambda_{s,T}\alpha_{s,T}\right](p_T-\bar{p}_T) \\ + \left[(1-\lambda_{s,T}\beta_{s,T})\delta - \lambda_{s,T}\gamma_{s,T}\right](s-p_0) + \lambda_{s,T} g - \lambda_{s,T}\eta_{s,T} \end{array} \right) g \end{array} \right),$$

where

$$E[v-p_0|s,p_T] = (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) + \delta(s-p_0),$$

$$\delta \equiv \frac{cov(v,s|p_T)}{var(s|p_T)} = \frac{(1-\rho^2)\sigma_v^2}{(1-\rho^2)\sigma_v^2 + \sigma_\varepsilon^2}.$$

The first-order-condition (FOC) for g gives:

$$g = \frac{1}{2\phi\lambda^2_{s,T} + 2\lambda_{s,T}} \left(\begin{array}{c} \left(-2\phi\lambda_{s,T}\delta + (1+2\phi\lambda_{s,T})\lambda_{s,T}\gamma_{s,T}\right)(s-p_0) \\ + \left(2\phi\lambda_{s,T}\left[1-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}\right] + (1+2\phi\lambda_{s,T})\lambda_{s,T}\alpha_{s,T}\right)(p_T-\bar{p}_T) \\ +(2\phi\lambda^2_{s,T} + \lambda_{s,T})\eta_{s,T} + 2\phi\lambda_{s,T}(\bar{p}_T - p_0) \end{array} \right),$$

The SOC is $2\phi\lambda^2_{s,T} + 2\lambda_{s,T} > 0$, which holds accordingly if $\lambda_{s,T} > 0$ holds. Comparing equation (22) with the FOC w.r.t g, we obtain

$$\gamma_{s,T} = \frac{-2\phi\lambda_{s,T}\delta + (1+2\phi\lambda_{s,T})\lambda_{s,T}\gamma_{s,T}}{2\phi\lambda_{s,T}^2 + 2\lambda_{s,T}} = -2\phi\delta, \tag{61}$$

$$\alpha_{s,T} = \frac{2\phi\lambda_{s,T}\left[1-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}\right] + (1+2\phi\lambda_{s,T})\lambda_{s,T}\alpha_{s,T}}{2\phi\lambda_{s,T}^2 + 2\lambda_{s,T}} = 2\phi\left[1-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}\right], \tag{62}$$

$$\eta_{s,T} = \frac{2\phi\lambda_{s,T}(\bar{p}_T - p_0) + (2\phi\lambda_{s,T}^2 + \lambda_{s,T})\eta_{s,T}}{2\phi\lambda_{s,T}^2 + 2\lambda_{s,T}} = 2\phi(\bar{p}_T - p_0), \tag{63}$$

By the projection theorem, equation (20) gives rise to

$$\begin{aligned} p &= E(v|p_T,s) + \frac{cov(v,y|p_T,s)}{var(y|p_T,s)}[y - E(y|p_T,s)] \\ &= p_0 + (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + \delta(s-p_0) + \frac{cov(v,y|p_T,s)}{var(y|p_T,s)}[y - E(y|p_T,s)], \end{aligned}$$

where

$$\begin{aligned} & \frac{cov(v,y|p_T,s)}{var(y|p_T,s)} \\ =\ & \frac{cov(v - E(v|p_T,s), y - E(y|p_T,s))}{var(y - E(y|p_T,s))} \\ =\ & \frac{cov\begin{pmatrix} (1-\delta)(v-p_0) - \delta\varepsilon - (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T), \\ \beta_{s,T}(1-\delta)(v-p_0) - \beta_{s,T}\delta\varepsilon - \beta_{s,T}(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) \end{pmatrix}}{var\left(\beta_{s,T}(1-\delta)(v-p_0) - \beta_{s,T}\delta\varepsilon - \beta_{s,T}(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + u\right)} \\ =\ & \frac{\beta_{s,T}\left[\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2\right]}{\beta_{s,T}^2\left[\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2\right] + \sigma_u^2}. \end{aligned}$$

Combining (23) and the above equation gives rise to

$$\lambda_{s,T} = \frac{cov(v,y|s,p_T)}{var(y|s,p_T)} = \frac{\beta_{s,T}\left[\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2\right]}{\beta_{s,T}^2\left[\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2\right] + \sigma_u^2}. \tag{64}$$

Substituting (58) into (64) leads to the expression for $\lambda_{s,T}$ presented in Proposition 4. By substitutions, we have those expressions for $(\beta_{s,T}, \xi_{s,T}^{(1)}, \xi_{s,T}^{(2)}, \gamma_{s,T}, \alpha_{s,T}, \eta_{s,T})$ listed in Proposition 4.

The expected price volatility can be computed by

$$
\begin{aligned}
& E[(p-p_T)^2] \\
= \; & E\left[\begin{array}{c} p_0 - p_T + (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T - \bar{p}_T) + \delta(s-p_0) \\ +\lambda_{s,T}\left[\beta_{s,T}(v-p_0) + u - \beta_{s,T}(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) - \beta_{s,T}\delta(s-p_0)\right] \end{array}\right]^2 \\
= \; & E\left[\begin{array}{c} p_0 - \bar{p}_T + \left[(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T} - 1\right](p_T - \bar{p}_T) \\ + \left[(1-\lambda_{s,T}\beta_{s,T})\delta + \lambda_{s,T}\beta_{s,T}\right](v-p_0) + (1-\lambda_{s,T}\beta_{s,T})\delta\varepsilon + \lambda_{s,T}u \end{array}\right]^2 \\
= \; & (p_0-\bar{p}_T)^2 + \lambda_{s,T}\beta_{s,T}\left[\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2\right] + \delta\sigma_v^2 + \sigma_T^2 - 2\rho\sigma_v\sigma_T + (1-\delta)\rho^2\sigma_v^2 \\
= \; & \left(\begin{array}{c} (p_0-\bar{p}_T)^2 + \frac{1}{2}\left[-\left(1-\rho^2\right)(1-\delta)\delta\sigma_v^2 + \delta^2\sigma_\varepsilon^2\right] \\ + \left[\frac{1}{2}\left(1-\rho^2\right)(1-\delta) + \delta + (1-\delta)\rho^2\right]\sigma_v^2 + \sigma_T^2 - 2\rho\sigma_v\sigma_T \end{array}\right) \\
= \; & \left[\frac{1}{2}(1-\delta)(1+\rho^2) + \delta\right]\sigma_v^2 + \sigma_T^2 - 2\rho\sigma_v\sigma_T + (p_0-\bar{p}_T)^2,
\end{aligned}
$$

where the fifth equality comes from employing δ. By the projection theorem, we have that

$$
\begin{aligned}
var(v|p) \; = \; & var(v) - \frac{[cov(v,p)]^2}{var(p)} \\
= \; & var(v) - \frac{\left[cov\left(\begin{array}{c} v, p_0 + (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) + \delta(s-p_0) + \lambda_{s,T}u \\ +\lambda_{s,T}\beta_{s,T}\left[v - p_0 - (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) - \delta(s-p_0)\right] \end{array}\right)\right]^2}{var\left(\begin{array}{c} p_0 + (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) + \delta(s-p_0) + \lambda_{s,T}u \\ +\lambda_{s,T}\beta_{s,T}\left[v - p_0 - (1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T) - \delta(s-p_0)\right] \end{array}\right)} \\
= \; & \sigma_v^2 - \frac{\left[(1-\delta)\rho^2 + 1 + \delta\right]^2\sigma_v^4}{2\left[\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2 + \delta^2\sigma_\varepsilon^2\right] + 4\delta\sigma_v^2 + 4(1-\delta)\rho^2\sigma_v^2} \\
= \; & \frac{(1-\rho^4)(1-\delta)^2\sigma_v^2 + 2\delta^2\sigma_\varepsilon^2}{2\left(1-\rho^2\right)\delta^2\sigma_v^2 + 2\left(1+\rho^2\right)\sigma_v^2 + 2\delta^2\sigma_\varepsilon^2}\sigma_v^2.
\end{aligned}
$$

The expected profit of the insider with disclosure of the noisy signal is

$$\begin{aligned}
E(\pi) &= E[(v-p)x] \\
&= E\left[\begin{pmatrix} v-p_0-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)-\delta(s-p_0)-\lambda_{s,T}u \\ -\lambda_{s,T}\beta_{s,T}\left[v-p_0-(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)-\delta(s-p_0)\right] \end{pmatrix}\begin{pmatrix} \beta_{s,T}(v-p_0) \\ +\xi^{(1)}_{s,T}(s-p_0) \\ +\xi^{(2)}_{s,T}(p_T-\bar{p}_T) \end{pmatrix}\right] \\
&= E\left[\begin{pmatrix} (1-\lambda_{s,T}\beta_{s,T})(1-\delta)(v-p_0)-(1-\lambda_{s,T}\beta_{s,T})\delta\varepsilon \\ -(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)-\lambda_{s,T}u \end{pmatrix}\begin{pmatrix} (\beta_{s,T}+\xi^{(1)}_{s,T})(v-p_0) \\ +\xi^{(1)}_{s,T}\varepsilon+\xi^{(2)}_{s,T}(p_T-\bar{p}_T) \end{pmatrix}\right] \\
&= \frac{1}{2}\beta_{s,T}\left[\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2+\delta^2\sigma_\varepsilon^2\right] \\
&= \frac{\sigma_u\sqrt{\left(1-\rho^2\right)(1-\delta)^2\sigma_v^2+\delta^2\sigma_\varepsilon^2}}{2}.
\end{aligned}$$

The expression for the expected cost of the government is found as follows:

$$\begin{aligned}
& E(c) \\
=\; & E[(p-v)g] \\
=\; & E\left[\begin{pmatrix} (\lambda_{s,T}\beta_{s,T}-1)(v-p_0)+(1-\lambda_{s,T}\beta_{s,T})\delta(s-p_0) \\ +(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\lambda_{s,T}u \end{pmatrix}\begin{pmatrix} \gamma_{s,T}(s-p_0) \\ +\alpha_{s,T}(p_T-\bar{p}_T)+\eta_{s,T} \end{pmatrix}\right] \\
=\; & E\left[\begin{pmatrix} (\lambda_{s,T}\beta_{s,T}-1)(1-\delta)(v-p_0)+(1-\lambda_{s,T}\beta_{s,T})\delta\varepsilon \\ +(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T}(p_T-\bar{p}_T)+\lambda_{s,T}u \end{pmatrix}\begin{pmatrix} \gamma_{s,T}(v-p_0)\ +\gamma_{s,T}\varepsilon \\ +\alpha_{s,T}(p_T-\bar{p}_T)+\eta_{s,T} \end{pmatrix}\right] \\
=\; & \begin{pmatrix} (\lambda_{s,T}\beta_{s,T}-1)(1-\delta)\gamma_{s,T}\sigma_v^2+(1-\lambda_{s,T}\beta_{s,T})\delta\gamma_{s,T}\sigma_\varepsilon^2+(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T}\alpha_{s,T}\sigma_T^2 \\ +\left[(\lambda_{s,T}\beta_{s,T}-1)(1-\delta)\alpha_{s,T}+(1-\lambda_{s,T}\beta_{s,T})(1-\delta)\frac{\rho\sigma_v}{\sigma_T}\gamma_{s,T}\right]\rho\sigma_v\sigma_T \end{pmatrix} \\
=\; & \phi\left[\left(1-\rho^2\right)(1-\delta)\delta\sigma_v^2-\delta^2\sigma_\varepsilon^2\right]=0.
\end{aligned}$$

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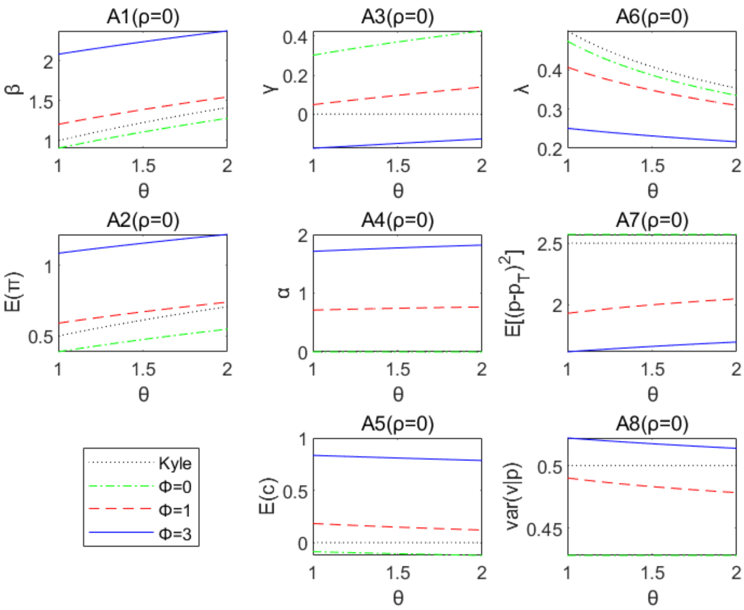

Figure 1: The baseline model with $\rho = 0$. In each panel, the dotted black line represents the standard Kyle setting without government intervention, the dotted dashed green line represents the case with $\phi = 0$, the dashed red line represents the one with $\phi = 1$, and the solid blue line represents the one with $\phi = 3$.

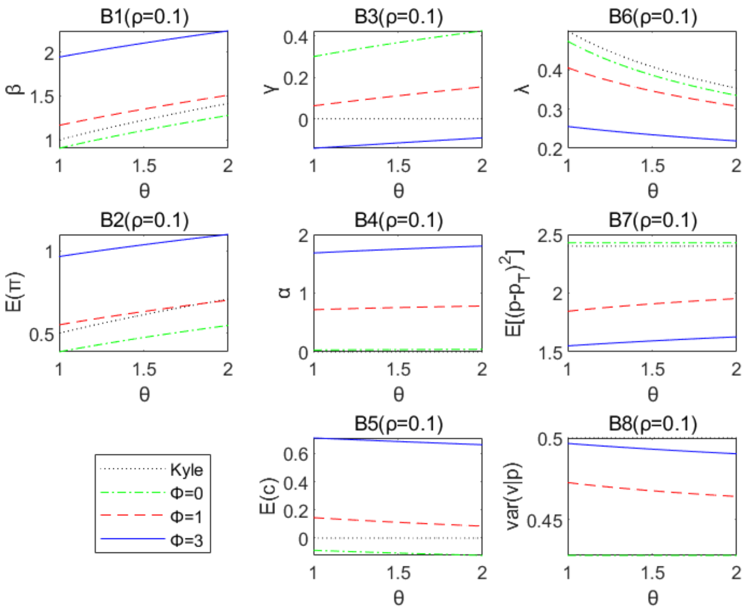

Figure 2: The baseline model with $\rho = 0.1$. In each panel, the dotted black line represents the standard Kyle setting without government intervention, the dotted dashed green line represents the case with $\phi = 0$, the dashed red line represents the one with $\phi = 1$, and the solid blue line represents the one with $\phi = 3$.

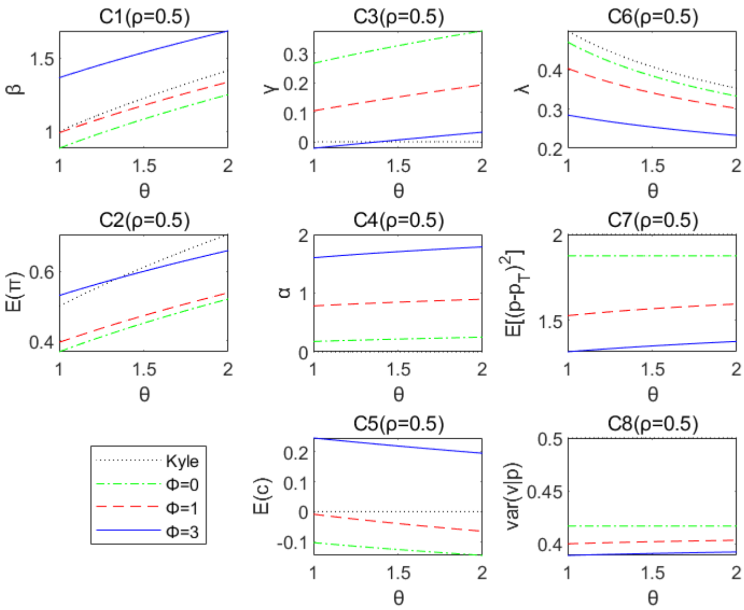

Figure 3: The baseline model with $\rho = 0.5$. In each panel, the dotted black line represents the standard Kyle setting without government intervention, the dotted dashed green line represents the case with $\phi = 0$, the dashed red line represents the one with $\phi = 1$, and the solid blue line represents the one with $\phi = 3$.

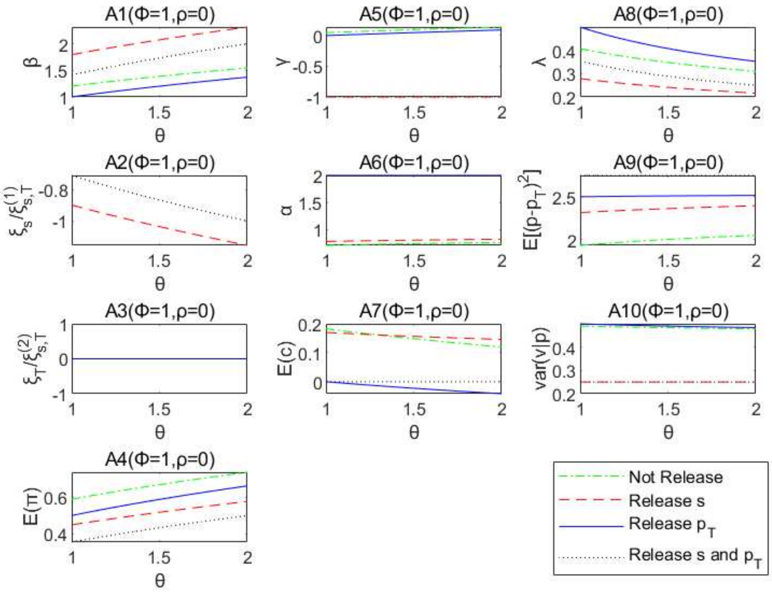

Figure 4: Comparisions: $\phi = 1$ and $\rho = 0$. In each panel, the dotted dashed green line represents the case without information disclosure, the dashed red line represents the one of releasing s, the solid blue line represents the one of releasing p_T, and the dotted black line represents the one of releasing s and p_T.

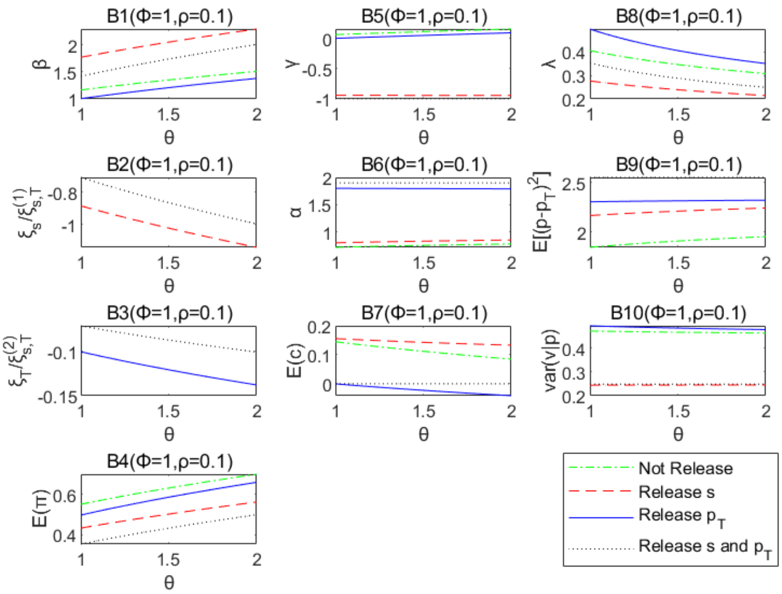

Figure 5: Comparisions: $\phi = 1$ and $\rho = 0.1$. In each panel, the dotted dashed green line represents the case without information disclosure, the dashed red line represents the one of releasing s, the solid blue line represents the one of releasing p_T, and the dotted black line represents the one of releasing s and p_T.

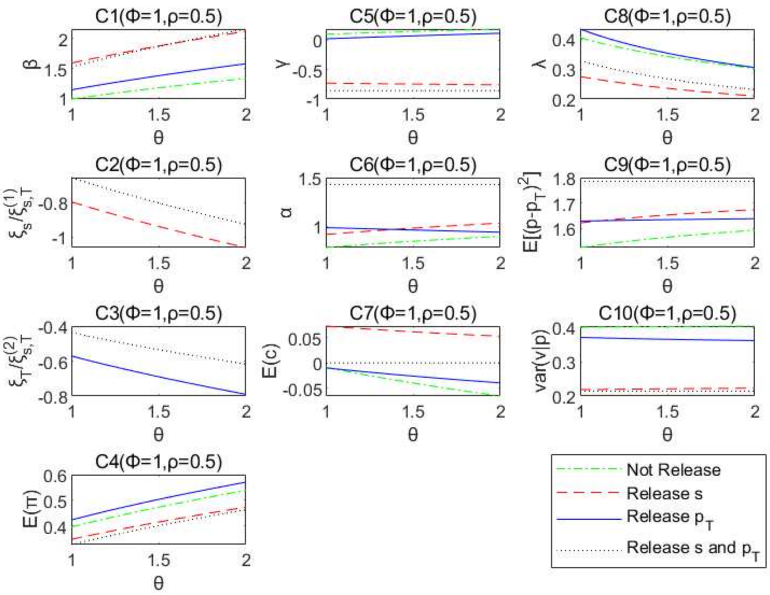

Figure 6: Comparisions: $\phi = 1$ and $\rho = 0.5$. In each panel, the dotted dashed green line represents the case without information disclosure, the dashed red line represents the one of releasing s, the solid blue line represents the one of releasing p_T, and the dotted black line represents the one of releasing s and p_T.

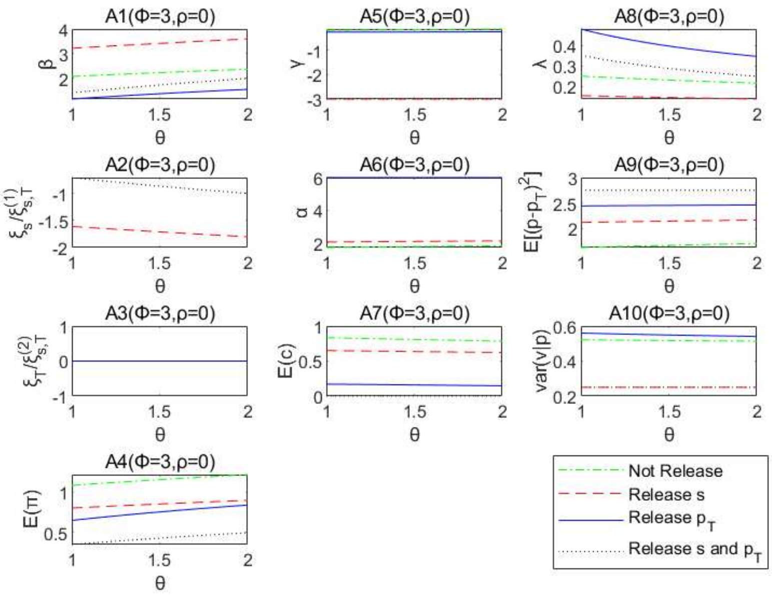

Figure 7: Comparisions: $\phi = 3$ and $\rho = 0$. In each panel, the dotted dashed green line represents the case without information disclosure, the dashed red line represents the one of releasing s, the solid blue line represents the one of releasing p_T, and the dotted black line represents the one of releasing s and p_T.

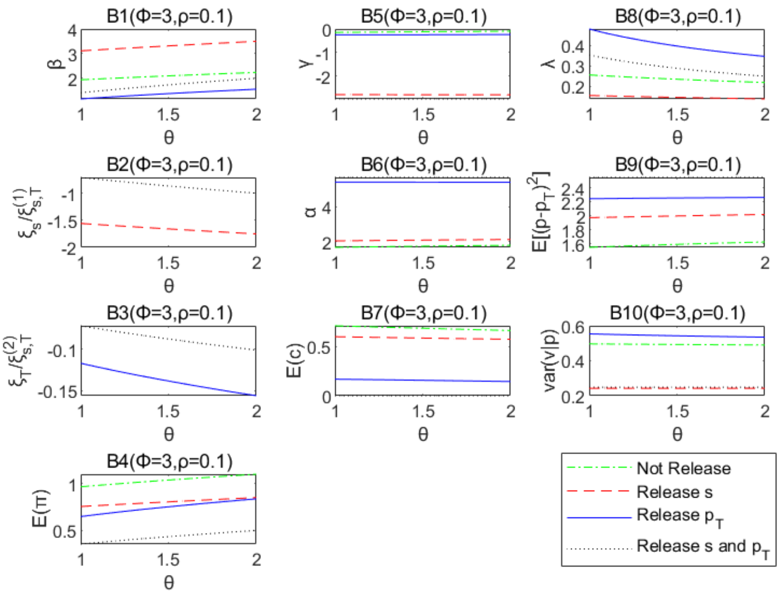

Figure 8: Comparisions: $\phi = 3$ and $\rho = 0.1$. In each panel, the dotted dashed green line represents the case without information disclosure, the dashed red line represents the one of releasing s, the solid blue line represents the one of releasing p_T, and the dotted black line represents the one of releasing s and p_T.

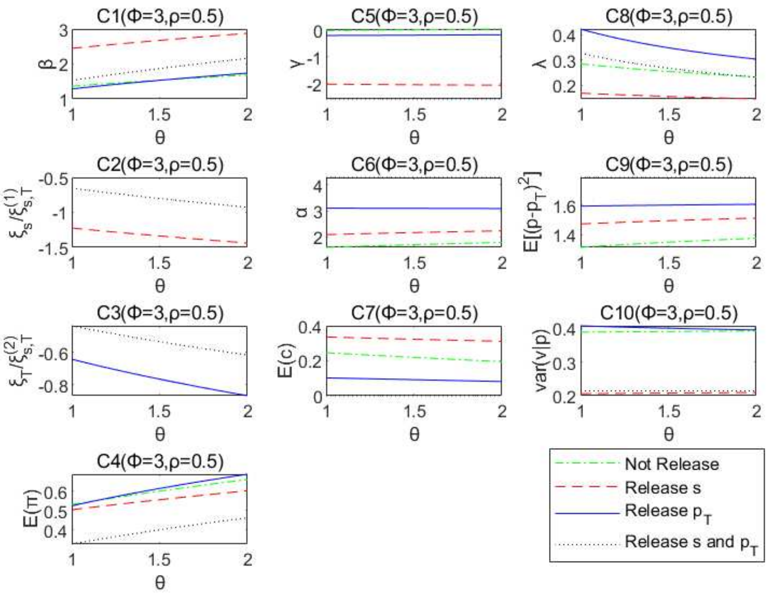

Figure 9: Comparisions: $\phi = 3$ and $\rho = 0.5$. In each panel, the dotted dashed green line represents the case without information disclosure, the dashed red line represents the one of releasing s, the solid blue line represents the one of releasing p_T, and the dotted black line represents the one of releasing s and p_T.