China’s Model of Managing the Financial System*

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Abstract

China’s economic model involves active government intervention in financial markets. We develop a theoretical framework that anchors government intervention on a mission to prevent market breakdown and volatility explosion caused by the reluctance of short-term investors to trade against noise traders. In the presence of information frictions the government can alter market dynamics by making noise in its intervention program an additional factor driving asset prices, and can divert investor attention toward acquiring information about this noise factor rather than fundamentals (as a result of complementarity in investors’ information acquisition). Through this latter channel, the widely-adopted objective of government intervention to reduce asset price volatility may exacerbate, rather than improve, information efficiency of asset prices.

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1 Introduction

China has experienced rapid growth in the last three decades, and has become an important part of the global economy. Its underdeveloped financial system, however, has recently been a source of great anxiety for investors and policy makers across the world. This anxiety has been driven, in part, by the turmoil in its stock markets in 2015, the sudden devaluation of its currency in 2015 that raised doubts about the government’s ability to manage its exchange rate, its overheating housing market, and its growing leverage at a national level. To fully understand these issues, it is important to systematically examine the distinct structures and features of the Chinese economy and financial system.

A striking feature of the Chinese financial system is how actively China’s government manages it in order to promote financial stability. The government does so through frequent policy changes, using a wide array of policy tools ranging from changes in interest rates and bank reserve requirements to stamp taxes on stock trading, suspensions and quota controls on IPO issuances, modifications to rules on mortgage rates and first payment requirements, providing public guidance through official media outlets, and direct trading in asset markets through government sponsored institutions.1 For example, during China’s stock market turmoil in summer 2015, the Chinese government organized a “national team” of securities firms to backstop the market meltdown, as documented by Huang, Miao and Wang (2016). As potential justification for such large-scale, active interventions, China’s financial markets are highly speculative,2 and largely populated by inexperienced retail investors.3 Its markets experience high price volatility and the highest turnover rate among major stock markets in the world.4 In addition, the Chinese government’s paternalistic culture motivates it to view stabilizing markets and protecting retail investors as a policy objective. While highly relevant

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1See Song and Xiong (2018) for a review of these intervention policies.

2Carpenter and Whitelaw (2017) review an extensive literature on the so-called A-share premium puzzle with the prices of A shares issued by publicly listed Chinese companies to domestic investors trading at substantial price premia and much higher turnover rates, relative to B shares and H shares issued by the same companies to foreign investors. Mei, Scheinkman, and Xiong (2009) attribute this phenomenon to speculative trading of Chinese investors. Furthermore, Xiong and Yu (2011) document a spectacular bubble in Chinese warrants from 2005-2008, during which Chinese investors actively traded a set of deep out-of-money put warrants that had zero fundamental value.

3In 2008, the China Securities Regulatory Commission (CSRC) issued the China Capital Markets Development Report, which shows that in 2007, retail accounts with balance less than one million RMB contributed to 45.9% of stock positions and 73.6% of trading volume on the Shenzhen Stock Exchange. This report particularly highlights speculative behavior of these small investors and the lack of mature institutional investors as important characteristics of China’s stock market.

for investors and policy makers, the impact of such active government intervention in asset markets might have unintended consequences. Understanding its tradeoffs, consequently, is important not only for promoting stability in the Chinese financial system, but also for navigating the post financial crisis environment, in which even governments in the OECD may be prepared to intervene after episodes of high volatility or severe market dysfunction.

We develop a conceptual framework to analyze these interventions, and, specifically, focus on government intervention through direct trading against noise traders in asset markets. To do this, we build upon the standard noisy rational expectations models of asset markets with asymmetric information, such as Grossman and Stiglitz (1980) and Hellwig (1980), and their dynamic versions, including He and Wang (1995) and Allen, Morris, and Shin (2006). In these models, noise traders create short-term price fluctuations and a group of rational investors, each acquiring a piece of private information, trade against these noise traders to provide liquidity and to speculate on their private information. Our setting includes a new large player, a government, who is prepared to trade against noise traders to stabilize the market.

That the asset fundamental in our setting is unobservable stems from realistic information frictions faced by investors and policy makers in the Chinese economy. Noise traders reflect inexperienced retail investors in the Chinese markets, who contributes to price volatility and instability. The political process, hampered by informational and moral hazard frictions, introduces unintended noise into the government’s intervention, with the magnitude of this noise increasing with the intensity of government’s intervention. We assume that investors are myopic to reflect the highly speculative nature of Chinese investors. In addition, each investor has to choose between acquiring a private signal about the asset fundamental or about this government noise before trading. This information acquisition decision reflects the fixed costs and severe limits to investor attention associated with acquiring information about the Chinese economy and future government policy.

In accordance with the Chinese government’s paternalistic culture in maintaining market stability, the government in our framework adopts a weighted objective of improving information efficiency of the asset price and reducing asset price volatility. These criteria are widely applied in government intervention not only in China but also in many other countries. Even within the OECD, governments engaged in unconventional monetary policy with large-scale asset purchases during the financial crisis and subsequent recession. Conventional
wisdom posits that reducing price volatility, which is easily implementable, is consistent with a more fundamental, yet difficult to implement, objective of improving the information efficiency of asset prices to guide capital allocation. This “divine coincidence” occurs because the government’s trading against noise traders simultaneously reduces price volatility and improves price efficiency.

With these elements, we build our analysis in several steps. First, we characterize a benchmark economy in which the asset fundamental is observable to all investors and the government. In the absence of government intervention, the asset price volatility may explode and the market may break down when the volatility of noise trading becomes sufficiently high. This breakdown occurs because investors are concerned only with the short-term return from trading the asset, and their required return to providing liquidity to noise traders increases with the volatility of noise trading. This, in turn, makes the asset price more sensitive to noise trading. As a result, the volatility of the asset price rises with noise trading volatility, and may explode when it becomes sufficiently large. This further raises the return required by investors and can cause the market to break down when there does not exist any risk premium that can induce the investors to trade. The volatility explosion and the possible ultimate market breakdown introduces a role for the government intervention to stabilize the market.

We then consider an extended setting in which the asset fundamental is now unobservable to both investors and the government, but investors receive private signals about the fundamental. Simply leaning against noise traders both reduces price volatility and improves informational efficiency, our “divine coincidence.” Government interventions, however, are never perfect, and the noise created by its market intervention becomes an additional asset pricing factor, even when it fully internalizes its impact on asset prices. This can give rise to unintended consequences as this new pricing factor can distract investors from acquiring private information about the fundamental, as they may speculate about about the government’s trading noise. This speculation about the government’s noise can further mitigate the price volatility caused by noise traders, but at the cost of significantly worsening the information efficiency of the asset price. The “divine coincidence” is, consequently, overturned when investors can choose what information to acquire. This breakdown anchors on a novel channel through which intertemporal complementarity between the information acquisition decisions of small investors and the future trading behavior of a large trader enables the
large trader to influence what information the small investors acquire.

We focus on two market outcomes, which we label “fundamental-centric” and “government-centric”, respectively. In the fundamental-centric outcome, investors each acquire a private signal about the fundamental and the asset price aggregates their information to partially reveal the fundamental. The government trades against both the noise traders, to minimize their price distortion, as well as against investors, who trade based on their respective private information. In contrast, when the government-centric equilibrium arises, investors all focus on learning about the government’s noise, and share a similar belief with each other and the government about the fundamental. As a result, they tend to trade alongside the government against the noise traders, which reinforces the government’s effort to reduce price volatility and renders its intervention more effective in mitigating the price distortion of the noise traders. This reduced price volatility, however, is at the expense of asset prices being less informative about the fundamental. Whether a fundamental-centric or government-centric outcome arises depends on how intensive the government trades, and a government-centric equilibrium is more likely to occur the greater the government’s dislike of price volatility and the volatility of noise trading.

Our model delivers several key insights not only for government intervention in China, but also more generally for intervention programs in other countries. First, it demonstrates that, even in the absence of informational frictions, there can be a role for government intervention to reduce price volatility and mitigate the possibility of a market breakdown. Second, such intervention can make noise in government policy an additional factor in asset prices, which may attract the speculation of investors and distract them from acquiring private information about the fundamental. This speculation, in turn, reinforces the impact of noise in the government’s policy on asset prices. These two implications capture important observations about China’s financial markets—speculation about government policies plays a central role in driving market dynamics, and market participants devote significant attention to government policies and, to a lesser extent, to economic fundamentals.

Our paper adds to the growing literature that studies the distinct characteristics of the Chinese economy and financial system. Xu (2011) and Qian (2017) provide broad reviews of the institutional foundation of China’s economic reform since late 1970s. Building on this foundation, Song, Storesletten, and Zilibotti (2011) study how banks discriminate against private firms, which are more productive than state firms, leading to a puzzling observation
of a fast-growing country exporting capital to other countries. Li, Liu and Wang (2015) show how state firms, despite being less efficient, can earn more profits than private firms by monopolizing upstream industries and extracting rent from more liberalized downstream industries. Xiong (2018) investigates how the short-termist behavior of local governments can drive China’s leverage boom, over-investment and opaque economic statistics. Different from the focus of these studies on the roles played by the government and state firms in the Chinese economy, our paper expands the theme by highlighting the profound effects of intensive government intervention on investor speculation and asset market dynamics. A recent book by Zhu (2016) argues that there is a gigantic asset bubble in China caused by the government’s implicit guarantees, which protect investors and households against potential losses in all sorts of investments, such as housing, shadow banking products, bonds, and stocks. Without explicitly assuming government guarantees, our model provides a more subtle mechanism for paternalistic government intervention to precipitate market speculation.

This mechanism adds to the literature that studies information choice in noisy rational expectations models. Hellwig and Veldkamp (2009) demonstrate that, in settings with strategic complementarity in actions, information choices also exhibit complementarity, leading agents to choose to learn the same information as others. Ganguli and Yang (2009) and Manzano and Vives (2011) investigate the complementarity in information choice among investors when they can choose to acquire private information about supply noise versus fundamentals in static settings, and the resulting multiplicity and stability of equilibria. Farboodi and Veldkamp (2016) examine the role of investors’ acquisition of information about order flows, instead of fundamentals, in explaining the ongoing trend of increasing price informativeness and declining market liquidity in financial markets. Different from the intratemporal complementarity in information choices studied by these papers, our model highlights intertemporal complementarity of investors’ information choice with government policy, in a similar spirit to Froot, Scharfstein, and Stein (1992), who illustrate how intertemporal complementarity in information acquisition can distract investors from learning about asset fundamentals. In our model, since the government, as a large player, directly impacts asset returns through its intervention, its policy noise becomes a source of speculation for investors. By building on this intertemporal complementarity, our model further shows that the government needs to account for investors’ information choice in choosing its intervention policy.

Our paper also contributes to the literature on the financial market implications of govern-
Bond and Goldstein (2015) study the impact on information aggregation in prices when uncertain, future government intervention influences a firm’s real outcomes. Cong, Grenadier, and Hu (2017) explore the information externality of government intervention in money market mutual funds in a global games environment in which investors face strategic coordination issues and intervention changes the information publicly available to them. Angeletos, Hellwig, and Pavan (2006) and Goldstein and Huang (2016) consider information design by an informed policy maker that can send messages through its actions to coordinate the response of private agents in a global games setting. In contrast to these studies, we focus on the incentives of market participants to acquire information when there is uncertainty about the scope of government intervention in financial markets through large-scale asset purchases. Our government, by internalizing investors’ information choice, can change the information reflected in asset prices, which can be to potential detriment of market efficiency.

The paper is organized as follows. Section 2 sets up the model with perfect information, and derives the equilibria with and without government intervention. Section 3 extends the setting to incorporate information frictions, and analyzes the effects of government intervention. Section 4 concludes with some additional discussion. We cover the salient features of the equilibria under different settings in the main text, while leaving more detailed descriptions of the equilibria and the key steps for deriving them in the appendix. We also provide a separate online appendix that contains all technical proofs involved in our analysis.

2 The Basic Model with Perfect Information

In this section, we present a baseline setting with perfect information to illustrate how government intervention helps to avoid market breakdown and volatility explosion caused by the reluctance of short-term investors to trade against noise traders. Our model can be seen as a generalized version of DeLong et al. (1990). We will expand the setting in the next section to incorporate realistic information frictions.

Consider an infinite horizon economy in discrete time with infinitely many periods: $t = 0, 1, 2, \ldots$. There is a risky asset, which can be viewed as stock issued by a firm that has a stream of cash flows $D_t$ over time:

$$D_t = v_t + \sigma_D \varepsilon_t^D.$$
The components $v_t$ is a persistent component of the fundamentals, while $\varepsilon_t^D$ is independent and identical cashflow noise with a Gaussian distribution of $\mathcal{N}(0,1)$ and $\sigma_D > 0$ measures the volatility of cashflow noise.

As the literature has extensively studied the direct effects of government policies on the profitability of firms, we intend to analyze a different channel, through which government intervention can impact the market dynamics without directly affecting the firm’s cash flow. Specifically, we assume that the asset’s fundamental $v_t$ follows an exogenous AR(1) process:

$$v_t = \rho_v v_{t-1} + \sigma_v \varepsilon_t^v,$$

where $\rho_v \in (0, 1)$ measures the persistence of $v_t$, $\sigma_v > 0$ measures its volatility, and $\varepsilon_t^v \sim \mathcal{N}(0, 1)$ is independently and identically distributed shock.

In this section, we assume that at time $t$, $v_{t+1}$ is observable to all agents in the economy. This setting serves as a benchmark. We will remove this assumption in the next section to make $v_{t+1}$ unobservable to both the government and investors and discuss how government intervention affects the investors’ information acquisition.

For simplicity, suppose that there is also a riskfree asset in elastic supply that pays a constant gross interest rate $R_f > 1$. In what follows, we define $R_{t+1}$ to be the excess payoff, not percentage return, to holding the risky asset:

$$R_{t+1} = D_{t+1} + P_{t+1} - R_f P_t.$$

There are three types of agents in the asset market: noise traders, investors, and the government. We describe them below.

### 2.1 Noise Traders

Motivated by the large number of inexperienced retail investors in China’s stock markets, we assume that in each period, these inexperienced investors, whom we call noise traders,
submit exogenous market orders into the asset market. This way of modeling noise trading is standard in the market microstructure literature. We denote the quantity of their orders by $N_t$ and assume that $N_t$ is an i.i.d. process:

$$N_t = \sigma_N \varepsilon_t^N,$$

where $\sigma_N > 0$ measures the volatility of noise trading (or noise trader risk in this market), and $\varepsilon_t^N \sim \mathcal{N}(0, 1)$ is independently and identically distributed shocks to noise traders. The presence of noise traders creates incentives for other investors to trade in the asset market.

## 2.2 Investors’ Problem

There are a continuum of investors in the market who trade the asset on each date $t$. We assume that these investors are myopic. They can be thought of as living for only two periods, in which they trade in the first and consume in the second. That is, in each period a group of new investors with measure 1 join the market, replacing the group from the previous period. We index an individual investor by $i \in [0, 1]$. Investor $i$ born at date $t$ is endowed with wealth $\bar{W}$ and has constant absolute risk aversion CARA preferences with coefficient of risk aversion $\gamma$ over its next-period wealth $W_{t+1}^i$:

$$U_t^i = E \left[ \exp \left( -\gamma W_{t+1}^i \right) \mid \mathcal{F}_t \right].$$

It purchases $X_t^i$ shares of the asset and invests the rest in the riskfree asset at a constant rate $R^f$, so that $W_{t+1}^i$ is given by

$$W_{t+1}^i = R^f \bar{W} + X_t^i R_{t+1}.$$

The investors have symmetric, perfect information, and their expectations are all taken with respect to the full-information set $\mathcal{F}_t = \sigma \left( \{v_{s+1}, N_s, D_s\}_{s \leq t} \right)$ in this section. As a result of CARA preferences, an individual investor’s trading behavior is insensitive to his initial wealth level.

The assumption of investor myopia is commonly used in dynamic models of asset markets with informational frictions for simplicity, e.g., Allen, Morris, and Shin (2006) and Bacchetta and van Wincoop (2006). In our setting, this assumption also serves to capture the speculative nature of Chinese investors, which is important for generating market breakdown when noise trader risk becomes sufficiently large.
2.3 Equilibrium without Government

To facilitate our discussion, we first characterize the rational expectations equilibrium without government intervention. Specifically, we derive the equilibrium price and show formally that the market volatility explodes and ultimately markets breaks down when the noise trader risk $\sigma_N$ rises above a certain threshold.

We first conjecture a linear rational expectations equilibrium. (Appendix A verifies that there cannot be any nonlinear equilibrium.) In this equilibrium, the asset price $P_t$ is a linear function of the fundamental $v_{t+1}$ and the noise trader shock $N_t$:

$$P_t = \frac{1}{Rf - \rho_v} v_{t+1} + p_N N_t,$$

where $\frac{1}{Rf - \rho_v} v_{t+1}$ is the expected present value of cashflows from the asset. With this conjected price function, an investor faces at time $t$ price risk in holding the asset from fluctuations of both $v_{t+1}$ and $N_t$, as given by

$$\text{Var}(R_{t+1}|F_t) = \sigma_D^2 + \left( \frac{1}{Rf - \rho_v} \right)^2 \sigma_v^2 + p_N^2 \sigma_N^2.$$

CARA utility with normally distributed payoffs implies identical asset demand $X^i_t$:

$$X^i_t = -\frac{1}{\gamma \sigma_D^2 + \left( \frac{1}{Rf - \rho_v} \right)^2 \sigma_v^2 + p_N^2 \sigma_N^2} N_t,$$

which trades off expected asset return with return variance over the subsequent period.

Then, imposing market-clearing in the asset market $X^i_t = N_t$ leads to a quadratic equation that pins down the price coefficient $p_N$. There exist two negative roots to $p_N$. We focus on the less negative root of the two, similar to Bacchetta and van Wincoop (2006, 2008), who argue that the less negative root is the only stable root. We also find this choice sensible since as $\sigma_N \to 0$ (i.e., noise trader risk vanishes from the economy), the less negative root has a nice property of $p_N \sigma_N \to 0$ (i.e., the price impact of noise traders diminishes), while the more negative root diverges. We always focus on this more stable root of the two in our analysis, hereafter.\(^7\)

The following proposition, with details provided in the Appendix, shows that the equi-

\(^7\)See Spiegel (1998) and Watanabe (2008) for more detailed discussions of the implications of the more negative root in multi-asset settings.
Figure 1: Asset price variance with and without government intervention with respect to the variance of noise trading $\sigma_N^2$. The solid line represents the case without government intervention, and the dashed line represents the case with government intervention at a given intensity of $\nu_N = 0.2$. This figure is based on the following model parameters: $\gamma = 1$, $R^f = 1.01$, $\rho_v = 0.75$, $\sigma^2_v = 0.01$, $\sigma^2_D = 0.8$, $\nu_N = 0.2$.

Equilibrium does not exist if $\sigma_N$ is higher than a threshold:

$$\sigma_N^* = \frac{R^f}{2\gamma \sqrt{\sigma^2_D + \left(\frac{1}{R^f - \rho_v}\right)^2 \sigma^2_v}}. \tag{1}$$

**Proposition 1** If the noise trader risk $\sigma_N \leq \sigma_N^*$, an equilibrium exists with $\frac{\partial (Var(R_{t+1}|F_t))}{\partial \sigma_N} > 0$, and $\frac{\partial (Var(R_{t+1}|F_t))}{\partial \sigma_N} \rightarrow \infty$ as $\sigma_N \rightarrow \sigma_N^*$, implying that the asset return variance is highest at $\sigma_N = \sigma_N^*$ with a value of $2 \left[ \sigma^2_D + \left(\frac{1}{R^f - \rho_v}\right)^2 \sigma^2_v \right]$. If $\sigma_N > \sigma_N^*$, no equilibrium exists.

This proposition shows that the asset return variance increases with the noise trader risk $\sigma_N$ and the rate of this increase explodes as $\sigma_N$ gets close to the threshold $\sigma_N^*$. Figure 1 illustrates the explosive return variance as $\sigma_N$ approaches $\sigma_N^*$. Furthermore, this proposition establishes that the market breaks down when $\sigma_N$ rises above $\sigma_N^*$.

The myopia of investors and the price-insensitive trading of noise traders jointly lead to the market breakdown. Myopia cause the investors to care only about the risk and return over the subsequent one period. As $\sigma_N$ rises, investors would demand a higher risk premium to take on a position against noise traders, reflected in a larger coefficient $p_N$, which, in turn,
leads to a higher asset return volatility. Through this feedback process, once $\sigma_N$ gets larger than $\sigma_N^*$, the asset return volatility becomes so large that the investors are not willing to take on any position regardless of the risk premium. If the investors have longer horizons, they would be willing to take on a position despite the large return volatility over the short-term, which would, in turn, stabilize the price impact of noise traders. As such, the reluctance of short-term investors to trade against noise traders is reminiscent of the classic result highlighted by De Long, et al. (1990), which shows that noise traders can create their own space in asset prices in the presence of myopic arbitrageurs. Because the asset has an infinite lifetime, the standard argument of backward induction from the last period cannot be used to eliminate the effect of noise traders.

The noise traders’ price-insensitive trades serve to capture market rigidity that sometimes occurs as a result of either forced fire sales or panic selling during market turmoil. For example, Bian et al. (2017) document the crash of China’s stock market in summer 2015 caused by the firesales of highly leveraged stock investors. Our simple model describes a setting in which the firesales of some investors may lead to the breakdown of the market because the other investors are too short-term driven to absorb these firesales. This kind of market breakdown represents systemic failure and warrants government intervention.

2.4 Equilibrium with Government Intervention

We now incorporate government intervention into the model. Song and Xiong (2018) summarize a wide range of policy tools used by the Chinese government to intervene in the financial system. In particular, during China’s stock market turmoil in summer 2015, the Chinese government organized the so-called "national team" to backstop the market meltdown. Huang, Miao and Wang (2016) offer a detailed account of this intervention program. Motivated by this episode, we choose to analyze in this paper the economic effects of a government trading program in the asset market, rather than other types of policy interventions.

Specifically, we augment the baseline setting to include a government that actively intervenes in the asset market. The government follows a linear trading rule:

$$X_t^G = \theta_{N,t}N_t + \sqrt{\text{Var}[\theta_{N,t}N_t | \mathcal{F}_{t-1}]}G_t.$$  

The first term $\theta_{N,t}N_t$ captures the government’s intended intervention strategy in trading against the noise traders, with the coefficient $\theta_{N,t}$ measuring the intensity of the intervention. We also include the second term $\sqrt{\text{Var}[\theta_{N,t}N_t | \mathcal{F}_{t-1}]}G_t$ to capture unintended noise that
arises from frictions in the intervention process, such as behavioral biases, lobbying effort, or information frictions. Specifically, $G_t = \sigma_G \varepsilon^G_t$ with $\varepsilon^G_t \sim N(0, 1)$ as independently and identically distributed shocks and $\sigma_G$ as a volatility parameter. The magnitude of this noise component scales up with the conditional volatility of the intended intervention strategy $\sqrt{\text{Var} \left[ \theta_{N,t} N_t \mid \mathcal{F}_{t-1} \right]}$, which is equal to $\sigma_N \theta_{N,t}$ with perfect information. This specification is reasonable as it is easier for frictions to affect the government’s intervention when the intervention strategy requires more intensive trading. Furthermore, the government can neither correct nor trade against its own noise, because the noise originates from its own system. Instead, the government can internalize the amount of noise by limiting its trading intensity, which is a key issue of our later analysis.

The primary motive of the Chinese government to directly trade in the asset market is to provide an immediate backstop against a widely perceived systemic crisis, as discussed by Huang, Miao and Wang (2016) and others. The longer-term target of the government’s trading program is, however, more ambiguous. In principle, a government should maximize the social welfare of its constituents, which is an objective that is both challenging to quantify and unrealistic to implement. Instead, there are two concrete objectives governments frequently employ, one to improve price efficiency (i.e., to minimize the deviation of asset prices from fundamentals), and the other to reduce asset market volatility. Each of these two objectives has its own appeal and can be micro-founded under suitable assumptions. The former is consistent with making asset prices more informative, and consequently more efficient in guiding resource allocation in the economy, while the latter is consistent with reducing the destabilizing effects of asset price volatility on leveraged investors and firms. In Appendix B, we provide a simple setting, in which social welfare is consistent with these two objectives.

These two objectives are also closely related and are often treated as being consistent with each other in government intervention. These objectives are indeed consistent in our baseline setting without informational frictions. By reducing the price impact of noise traders, government intervention reduces both asset price deviation from fundamentals and price volatility. Our analysis will further compare these two objectives and show that they may diverge in the presence of information frictions.

We adopt the following general specification to represent the government’s myopic pref-

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8For example, a recent study by Stein and Sunderam (2016) adopts reducing volatility of long-term interest rate as the objective of the Federal Reserve Board in managing its U.S. monetary policy.
ference for intervention in the asset market at date $t$:

$$U_t^G = \min_{\vartheta_{N,t}} \gamma_\sigma \text{Var} \left[ \Delta P_t (\vartheta_{N,t}) \mid \mathcal{F}_{t-1} \right] + \gamma_v \text{Var} \left[ P_t (\vartheta_{N,t}) - \frac{1}{R_f - \rho_v} v_{t+1} \mid \mathcal{F}_{t-1} \right].$$

The first term $\gamma_\sigma \text{Var} \left[ \Delta P_t (\vartheta_{N,t}) \mid \mathcal{F}_{t-1} \right]$ captures a goal to minimize the conditional asset price variance, with the coefficient $\gamma_\sigma \geq 0$ measuring the government’s aversion to price volatility. The second term $\gamma_v \text{Var} \left[ P_t (\vartheta_{N,t}) - \frac{1}{R_f - \rho_v} v_{t+1} \mid \mathcal{F}_{t-1} \right]$ captures a goal to reduce price inefficiency, with the coefficient $\gamma_v \geq 0$ measuring the government’s aversion to the conditional variance of the asset price deviation from the asset’s fundamental value $\frac{1}{R_f - \rho_v} v_{t+1}$. In choosing $\vartheta_{N,t}$, the government recognizes that its intervention directly affects the asset price $P_t (\vartheta_{N,t})$. In other words, the government is a large player that internalizes its impact on the asset market. Since the two components in the government’s objective are both second moments, we shall consider only stationary policies, $\vartheta_{N,t} = \vartheta_N$. Furthermore, this objective function can be scaled up or down by any positive constant without affecting the government’s optimal choice.

There are several notable features of our setting with government intervention that merit discussion. First, while we model government intervention as direct trading in asset markets, the policy interventions relevant to our mechanism are even more pervasive, and take on various forms in practice. For example, the Chinese government has frequently employed a wide array of policy various tools to steward its financial markets, such as changing interest rates, required bank reserve ratios, short-sale constraints and stamp tax rates for stock trading, tightening IPO issuances, and forcing deleveraging of broker margin accounts in mid-2015. Through these policy changes, the government can indirectly affect costs of capital, liquidity, and costs of trading in financial markets. To the extent that the government makes these policy changes in response to (perceived) noise trading in asset markets, and its decision process may introduce additional noise either from noise in the government’s own information or from moral hazard and political economy concerns, we expect the key insight of our model to be valid for these more general policy interventions as well.

Second, the government’s objective function does not contain any budget constraint or cost of intervention. This simplification is particularly suitable for the Chinese government because of its vast fiscal resources. Also, it is important to recognize that the government’s trading against noise trading is profitable in our model, as well as in practice. Furthermore, specifying a budget constraint would give rise to a profit-making incentive for the govern-
ment, which should not be the objective of a benevolent government, and would interfere with our analysis of the objectives that are the focus of our analysis.\textsuperscript{9} Interestingly, despite the absence of any intervention cost, there is an interior optimum to the government’s intervention strategy because it internalizes the amount of noise that its intervention introduces into the market.

Third, our specifications of the government’s intervention strategy and objective function are both symmetric to market fluctuations. One may argue that in practice, the government might be more concerned with preventing market crashes than market booms. To the extent that an unsustainable boom would eventually lead to a market crash, we believe it is reasonable to make the government equally concerned about mitigating both booms and crashes that are induced by noise traders. For instance, during the stock market boom of 2007, the government raised the stamp tax on stock trading to reduce the price pressure from retail investors. It also forced the deleveraging of investors with broker margin accounts to deflate the stock market boom in mid-2015.

Fourth, we assume that the government’s intervention strategy and objective function are common knowledge to all market participants. In doing so, we implicitly assume that the government can commit to its intervention strategy, and that it can perfectly communicate this strategy to the market. In this sense, one may view our results as the consequences of policy beyond the commitment and communication channels of government intervention, which are of independent importance and are discussed in Section 3.5.

As the government trades alongside investors to accommodate the trading of noise traders, the market-clearing condition \( \int_0^1 X_t^i di + X_t^G = N_t \) implies the following equilibrium asset price function with the government noise as an additional factor:

\[
P_t = \frac{1}{R^f - \rho_v} v_{t+1} + p_N N_t + P_g G_t.
\]

In Appendix A, we show that a market equilibrium exists when

\[
\sigma_N < \frac{1}{(1 - \vartheta_N) \sqrt{1 + \left( \frac{\vartheta_N}{1 - \vartheta_N} \right)^2 \sigma_G^2}} \sigma_N^*.
\]

where \( \sigma_N^* \) is given in equation (1). The more aggressively the government trades to accommodate noise trading, the closer is \( \vartheta_N \) to 1, and the slacker is the equilibrium existence.

\textsuperscript{9}In a previous draft of the paper, we introduced a cost to trading by the government, with the cost being proportional to the variance of the government’s position changes in each period, and obtained similar results as in our current setting without the cost. We prefer our current setting for its simplicity and elegance.
condition compared to the case without the government intervention (i.e., $\theta_N = 0$.) This is shown in Figure 1, which depicts the shift in the market breakdown upper-bound and also the reduced asset price volatility before $\sigma_N$ reaches the upper-bound.

To the extent that the asset price variance and the variance of the asset price from its fundamental value both explode when the market breaks down, the government’s aversion to any of these outcomes would motivate the government to choose a sufficiently large $\theta_N$ so that the condition in (2) is satisfied. Thus, a market equilibrium always prevails. Furthermore, the government objective of improving price efficiency is qualitatively consistent with an alternative of reducing price volatility.

Taken together, government intervention in asset markets helps to ensure market stability, especially during times of extreme market dysfunction, when noise trader risk is high. With informational frictions, however, the intervention to stabilize asset prices has additional effects on market dynamics, which we investigate in the next section.

3 An Extended Model with Information Frictions

We now extend the model to introduce realistic information frictions that investors and the government face in financial markets, while keeping the market structure and the trading preferences of investors and the government similar to the perfect-information setting. Specifically, we assume that the asset fundamental $v_{t+1}$ and noise trading $N_t$ are both unobservable at time $t$ to all agents in the economy. This extended model allows us to analyze how government intervention interacts with both the trading and information acquisition decisions of investors, ultimately affecting the information efficiency of asset prices.

Furthermore, for simplicity, we assume that the noise in government trading $G_t$ is publicly observable at date $t$, albeit not before $t$. As the government noise affects the asset price in equilibrium, investors have an incentive to acquire information about the next-period’s government noise, and this incentive may be even greater than the incentive to acquire information about the asset fundamental. Indeed, our model shows that while government intervention dampens price volatility when this occurs, it may worsen rather than improve the information efficiency of the asset price.

\footnote{In an earlier draft of the paper, we have analyzed the case with $G_t$ being unobservable even after $t$. The results are qualitatively similar to our current setting, although the analysis is substantially more complex.}
3.1 Information and Equilibrium

This subsection describes the information structure of the economy.

3.1.1 Public Market Information

All market participants observe the full history of all public information, which includes all past dividends, asset prices, and government noise:

\[
\mathcal{F}_t^M = \{D_s, P_s, G_s\}_{s \leq t},
\]

which we will hereafter refer to as the "market" information set. We define

\[
\hat{v}_{t+1}^M = E[v_{t+1} | \mathcal{F}_t^M]
\]

as the conditional expectation of \(v_{t+1}\) with respect to \(\mathcal{F}_t^M\). The government needs to trade against the noise trading based on its conditional expectation of \(N_t\). Without any private information, its expectation of \(N_t\) is equal to the expectation conditional on \(\mathcal{F}_t^M\). At the risk of abusing notation, we define

\[
\hat{N}_t^M = E[N_t | \mathcal{F}_t^M].
\]

Note that \(\hat{N}_t^M\) represents expectation of the current-period \(N_t\) rather than \(N_{t+1}\). Furthermore, we define

\[
\hat{G}_{t+1}^M = E[G_{t+1} | \mathcal{F}_t^M]
\]

as the market’s conditional expectation of the next-period \(G_{t+1}\). These three belief variables, \(\hat{v}_{t+1}^M, \hat{N}_t^M\), and \(\hat{G}_{t+1}^M\), are time-\(t\) expectations of \(v_{t+1}, N_t\), and \(G_{t+1}\), respectively. Together with the publicly observed current-period \(G_t\), they summarize the public information at time \(t\) regarding the aggregate state of the market. We collect these variables as a state vector:

\[
\Psi_t = \left[ \hat{v}_{t+1}^M \quad \hat{N}_t^M \quad \hat{G}_{t+1}^M \quad G_t \right].
\]

3.1.2 Government

At date \(t\), the government’s information set contains only the publicly available information \(\mathcal{F}_t^M\). Like before, we assume that the government has an intervention program, instituted

\[11\] In a previous draft, we adopted an alternative setting, in which the government possesses private signals about the fundamental. This private information causes the government to hold different beliefs about
to trade against the noise traders based on the conditional market expectation $\hat{N}_t^M$:.

$$
X_t^G = \theta_{N,t} \hat{N}_t^M + \sqrt{\text{Var} \left[ \theta_{N,t} \hat{N}_t^M \mid \mathcal{F}_{t-1}^M \right]} G_t. \quad (3)
$$

Furthermore, the government has a similar myopic objective as before in choosing its intervention strategy at date $t$:

$$
U_t^G = \min_{\theta_{N,t}} \gamma_{\sigma} \text{Var} \left[ P_t \left( \theta_{N,t} \right) \mid \mathcal{F}_{t-1}^M \right] + \gamma_{v} \text{Var} \left[ P_t \left( \theta_{N,t} \right) - \frac{1}{R_t - \rho_v} v_{t+1} \mid \mathcal{F}_{t-1}^M \right]. \quad (4)
$$

As both of these variance terms are conditional on the government’s information set $\mathcal{F}_{t-1}^M$, one can view the government as choosing its intervention strategy $\theta_{N,t}$ at date $t$ before the investors observe any private information. The two terms in the government’s objective are centered second moments, which are deterministic in our Gaussian setting, thus they are both computable despite the non-nesting of information sets between the government and the investors.

In maximizing (4), the government is fully aware of how its trading impacts the asset price and, through this channel, the informativeness of the asset price as a signal about $v_{t+1}$ and $G_{t+1}$. The informativeness of the asset price impacts not only the government’s ability to learn from the asset price, but also that of the investors. Importantly, we allow the government to internalize its impact on the information acquisition decisions of investors. One can thus view the government’s intervention program as an information design problem in which the government selects an information structure for the asset price that is incentive compatible with the trading and information acquisition actions of the investors.

The fundamental and noise trading from investors and, more importantly, makes the government’s trading not fully observable to the investors. Through this latter channel, the noise in the government’s signals endogenizes the government noise $G_t$. Such a structure substantially complicates the analysis by introducing a double learning problem for the investors to acquire information about the government’s belief, which is itself the outcome of a learning process. It is reassuring that this more elaborate setting gives similar results as in our current setting with exogenous government noise.

A more general intervention strategy would allow the government to trade linearly with respect to not only $N_t^M$ but also $v_{t+1}^M$. As the government does not have any private information, this more general strategy may quantitatively affect equilibrium price fluctuations, but does not affect the information acquisition choice of investors, which is the central focus of our analysis.

While our model specifies linear intervention strategies, the key insight of our model, that intense government interventions can potentially distort investors’ information choices, will still be relevant even when the government adopts nonlinear strategies. See Section 4 for a discussion on government interventions with a band strategy in foreign exchange markets.

Since the government possesses inferior information to private agents, our setting represents a correlated equilibrium in a Bayesian game with coordination, in the spirit of Myerson (1994), rather than a game of Bayesian Persuasion by an informed policy maker with commitment, e.g., Kamenica and Gentzkow (2011).
3.1.3 Investors

In each period, the investors face uncertainty in the asset fundamental, the noise trading, and the government noise. Specifically, at date \( t \), each investor can choose to acquire a private signal either about the next-period asset fundamental \( v_{t+1} \) or about the next-period government noise \( G_{t+1} \). We denote the investor’s choice as \( a^i_t \in \{0, 1\} \), with 1 representing the choice of a fundamental signal and 0 the choice of a signal about the government noise. When the investor chooses \( a^i_t = 1 \), the fundamental signal is

\[
s^i_t = v_{t+1} + [a^i_t \tau_s]^{-1/2} \varepsilon^{s,i}_t,
\]

where \( \varepsilon^{s,i}_t \sim \mathcal{N}(0, 1) \) is signal noise, independent of all other random variables in the setting, and \( \tau_s \) represents the precision of the signal if chosen. When the investor chooses \( a^i_t = 0 \), the government signal is

\[
g^i_t = G_{t+1} + [(1 - a^i_t) \tau_g]^{-1/2} \varepsilon^{g,i}_t,
\]

where \( \varepsilon^{g,i}_t \sim \mathcal{N}(0, 1) \) is signal noise, independent of all other random variables in the setting, and \( \tau_g \) represents the precision of the signal if chosen. These signals allow the investor to better predict the next-period asset return by forming more precise beliefs about \( v_{t+1} \) and \( G_{t+1} \). Motivated by limited investor attention and realistic fixed cost in information acquisition, we assume that each investor needs to choose one and only one of these two signals.

At date \( t \), each investor first makes his information acquisition choice \( a^i_t \) based on the public information set \( \mathcal{F}^M_{t-1} \) from the previous period. After receiving his private information \( a^i_t s^i_t + (1 - a^i_t) g^i_t \) and the public information \( D_t, P_t, \) and \( G_t \) released during the period, the investor chooses his asset position \( X^i_t \) to maximize his expected utility over his wealth at \( t + 1 \):

\[
U^i_t = \max_{a^i_t \in \{0, 1\}} \mathbb{E} \left[ \max_{X^i_t} \mathbb{E} \left[ -\exp (-\gamma W^i_{t+1}) \mid \mathcal{F}_t \right] \mid \mathcal{F}^M_{t-1} \right],
\]

15 Generally speaking, the investors may also acquire private information about noise trading, rather than asset fundamental and government noise. Introducing such a third type of private information complicates the analysis without a particular gain in insight. In our current setting, each investor can indirectly infer the value of noise trading through the publicly observed asset price.

16 Instead of a discrete information acquisition choice \( a \in \{0, 1\} \), one could generalize our framework to allow for a signal that reveals partially information about the fundamental and partially about the government noise by allowing for a continuous choice \( a \in [0, 1] \). We conjecture that, in such a setting, instead of having the government-centric or the fundamental-centric outcome, investors would tilt their information acquisition too much towards acquiring government information, which corresponds to too low a choice of \( a \).
where the investor’s full information set \( \mathcal{F}_t^i \) is
\[
\mathcal{F}_t^i = \mathcal{F}_t^M \cup \{ a_t^i s_t^i + (1 - a_t^i) g_t^i \}.
\]
The investor’s objective guarantees sequential rationality of his information acquisition and trading decisions. Given his beliefs about how he will trade at date \( t \), the investor chooses what information to acquire based on public information up to \( t - 1 \), and then chooses his trading strategy.

### 3.1.4 Noisy Rational Expectations Equilibrium

Market clearing of the asset market requires that the net demand from the investors and the government equals the supply of the noise traders at each date \( t \):
\[
\int_0^1 X_t^i \, di + X_t^G = N_t.
\]
By assuming elastic supply of riskless debt, the credit market clears automatically.

We also assume that the investors and the government have an initial prior with Gaussian distributions at \( t = 0 \):
\[
(v_0, N_0) \sim \mathcal{N} \left( (\bar{v}, \bar{N}), \Sigma_0 \right),
\]
where
\[
\Sigma_0 = \begin{bmatrix}
\Sigma_0^v & 0 \\
0 & \Sigma_0^N
\end{bmatrix}.
\]
Note that the variables in both \( \mathcal{F}_t^M \) and \( \mathcal{F}_t^i \) all have Gaussian distributions. Thus, conditional beliefs of the investors and the government about \( v_t \) and \( N_t \) under any of the information sets are always Gaussian. Furthermore, the variances of these conditional beliefs follow deterministic dynamics over time and will converge to their respective steady-state levels at exponential rates. Throughout our analysis, we will focus on steady-state equilibria, in which the belief variances of the government and investors have reached their respective steady-state levels and their policies are time homogeneous.

At time \( t \), a Noisy Rational Expectations Equilibrium is a list of policy functions:
\[
\partial_{\dot{N}} (\Psi_{t-1}), a^i (\Psi_{t-1}), \text{ and } X^i (\Psi_t, a_t^i s^i_t + (1 - a_t^i) g^i_t, P_t),
\]
and a price function \( P (\Psi_t, v_{t+1}, N_t, G_{t+1}) \), which jointly satisfy the following:

- **Government optimization:** Before the investors choose their information acquisition policies \( \{ a_t^i \} \) and trading policies \( \{ X_t^i \} \), the government chooses its intervention policy
\[
X^G (\Psi_t) = \partial_{\dot{N}} \dot{N}_t^M + \sqrt{\text{Var} \left[ \partial_{\dot{N}} \dot{N}_t^M \mid \mathcal{F}_t^M, \{ a_t^i \} \right]} G_t
\]
with \( \partial_{\dot{N}} \) chosen based on its ex ante information set \( \mathcal{F}_{t-1}^M \) to maximize its objective, taking into account the impact of this choice on the investors’ information acquisition and trading strategies.

- **Investor optimization:** Each investor \( i \) takes as given the government’s intervention strategy to make his information acquisition choice \( a_t^i = a^i (\Psi_{t-1}) \) based on his ex ante
information set $\mathcal{F}_{t-1}^M$ and then makes his investment choice $X_i (\Psi_t, a_t^i s_t^i + (1 - a_t^i) g_t^i, P_t)$ based on other investors’ information acquisition choices $\{a_t^{-i}\}_{-i}$ and his full information set $\mathcal{F}_t^i$.

- Market clearing:

$$\int_0^1 X_i (\Psi_t, a_t^i s_t^i + (1 - a_t^i) g_t^i, P_t) \, di + X^G (\Psi_t) = N_t.$$  

- Consistency: investor $i$ and the government form their expectations of $v_{t+1}$, $G_{t+1}$, and $N_t$ based on their information sets $\mathcal{F}_t^i$ and $\mathcal{F}_t^M$, respectively, according to Bayes’ Rule.

In the main part of our analysis, we assume that the government can commit to an intervention strategy, as defined above, by choosing its intervention strategy before the investors choose their information and trading strategies. We also discuss a time-inconsistency problem if the government cannot commit in Section 3.4.

### 3.2 Equilibrium with Government Intervention

We now analyze the equilibrium. To simplify presentation, we describe key elements of the equilibrium in this subsection in order to convey the key economic mechanism of the model. We provide the complete steps of deriving the equilibrium and formulas in Appendix B.

#### 3.2.1 Price Conjecture and Equilibrium Beliefs

With the government intervention introducing noise $G_t$ into the equilibrium asset price as an additional factor, each investor faces a choice at date $t$ in whether to acquire private information about either the next-period fundamental $v_{t+1}$ or government noise $G_{t+1}$. When all investors choose to acquire information about the government noise, the asset price does not aggregate any private information about $v_{t+1}$ but rather brings the next-period government noise $G_{t+1}$ into the current-period asset price. To analyze the equilibrium asset price, we begin by conjecturing a linear price function:

$$P_t = \frac{1}{R^f - \rho_v} \hat{v}_{t+1}^M + p_g G_t + p_G \hat{G}_{t+1}^M + p_v (v_{t+1} - \hat{v}_{t+1}^M) + p_G (G_{t+1} - \hat{G}_{t+1}^M) + p_N N_t. \quad (5)$$

\[17\] This conjectured functional form is not unique because the market’s beliefs about $v_{t+1}$, $N_t$, and $G_{t+1}$ are correlated objects ex-post after observing prices. That is, $\hat{N}_t^M$ can be replaced by a linear combination of $P_t$, $\hat{v}_{t+1}^M$, and $\hat{G}_{t+1}^M$, and thus does not have to appear in the price function, even though $\hat{N}_t^M$ determines the government intervention.
The first term \( \frac{1}{p_v} \hat{v}_{t+1}^M \) is the expected asset fundamental conditional on the market information \( \mathcal{F}_t^M \) at date \( t \), the term \( p_v G_t \) reflects the noise introduced by the government into the asset demand in the current period, while the term \( p_M \hat{G}_{t+1}^M \) reflects the market expectation of the government noise in the next period. These three pieces serve as anchors in the asset price based on the public information. The fourth term \( p_v (v_{t+1} - \hat{v}_{t+1}^M) \) captures the fundamental information aggregated through the investors’ trading. Following the insight from Hellwig (1980), if each investor acquires a private signal about the asset fundamental \( v_{t+1} \), their trading aggregates their private signals and allows the equilibrium price to partially reflect \( v_{t+1} \). If all investors choose to acquire information about the next-period government noise \( G_{t+1} \), rather than \( v_{t+1} \), the coefficient of this term \( p_v \) would be zero. Instead, their trading aggregates their private information about \( G_{t+1} \), as captured by the fifth term \( p_v G_{t+1} - \hat{G}_{t+1}^M \). The final term \( p_N N_t \) represents the price impact of noise trading.

Given the asset price in (5), an individual investor not only needs to infer the asset fundamental \( v_{t+1} \) but also the government noise \( G_{t+1} \). As each individual investor has a piece of private signal \( s^i_t + (1 - a^i_t) g^i_t \), his learning process simply requires adding this additional signal to the market beliefs. We summarize the filtering process through the updating equation as

\[
\begin{bmatrix}
\hat{v}_{t+1}^i \\
\hat{G}_{t+1}^i
\end{bmatrix}
= \begin{bmatrix}
\hat{v}_{t+1}^M \\
\hat{G}_{t+1}^M
\end{bmatrix}
+ \text{Cov} \left\{ \begin{bmatrix}
v_{t+1} \\
G_{t+1}
\end{bmatrix}, a^i_t s^i_t + (1 - a^i_t) g^i_t \right\} \mathcal{F}_t^M
\cdot \text{Var} \left\{ a^i_t s^i_t + (1 - a^i_t) g^i_t \right\}^{-1} \begin{bmatrix}
a^i_t (s^i_t - \hat{v}_{t+1}^M) + (1 - a^i_t) \left( g^i_t - \hat{G}_{t+1}^M \right)
\end{bmatrix}
\]

The variance and co-variance in this expression depend on various endogenous subjects such as the informativeness of the equilibrium asset price and the precision of the market beliefs, and are fully derived in Appendix B. This expression makes clear that the investor’s private signal helps him to infer the asset fundamental and the government noise in the next period, both of which impact the asset return.

The linear relationship between the investor’s conditional expectations and private signals, \( s^i_t \) and \( g^i_t \), also offers convenience in imposing market clearing. Since the noise in investors’ private signals satisfies a weak Law of Large Numbers, \( \int \chi \varepsilon^s_t di = \int \chi \varepsilon^g_t di = 0 \) over an arbitrary subset of the unit interval \( \chi \), aggregating the investors’ signals, \( s^i_t \) and \( g^i_t \), will reveal both of the underlying variables \( v_{t+1} \) and \( G_{t+1} \). However, market clearing also

---

\(^{18}\)Note that there is no need to incorporate a term related to investors’ (higher order) cross-beliefs about \( v_{t+1} \) or \( G_{t+1} \) because \( \int_0^1 a^i_t s^i_t di = v_{t+1} \) and \( \int_0^1 (1 - a^i_t) g^i_t di = G_{t+1} \) by the Law of Large Numbers.
includes the position of noise traders, which prevents the asset price from fully revealing these variables.

3.2.2 Investment and Information Acquisition Policies

We now examine the optimal policies of an individual investor $i$ at date $t$, who takes the intervention policy of the government as given. To derive his optimal investment policy, it is convenient to decompose the expected excess return from the asset based on his information set relative to the public market information set. We can update $E[R_{t+1} | \mathcal{F}_t^M]$ from $E[R_{t+1} | \mathcal{F}_M]$ by the Bayes’ Rule according to

$$E[R_{t+1} | \mathcal{F}_t^M] = E[R_{t+1} | \mathcal{F}_t^M \cup a_i^t s_i^t + (1 - a_i^t) g_i^t]$$

$$= E[R_{t+1} | \mathcal{F}_t^M] + \frac{Cov[R_{t+1}, a_i^t s_i^t + (1 - a_i^t) g_i^t | \mathcal{F}_t^M]}{Var[a_i^t s_i^t + (1 - a_i^t) g_i^t | \mathcal{F}_t^M]} \cdot \left[a_i^t (s_i^t - \tilde{v}_M^{t+1}) + (1 - a_i^t) \left(g_i^t - \tilde{G}_t^{M+1}\right)\right].$$

This expression shows that the investor’s private information through either $s_i^t$ or $g_i^t$ can help him in better predicting the excess asset return relative to the market information. This is because by using $s_i^t$ and $g_i^t$ to form better predictions of $v_{t+1}$ and $G_{t+1}$, the investor can better predict the asset return in the subsequent period.

Given the investor’s myopic CARA preferences, his demand for the asset is

$$X^i = \frac{1}{\gamma} \frac{E[R_{t+1} | \mathcal{F}_t^M]}{Var[R_{t+1} | \mathcal{F}_t^M]}, \quad (6)$$

In choosing whether to acquire either $s_i^t$ or $g_i^t$ at date $t$, the investor maximizes his expected utility based on the ex-ante market information:

$$E[U_t^i | \mathcal{F}_{t-1}^M] = \max_{a_i^t \in \{0, 1\}} -E\left\{E\left[\exp\left(-\gamma R_t W - \frac{1}{2} \frac{E[R_{t+1} | \mathcal{F}_t^M]^2}{Var[R_{t+1} | \mathcal{F}_t^M]}\right) \mid \mathcal{F}_t^M\right] \mid \mathcal{F}_{t-1}^M\right\}.$$

This expected utility has already incorporated the investor’s optimal trading strategy in (6). We have also applied the Law of Iterated Expectations to emphasize that by first taking expectations with respect to the date-$t$ market information $\mathcal{F}_t^M$, we can arrive at a tractable characterization of each investor’s information acquisition decision.

The investor’s expected CARA utility in our Gaussian framework is fully determined by the second moment of the return distribution conditional on his information set $\mathcal{F}_t^i$. This nice feature allows us to simplify his information acquisition choice to

$$a_i^t = \arg \max_{a_i^t \in \{0, 1\}} -Var[\Delta P_{t+1} | \mathcal{F}_t^M, a_i^t s_i^t + (1 - a_i^t) g_i^t].$$
This objective involves only the conditional price change variance, which is stationary in the steady-state equilibria that we consider. Thus, the information acquisition choice faced by each individual investor is time-invariant. Intuitively, given the Gaussian price distribution and exponential utility for the investors, the benefit of having more precise private information lies with reducing uncertainty over the excess asset return. By noting that

{\begin{align*}
\text{Var} \left[ R_{t+1} \mid F_t^M, a_t^i s_t^i + (1 - a_t^i) g_t^i \right] &= \text{Var} \left[ R_{t+1} \mid F_t^M \right] - \frac{\text{Cov} \left[ R_{t+1}, a_t^i s_t^i + (1 - a_t^i) g_t^i \mid F_t^M \right]^2}{\text{Var} \left[ a_t^i s_t^i + (1 - a_t^i) g_t^i \mid F_t^M \right]},
\end{align*}}

we arrive at the following proposition, which corresponds to Propositions A6 and A7 in Appendix B.

**Proposition 2** At date $t$, an investor $i$ chooses to acquire information about the next-period fundamental $v_{t+1}$ (i.e., $a_t^i = 1$) if

{\begin{align*}
\frac{\text{Cov} \left[ R_{t+1}, v_{t+1} \mid F_t^M \right]^2}{\text{Var} [ v_{t+1} \mid F_t^M ]} < \frac{\text{Cov} \left[ R_{t+1}, s_t^i \mid F_t^M \right]^2}{\text{Var} [ s_t^i \mid F_t^M ]},
\end{align*}}

or about the next-period government noise $G_{t+1}$ (i.e., $a_t^i = 0$) if

{\begin{align*}
\frac{\text{Cov} \left[ R_{t+1}, v_{t+1} \mid F_t^M \right]^2}{\text{Var} [ v_{t+1} \mid F_t^M ]} > \frac{\text{Cov} \left[ R_{t+1}, s_t^i \mid F_t^M \right]^2}{\text{Var} [ s_t^i \mid F_t^M ]},
\end{align*}}

or be indifferent between these two choices otherwise. In the special case that $\rho_v = 0$, it is sufficient that condition (A4) be satisfied for all investors to learn about $G_{t+1}$.

The investor chooses his signal to maximize his informational advantage over the public information set when trading. Proposition 2 states that this objective is equivalent to choosing the signal that reduces more the conditional variance of the excess asset return, taking as given the precision of the market’s information. Interestingly, this proposition shows that the investor may choose to acquire the signal on the government noise over the signal on the asset fundamental. This is because the government noise affects the asset return when the investor sells his asset holding on the next date. As a result, the more the government noise covaries with the unpredictable component of the asset return from the market information set, the more valuable the signal about the government noise is to the investor.

Models of information aggregation, such as Grossman and Stiglitz (1980) and Hellwig (1980), information choices among investors are typically strategic substitutes. That is, all else equal, if some investors at time $t$ acquire private information, for example, about $v_{t+1}$, then the equilibrium asset price at time $t$ will become more informative about it, and this reduces the incentives of other investors to acquire information about $v_{t+1}$. In models in which investors can acquire different sources of information, including Ganguli and Yang (2009), Manzano and Vives (2011), and Farboodi and Veldkamp (2016), information choices can exhibit intratemporal strategic complementarity. As some investors learn more
about one source of information, asset prices become more informative of the fundamentals, *strengthening* the incentive of other investors to acquire information, albeit about a different source.

Interestingly, our model features intertemporal complementarity between investors’ information choices and government policy across periods. Similar, for instance, to Froot, Scharfstein, and Stein (1992), investors have incentive to align their information choices across generations when the asset fundamental is persistent.\(^{19}\) If more investors at time \(t + 1\) acquire information about \(v_{t+2}\), then there is greater incentive for investors at time \(t\) to acquire information about \(v_{t+1}\), as \(v_{t+2}\) partially reflects \(v_{t+1}\). Novel to our setting, however, is that there is also intertemporal complementarity between the government’s announced trading policy at time \(t + 1\) and investors’ choice to learn about \(G_{t+1}\) at date \(t\), since the government is a large trader with price impact. Importantly, the government internalizes that it can influence the investors’ information choices when choosing its policy.\(^{20}\) In contrast to Hellwig and Veldkamp (2009), in which intratemporal complementarity in agents’ actions leads to complementarity in their information choices, here the government’s future intervention policy induces investors today to learn about future noise in government intervention, since the government’s policy materially impacts their return from trading the risky asset. As we will discuss later, such complementarity may be sufficiently strong to dominate the substitution effect in information choice across investors, and to cause all of them in equilibrium to acquire either fundamental information or information about the government noise. Proposition 2 provides a sufficient condition for all investors to choose to learn about future noise in government trading.

The choice of an individual investor to acquire information about the government noise rather than the asset fundamental introduces an externality for the overall market. When investors devote their limited attention to do so, less information about the asset fundamental is imputed into the asset price, which causes the asset price to be a poorer signal about the asset fundamental. In addition, as investors devote attention to learning about \(G_{t+1}\), the

\(^{19}\)This intertemporal complementarity mechanism does not operate through \(G_t\), since government noise \(G_t\) is not persistent, but independent over time. If we were to relax this simplifying assumption, as we did in a previous version of the paper, the model will display even stronger complementarity in investors’ information decisions.

\(^{20}\)This is also in contrast to the literature on information aggregation with strategic traders, as in, for instance, Kyle (1989). Since the solution concept in these models is an "equilibrium in demand curves", large traders do not internalize that they can impact the learning and information decisions of other large traders. As such, these equilibria are ex post efficient up to the impact of market power.
asset price will aggregate more of the investors’ private information about $G_{t+1}$, causing the next-period government noise to impact the current-period asset price. In this sense, the investors’ speculation of government noise may exacerbate its impact on asset prices.

### 3.2.3 Government Policy and Market Equilibrium

We now turn to the problem faced by the government at date $t$. The government chooses the coefficient $\vartheta_{N_t}$ in its linear intervention policy specified in (3) to maximize its objective in (4). Note that in the steady state, each term in the objective represents a second moment that is stationary, the government’s intervention policy should also be stationary. Thus, we consider only time-invariant policy coefficient $\vartheta_N$. In choosing its intervention policy, the government fully internalizes the impact of its intervention on the equilibrium asset price $P(\vartheta_N)$, which includes the direct impact of its trading and its impact on the investors’ information choices $\{a_t^i\}$. 

Given the investors’ optimal information acquisition and trading strategies and the government’s intervention strategy, we have the following market clearing condition:

$$N_t = \vartheta_N \hat{N}_t^M + \sqrt{\text{Var} \left[ \vartheta_N \hat{N}_t^M \mid \mathcal{F}_t^{M-1} \right]} G_t + \int \frac{a_t^i E \left[ R_{t+1} \mid \mathcal{F}_t^M, s_t^i \right]}{\gamma \text{Var} \left[ R_{t+1} \mid \mathcal{F}_t^M, s_t^i \right]} di + \int \frac{1 - a_t^i E \left[ R_{t+1} \mid \mathcal{F}_t^M, g_t^i \right]}{\gamma \text{Var} \left[ R_{t+1} \mid \mathcal{F}_t^M, g_t^i \right]} di.$$ 

The weak Law of Large Numbers implies that aggregating the investors’ asset positions will partially reveal their private information about $v_{t+1}$ if $a_t^i = 1$ and $G_{t+1}$ if $a_t^i = 0$. By matching the coefficients of all the terms on both sides of this equation, we obtain a set of equations to determine the coefficients of the conjectured equilibrium price function in (5).

While we have an analytical expression for the asset market equilibria given the government’s trading policy, solving the government’s optimal intervention policy requires a numerical exercise to maximize its objective. As such, we rely on numerical analysis to examine the equilibrium. Given the government’s objective to minimize a mix of price variance and price deviation from the fundamental, it will always prevent any market breakdown even in the presence of information frictions. Our numerical analysis indeed confirms the existence of equilibrium across all of the sets of model parameters that we have examined.

While an equilibrium always exists, there can exist several types of equilibria.

- **Fundamental-centric outcome.** When all investors choose to acquire information about the asset fundamental, the asset price aggregates the investors’ private informa-
tion and partially reflects the asset fundamental, and does not reflect the next-period government noise. As a result, the asset price takes a particular form of

\[ P_t = \frac{1}{R_t^f - \rho_v} \hat{v}_{t+1}^M + p_g G_t + p_v (v_{t+1} - \hat{v}_{t+1}^M) + p_N N_t, \]  

which is different from the general asset price specification in (5) in that the terms \( p_G \hat{G}_{t+1}^M \) and \( p_G (G_{t+1} - \hat{G}_{t+1}^M) \) do not appear.

- **Government-centric outcome.** When all investors choose to acquire information about the next-period government noise, the asset price partially reflects the next-period government noise but not the asset fundamental:

\[ P_t = \frac{1}{R_t^f - \rho_v} \hat{v}_{t+1}^M + p_g G_t + p_G \hat{G}_{t+1}^M + p_N N_t, \]

which is different from the general specification in (5) in that the term \( p_v (v_{t+1} - \hat{v}_{t+1}^M) \) does not appear.

- **Mixed outcome.** It is also possible to have a mixed equilibrium with a fraction of the investors acquiring information about the asset fundamental and the others about the government noise. In such a mixed equilibrium, the general price function specified in (5) prevails.

Depending on the model parameters, all of these three types of equilibria may appear.\(^{21}\) We will illustrate these equilibria in the next subsection. For our illustration, we also include a benchmark case without government intervention, which arises when \( \gamma_\sigma = \gamma_v = 0 \). This benchmark gives the classic Hellwig (1980) equilibrium, in which each investor acquires a fundamental signal, and the equilibrium asset price follows the form in (7).

### 3.3 Effects of Government Intervention

In this subsection we analyze effects of government intervention through a series of numerical examples. For these numerical exercises, we use a set of baseline parameter values listed in Table I, except when a certain parameter is specifically chosen to take a different value.

We first analyze the equilibrium when we set either \( \gamma_\sigma \) or \( \gamma_v \) to be zero. Interestingly, once we set \( \gamma_\sigma = 0 \), the market equilibrium is invariant to the exact value of \( \gamma_v \) as long as

\(^{21}\)In our current setting, the government first commits to its intervention strategy before the investors acquire their information. As a result, multiple equilibria would not arise for a given set of model parameters. If the government cannot pre-commit to its intervention strategy, however, multiple equilibria are possible.
Table I: Baseline Model Parameters

<table>
<thead>
<tr>
<th>Government:</th>
<th>$\gamma_\sigma = 1.25$, $\gamma_v = 1$, $\sigma^2_G = 2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Fundamental:</td>
<td>$\rho_v = 0.75$, $\sigma^2_v = 0.01$, $\sigma^2_D = .8$</td>
</tr>
<tr>
<td>Noise Trading:</td>
<td>$\sigma^2_N = 0.2$</td>
</tr>
<tr>
<td>Investors:</td>
<td>$\gamma = 1$, $\tau_s = 500$, $\tau_g = 500$, $R_f = 1.01$</td>
</tr>
</tbody>
</table>

it is positive. This is because the government’s optimal intervention strategy is invariant to scaling up its objective function by any positive factor. Similarly, if $\gamma_v = 0$, the equilibrium is also invariant to the exact value of $\gamma_\sigma$ as long as it is positive. Figure 2 illustrates a series of market equilibria by varying the noise trader risk $\sigma^2_N$. Panel A depicts the conditional price variance $Var\left[P_t(\partial_N) \mid \mathcal{F}^M_{t-1}\right]$, while Panel B depicts the conditional variance of the asset price deviation from the fundamental $Var\left[P_t(\partial_N) - \frac{1}{R_f - \rho_v} v_{t+1} \mid \mathcal{F}^M_{t-1}\right]$. In both of these panels, the solid line corresponds to the variable of interest when $\gamma_\sigma = 0$ and $\gamma_v > 0$, while the dashed line corresponds to the variable when $\gamma_v = 0$ and $\gamma_\sigma > 0$. We also plot a short-dashed line to illustrate, as a benchmark, the Hellwig equilibrium without any government intervention by setting $\gamma_\sigma = \gamma_v = 0$.

When $\gamma_\sigma = 0$ and $\gamma_v > 0$, the government’s single objective is to improve the price informativeness. In contrast, when $\gamma_v = 0$ and $\gamma_\sigma > 0$, the government’s single objective is to reduce price volatility. Figure 2 shows that while these two objectives are often treated as equivalent, they lead to sharply different equilibria—a fundamental-centric equilibrium for the case with $\gamma_\sigma = 0$ and $\gamma_v > 0$, as shown by the solid line, and a government-centric equilibrium for the case with $\gamma_\sigma = 0$ and $\gamma_v > 0$, as shown by the dashed line. Across the different values of $\sigma^2_N$, the fundamental-centric equilibrium has uniformly higher price variance but lower variance of price deviation from fundamental. These differences reflect the investors’ different information choices in these equilibria.

In the case of $\gamma_v = 0$ and $\gamma_\sigma > 0$, a government-centric equilibrium always emerges. In this equilibrium, the government trades as much as it can to reduce the price impact of noise traders, and the price impact of its own noise $G_t$ becomes so large relative to that of the fundamental that the investors choose to acquire private information about the government noise factor rather than the fundamental factor. Consequently, the information efficiency of
Figure 2: Equilibrium dynamics across noise trader risk. Panel A depicts the conditional price variance $\text{Var}[P_t(\tilde{\theta}_N) | F_{t-1}]$, while Panel B the conditional variance of price deviation from the fundamental $\text{Var}[P_t(\tilde{\theta}_N) - \frac{1}{R^\nu - \rho_v} \nu_{t+1} | F_{t-1}]$. In both panels, the solid line is for the case when $\gamma_\sigma = 0$ and $\gamma_v > 0$, the dashed line for the case when $\gamma_v = 0$ and $\gamma_\sigma > 0$, and the short-dashed line for the Hellwig benchmark with $\gamma_v = \gamma_\sigma = 0$.

the asset price is poor (i.e., the conditional variance of price deviation from the fundamental is high) relative to the fundamental-centric equilibrium, and could become even worse than the Hellwig equilibrium without any government intervention when $\sigma^2_N$ is in the lower range of the plot in Panel B. However, the lower price variance is sufficient to fulfill the objective of the government given that $\gamma_v = 0$.

When $\gamma_\sigma = 0$ and $\gamma_v > 0$, the government’s single objective is to improve the information efficiency of the asset price. Consequently, its optimal strategy is to trade against the noise traders within the limit of not making its own noise impact overly dominant so that the investors would still choose to acquire information about the fundamental. This leads to the fundamental-centric equilibrium, in which the improved information efficiency relative to that in the government-centric equilibrium comes at an expense of greater price variance. As we discussed earlier, the strategic complementarity in the investors’ information choices across periods also implies that the improved information efficiency in the fundamental-centric equilibrium further reinforces each investor’s choice to acquire fundamental information.

Taken together, Figure 2 illustrates not only the existence of the fundamental-centric and government-centric equilibria, but also the breakdown of the divine coincidence between
Figure 3: Equilibria across noise trader risk with $\gamma_v = 1$ and $\gamma_\sigma = 1.25$. Panel A depicts the conditional price variance $\text{Var} \left[ P_t \left( \hat{\theta}_N \right) \mid \mathcal{F}_{t-1}^M \right]$, Panel B the conditional variance of price deviation from the fundamental $\text{Var} \left[ P_t \left( \hat{\theta}_N \right) - \frac{1}{1-\rho_v} v_{t+1} \mid \mathcal{F}_{t-1}^M \right]$, Panel C the government’s disutility, and Panel D the variance of the government’s asset position. In all panels, the solid line corresponds to the fundamental-centric equilibrium, the dashed line the government-centric equilibrium, and the short-dashed line the Hellwig benchmark without government trading.

We now examine the equilibrium when the government has a mixed objective of improving information efficiency and reducing price variance, by letting $\gamma_\sigma = 1.25$ and $\gamma_v = 1$. Figure 3 shows how the equilibrium varies with noise trader risk $\sigma_N^2$. This figure shows several interesting features. First, the fundamental-centric equilibrium emerges when $\sigma_N^2$ is lower than a threshold around 0.195, while a government-centric equilibrium emerges when $\sigma_N^2$ gets larger than the threshold. Below the threshold, the motivation for government intervention is modest, and the government trades against noise traders to the extent not to distract the investors from acquiring information about the fundamental. Consequently, both the price variance and the variance of price deviation from the fundamental are lower than the Hellwig benchmark. When $\sigma_N^2$ rises above the threshold, the market switches into the government-centric equilibrium, in which the government noise factor becomes sufficiently dominant in the asset price and the investors choose to acquire information about the government noise.
factor rather than the fundamental.

Second, consistent with the illustration in Figure 2, the government-centric equilibrium comes with lower price variance but worse information efficiency than the fundamental-centric equilibrium. When $\sigma^2_N$ is just above the threshold, the information efficiency in the government-centric equilibrium can be even worse than that in the Hellwig benchmark without any government intervention.

Third, Panel D of Figure 3 shows an interesting yet surprising observation that the government trades less in the government-centric equilibrium than in the fundamental-centric equilibrium, even though one would expect the government to trade more aggressively against noise traders in the government-centric equilibrium. This observation reflects another important dimension of the market dynamics. In the fundamental-centric equilibrium, each investor has his own private information about the asset fundamental and the private information causes the investors to hold different beliefs from each other and from the government about not only the asset fundamental but also the current-period noise trading. As a result, the government has to trade against not only noise traders but also the investors. The investors’ trading disseminates their private fundamental information into the asset price and improves its information efficiency, but partially offsets the government’s effort to counter noise traders. In contrast, in the government-centric equilibrium, the investors’ private information is about the next-period government noise, and, like the government, the investors all use the same public information to infer the current-period noise trading. Consequently, the investors tend to trade against noise traders along the same direction as the government, and thus reinforcing the effectiveness of the government’s intervention in reducing volatility.

Figure 4 depicts the boundary between the government-centric equilibrium and the fundamental-centric equilibrium on a plane of $\gamma_\sigma$ and $\sigma^2_N$ with other parameter values given in Table I. As the government assigns a higher weight to reducing price variance, the market shifts from the fundamental-centric equilibrium to the government-centric equilibrium at a lower value of $\sigma^2_N$.

### 3.4 Discussion of a Time-Inconsistency Problem

So far, we have considered a government that can perfectly commit to a specific intervention policy in advance, at least prior to each round of trading. We have implicitly assumed that the government moves first by announcing a trading schedule to investors that maximizes its
policy objective, commits to following this schedule like a Stackelberg leader, and investors move only subsequently. Under certain conditions, the fundamental-centric equilibrium occurs when the government has an incentive to commit to limit the role played by its noise in affecting asset prices so that the investors acquire information about the asset fundamental. In practice, however, the government may not always be able to act first. With the flexibility and liquidity offered by financial markets, investors are sometimes able to trade before the government even announces an intervention policy. In such situations, the government’s commitment power becomes an important issue for policy.

Interestingly, in a setting in which the government does not have the commitment power, and moves either simultaneously with or after investors, a time-inconsistency problem may emerge that can reinforce the government-centric equilibrium. In this setting, the government may want to initially convince investors that it will not intervene aggressively to induce them to acquire information about the asset fundamental. After investors have collected fundamental information, however, this effort becomes a sunk cost from the government’s perspective. Even with a single objective of improving information efficiency, the government then has incentive to change its intentions ex post, and to trade more aggressively against noise traders than it promised. Intuitively, once private information has been collected, attenuating noise trading both reduces nonfundamental price volatility and improves informational efficiency, as in the classical settings of Grossman and Stiglitz (1980) and Hellwig (1980). Rationally anticipating this opportunistic behavior of the government, in-

Figure 4: Boundary between fundamental-centric and government-centric equilibria based on the baseline parameter values listed in Table I.
vestors would always choose to collect information about the government’s noise instead. In this way, the time-inconsistency problem may lead to the government-centric equilibrium outcome, even when the government prefers the fundamental-centric outcome.

Absent an external commitment device, the government cannot credibly pre-commit that it will not trade aggressively. Of course, a government that cares more about improving information efficiency than about reducing price volatility could find ways to implement the fundamental-centric equilibrium. One solution is to delegate the intervention policy to an independent “conservative” government agency, as Rogoff (1985) suggested for monetary policy. Alternatively, the government could also build a reputation that it is of a type that places little emphasis on countering price volatility, and focuses on promoting informational efficiency. In such an extended model, there are many possible types of governments, each with a different \((\gamma_v, \gamma_a)\) policy pair, and investors form beliefs about the type of government that they are facing by learning from its past interventions. In developed economies, investors may be sufficiently convinced from past actions that these governments are more efficiency-focused than price volatility-averse. As a consequence, to preserve their reputation these governments are reluctant to interfere aggressively in the market place, and may only intervene in extreme situations of market dysfunction. In contrast, governments in emerging countries, like China, may not be endowed with the same amount of reputational capital, and, as such, are not able to convey credibly their intention to refrain from intervening too intensively. Fully incorporating reputational concerns in our analysis poses significant challenges, since the analysis is no longer tractable. Instead, we leave the formal characterization of this time-inconsistency problem for future research. In a related paper, Brunnermeier, Sockin, and Xiong (2017) explore this time-inconsistency problem in the context of China’s financial reform.

4 Empirical Implications and Further Discussion

We believe our theoretical framework captures several important features of China’s financial system and yields testable empirical predictions, both in the cross-section and time-series. First, our framework builds upon a group of noise traders whose trading may cause asset price volatility to explode and even the market to break down. This feature is consistent with the joint presence of a large population of inexperienced, and potentially overconfident, retail investors and large asset price volatility in China’s financial markets, which is often
cited by the Chinese government as the key reason for intensive policy interventions in asset markets.

Second, intensive interventions make noise induced by the government’s intervention programs an important pricing factor in asset prices. While our analysis focuses on government intervention through direct trading in asset markets, similar noise effects would arise through other policy interventions. Indeed, many commentators of China’s financial system have pointed out the importance of government policies in driving asset market dynamics in China.\(^{22}\) This common factor in asset prices is one testable prediction and helps to explain the unusually large price comovements among individual stocks in China. According to Morck, Yeung, and Yu (2000), China has the second highest stock price synchronicity in the world (next only to Poland).

Third, as an important pricing factor, government noise, in turn, attracts speculation of short-term investors by diverting their attention away from asset fundamentals, and investor speculation further reinforces the impact of government noise on asset prices. This feature is also consistent with a widely-held view that Chinese investors pay excessive attention to government policies, which can have a powerful impact on asset prices in the short-run, but insufficient attention to asset fundamentals, which operate over longer horizons. It would be a fruitful area of research to systematically examine this issue in the data, especially given the substantially expanded capacity in recent years to analyze large data in news media. A key issue is the amount of attention that news media and investors in China allocate to news about government policies versus firm news. Our model implies that government policies are more dominant in China than in other countries where the government intervenes less in financial markets.

Fourth, with an objective to reduce asset price volatility, intense government intervention may move the market into a government-centric outcome, in which investors all focus on speculation of the noise in the government’s policies while ignoring asset fundamentals.\(^{23}\) Through this channel, government intervention reduces asset price volatility at an expense of worsened information efficiency. This implication highlights a potential tension the two

\(^{22}\) The reluctance of the Chinese central government to allow local governments or SOEs to default, for instance, has historically led investors to value their liabilities with this implicit guarantee.

\(^{23}\) For instance, the Chinese government directed household savings into the stock market in late 2014 to alleviate price pressure in its overheating housing market. Speculating that the government would engineer a stock market boom, investors took highly levered positions, despite the weakness of the Chinese economy, that led to the run-up and crash in 2015.
government objectives, reducing price volatility and improving information efficiency, suggesting a tradeoff rather than divine coincidence. Our analysis shows that, by choosing a single focused objective of maintaining market stability, government intervention may have unintended consequences by distorting market incentives in acquiring information and leading to less, rather than more, efficient asset markets. One empirical time-series prediction is that during periods when the government puts a greater weight on market stability, such as times of severe market distress, market participants have less incentives to acquire fundamental information, thereby leading to less informative asset prices and stronger comovement across assets.

Government intervention is also particularly relevant for foreign exchange market. One may argue that in the foreign exchange market, the government often adopts a band strategy of intervening only when the exchange rate hits certain bands. While such a “band strategy” is different from the linear intervention strategy explored in our model, we believe that the basic insights of our analysis remain relevant. As long as market participants face uncertainty regarding the band’s bounds and the intensity of the government’s intervention strategy, perhaps as a result of imperfect government commitment or credibility or potential limits in its foreign reserves, they would still engage in speculation about future government intervention.

Finally, while our analysis is directly motivated by the intensive intervention programs pursued by the Chinese government in managing its financial system, we believe the implications of our analysis may be also relevant for other market settings with intensive government intervention. For example, many OECD countries engaged in large-scale asset purchase programs during the financial crisis and the subsequent recession. As recognized by market commentators, such government intervention programs may also substantially alter the dynamics of asset markets in these countries. The recent low volatility environment in OECD countries, for instance, may be a symptom of the focus of market participants on future central bank policies rather than asset fundamentals, and our analysis cautions that such low volatility may be at the cost of informational and allocation efficiency.
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Appendix A  Deriving Perfect Information Equilibrium

In the benchmark equilibrium with perfect information, all investors and the government observe the asset fundamental $v_{t+1}$ and the noise trading $N_t$. Let us conjecture a linear equilibrium, in which the stock price takes a linear form:

$$P_t = p_v v_{t+1} + p_N N_t + p_g G_t.$$  \hspace{1cm} (A1)

Given that dividends are $D_t = v_t + \varepsilon^D_t$, the stock price must react to a deterministic unit shift in $v_t$ by the present value of dividends deriving from that shock, $\frac{1}{R^f - \rho_v}$. Furthermore, we can express the government’s linear trading rule for its asset demand as $X_t^G = \vartheta_N N_t + \vartheta_N \sigma_N G_t$. Forcing $\vartheta_N = 0$ corresponds to the case without government intervention. Since all investors are symmetrically informed, they will have identical demand for the asset $X_t^i = X_t^S$, which, along with the government’s trading, accommodates the trading of noise traders. Given that investors have myopic CARA preferences, and that dividends and prices are linear in $v_t$, $v_{t+1}$, $N_t$, and $G_t$, and therefore also normally distributed, it follows that their optimal trading policy is to have a mean-variance demand for the risky asset:

$$X_t^S = \frac{1}{\gamma} \frac{E[D_{t+1} + \Delta P_{t+1} \mid F_t]}{\text{Var}[D_{t+1} + \Delta P_{t+1} \mid F_t]} = \frac{\frac{\vartheta_N}{\gamma} \sigma_N^2 + \left(\frac{1}{R^f - \rho_v}\right)^2 \sigma_v^2 + p_N^2 \sigma_N^2 + p_g^2 \sigma_G^2}{\frac{\vartheta_N}{\gamma} \sigma_N^2 + \left(\frac{1}{R^f - \rho_v}\right)^2 \sigma_v^2 + \left(1 + \frac{\vartheta_N}{1 - \vartheta_N}\right) \sigma_G^2}.$$  \hspace{1cm} (A2)

By imposing market clearing

$$X_t^S + \vartheta_N N_t + \vartheta_N \sigma_N G_t = N_t,$$

we arrive at several conditions that relate the coefficients $\vartheta_N$ to the price coefficients $p_v$, $p_g$, and $p_N$. Importantly, these relationships will give rise to a necessary condition for the existence of an equilibrium that depends on the government’s trading rule.

Finally, by substituting the price conjecture and market clearing conditions into the government’s optimization, we obtain the following proposition.

**Proposition A1** When $v_{t+1}$ and $N_t$ are observable to investors and the government, the asset price takes the linear form in (A1) and investors’ asset demand in (A2). The government’s trading rule $X_t^G = \vartheta^N N_t + \vartheta^N \sigma_N G_t$ solves

$$U^G = \sup_{\vartheta^N} - (\gamma_v + \gamma_\sigma) \left( 1 + \left(\frac{\vartheta_N}{1 - \vartheta_N}\right)^2 \sigma_G^2 \right) p_N^2 \sigma_N^2$$

such that

$$\vartheta^N = 1 + \frac{1}{\gamma} \frac{p_N R^f}{\sigma_N^2 + \left(\frac{1}{R^f - \rho_v}\right)^2 \sigma_v^2 + \left(1 + \frac{\vartheta_N}{1 - \vartheta_N}\right) \sigma_G^2} p_N^2 \sigma_N^2.$$

The asset market breaks down whenever

$$R^f < 2 \left(1 - \vartheta^N\right) \gamma \sqrt{\left(1 + \left(\frac{\vartheta_N}{1 - \vartheta_N}\right)^2 \sigma_G^2\right) \left(\sigma_D^2 \sigma_N^2 + \left(\frac{1}{R^f - \rho_v}\right)^2 \sigma_v^2 \sigma_N^2\right)}.$$
Furthermore, price volatility is increasing in \( \sigma_N^2 \) and therefore highest closest to breakdown. Finally, this linear price equilibrium is the unique equilibrium when the government follows a given linear intervention strategy.

Though we derive the model with government intervention here, in the main text we discuss the perfect information settings both with and without government intervention. In the absence of government intervention, by setting \( \vartheta^N = 0 \), the condition for market breakdown in Proposition A1 simplifies to

\[
R^f < 2\sqrt{\sigma_D^2 \sigma_N^2 + \left( \frac{1}{R^f - \rho_v} \right)^2 \sigma_v^2 \sigma_N^2}.
\]

**Appendix B  Microfoundation for Government Objective**

In this appendix, we introduce an investment project with a return tied to the financial asset examined in our main model. By analyzing how the asset price affects the investment return, we show that the social welfare is decreasing with the asset price volatility and the variance of the asset price deviation from fundamental.

We directly adopt the asset from our main model, which offers a stream of dividends \( D_t = v_t + \sigma_D \varepsilon_t^D \) over time. As we described in the main model, the asset price is determined by market trading:

\[
P_t = \frac{1}{R^f} \hat{v}_{i+1}^M + p_v (v_{t+1} - \hat{v}_{i+1}^M) + p_N N_t,
\]

with \( v_t \) as the unobservable fundamental in the asset’s dividend payout and \( N_t \sim \mathcal{N}(0, \sigma_N^2) \) as noise trading. For simplicity, we assume that \( v_t \) is i.i.d. in this Appendix, and that it has mean \( \bar{v} \).

Consider a representative firm with three dates \( t \in \{0, 1, 2\} \), which are chosen without any loss of generality, and three types of agents: the firm manager, investors, and lenders. At date 1, the firm rents capital \( K_1 \) from investors at a rental rate \( r_1 \), and hire labor \( L_1 \) at a fixed wage \( w \) in a perfectly elastic labor market. At date 2, the firm produces output \( Y_2 \) according to the Cobb-Douglas production function:

\[
Y_2 = e^{\beta v_2 + \varepsilon^y} K_1^\alpha L_1^{1-\alpha}, \quad \varepsilon^y \sim \mathcal{N}(0, \sigma_y^2), \quad v_2 \sim \mathcal{N}(\bar{v}, \sigma_v^2)
\]

where \( \alpha \in (0,1) \) is a constant, \( \varepsilon^y \) is random noise, and \( v_2 \) is the same as the asset’s fundamental at \( t = 2 \). As \( v_2 \) is not observable to the firm manager at \( t = 1 \), the asset price \( P_1 \) provides useful information. Thus, the firm manager chooses \( \{K_1, L_1\} \) at date 1 to maximize its expected profit \( \Pi_1 \):

\[
\Pi_1 = \sup_{K_1, L_1} E \left[ Y_2 - r_1 K_1 - w L_1 | \mathcal{F}_1^M \right]
\]

with \( \mathcal{F}_1^M = \{P_1\} \). Furthermore, note that \( P_2 \sim \mathcal{N}(0, \sigma_p^2) \)^24

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^24 As the shares of investors are nontradable, this is one of many valuations consistent with equilibrium. It can be viewed as the opportunity cost of retaining the share rather than selling it in capital markets to speculators and noise traders.
In addition to the informational role of the asset price, we also allow the asset price to play another important role—it affects collateral value of the asset. Suppose that at $t = 0$, a unit continuum of risk-neutral investors are endowed with initial capital $k_0$ and a share in the asset. For simplicity, we assume that this share is not tradable. Instead, the investors can use their asset holding as collateral to borrow more funds from lenders to invest in the firm. Specifically, investors invest $I_0$ at date 0 to create new capital elastically by borrowing funds from lenders, but cannot commit to repay because of limited liability. While the dividend from the asset, $D_2$, and the rent from capital, $r_1k_1$, are not pledgeable, investors can pledge their asset holding as collateral. They receive debt financing at rate $i_0$ subject to a Value-at-Risk (VaR) constraint that the probability that the collateral value, $P_2$, is less than the repayment $i_0I_0$ must be less than $\pi \in [0, 1]$:  

$$E \left[ \mathbf{1}_{\{(v_2, N_2) \in D_2\}} I_0 \right] \leq \pi,$$

where

$$D_2 = \{(v_2, N_2) : P_2 - i_0I_0 < 0\},$$

is the region of default. Investors choose investment $I_0$ to maximize their expected profit

$$u_0 = \sup_{I_0} E \left[ D_2 + r_1k_1 + (P_2 - i_0I_0) \mathbf{1}_{\{(v_2, N_2) \in D_2\}} I_0 - RfI_0 \mathbf{1}_{\{I_0 \leq 0\}} \right],$$

subject to the law of motion of capital, $k_1 = k_0 + I_0$, and the VaR constraint. Market-clearing imposes that $K_1 = k_1$. Through the VaR constraint, the asset price volatility reduces its collateral value $I_0$.

Given the VaR constraint, risk-neutral lenders determine the interest rate on lending to investors $i_0$ subject to breaking even:

$$E \left[ (i_0 - Rf) I_0 + (P_2 - i_0I_0) \mathbf{1}_{\{(v_2, N_2) \in D_2\}} \right] = 0.$$

Given that $P_t$ is linear, it follows that all agents’ posterior about $v_2$ at date 1 is Gaussian $v_2 \mid \mathcal{F}_1^M \sim \mathcal{N} \left( \tilde{v}_2^M, \Sigma_{M,vv}^M \right)$, where

$$\tilde{v}_2^M = \frac{p_N^2\sigma_N^2}{p_v^2\sigma_v^2 + p_N^2\sigma_N^2} \bar{v} + \frac{p_N^2\sigma_N^2}{p_v^2\sigma_v^2 + p_N^2\sigma_N^2} \eta_t,$$

$$\Sigma_{M,vv}^M = \frac{p_N^2\sigma_N^2}{p_v^2\sigma_v^2 + p_N^2\sigma_N^2} \sigma_v^2,$$

and $\eta_t = \frac{p_v + (p_v - p_N) \bar{v}^M}{p_v}$. The following proposition highlights the salient features of the equilibrium when the VaR constraint binds.  

**Proposition A2** Suppose $\bar{v} > v^*$ and $\sigma_P < \sigma_P^*$, where $v^*$ and $\sigma_P^*$ are given in the Internet Appendix. Then, the VaR constraint binds, and

25While our arguments would also hold more generally when the VaR constraint does not bind, it is easier for exposition to focus on this stark case in which investors are credit constrained.
1. each investor’s investment in physical capital, $I_0$, and the cost of financing $i_0$ are given by

$$I_0 = \frac{1}{R^f} \left( \bar{v} - (1 - \pi) (1 - \pi) + \phi (1 - \pi) \right) \sigma_P,$$

$$i_0 = \frac{R^f}{1 - \pi + \frac{\pi \bar{v} - \phi (1 - \pi) \sigma_P}{\bar{v} - \Phi^{-1} (1 - \pi) \sigma_P}},$$

and $I_0$ is decreasing, while $i_0$ is increasing, in the asset price volatility $\sigma_P$;

2. the expected output from the investment $E [Y_2]$ takes the form:

$$E [Y_2] = \frac{R^f k_0 + \bar{v} - ((1 - \pi) (1 - \pi) + \phi (1 - \pi) \sigma_P e^{\frac{1}{2} \theta_0 + \frac{1}{2} \left( \frac{\theta}{\theta - 1} \right) \left( \sigma^2_{P} - (1 - \alpha) M;vv \right)} + \frac{1}{\theta} \sigma^2_{P}}{R^f \left( \frac{1 - \alpha}{\theta} \right) \sigma^2_{P}}},$$

and is decreasing in both $\sigma_P$ and the conditional variance of the belief of $v_2$, $\Sigma^{M,vv}$.

Proposition A2 demonstrates that the asset price volatility rations credit by raising the financing cost for investors in financial markets, and this limits the capital that they invest in firms. Asset prices also affect firm behavior by impacting the conditional variance of the firm fundamental, $\Sigma^{M,vv}$. The expected output is decreasing in $\Sigma^{M,vv}$ since firms, on average, underreact to $v_2$ because of informational frictions.

Suppose that the government seeks to maximize the expected output, $E [Y_2]$, with market intervention, $\sigma_N$. With risk-neutral agents, this can be equivalent to maximizing utilitarian social welfare. Recognizing that $\Sigma^{M,vv}$ is increasing in the deviation of the price from its fundamental value, $\sigma^2_{P} = Var [P_1 - p_v v_2]$, we can log-linearize the expected output around the reference vector of no impact of noise traders $\left\{ (\frac{1}{R^f})^2 \sigma^2_{P}, 0 \right\}$, where $(\frac{1}{R^f})^2 \sigma^2_{P}$ is the asset’s fundamental volatility, to arrive at:

$$V_0 = \sup \sigma_N \gamma - \gamma_\sigma Var [P_2] - \gamma_v \gamma Var [P_1 - p_v v_2],$$

where

$$\gamma_\sigma = \frac{(1 - \pi) (1 - \pi) + \phi (1 - \pi) \sigma_P}{R^f k_0 + \bar{v} - ((1 - \pi) (1 - \pi) + \phi (1 - \pi) \sigma_P) \frac{1}{R^f} \sigma P 2 \sigma_v} > 0,$$

$$\gamma_v = \frac{1}{2} \left( \frac{1}{\alpha} \right)^2 (1 - \alpha) \frac{d c_M, \Sigma^{M,vv}}{d \sigma^2_{P} \sigma^2_{P} = 0} > 0,$$

since $\frac{d c_M, \Sigma^{M,vv}}{d \sigma^2_{P}} > 0$. Our interest is in the potential tension between these two motives.

### Appendix C Deriving Equilibrium with Information Frictions and Government Intervention

In this Appendix, we derive the equilibrium with information frictions and government intervention in several steps. We assume that the economy is initialized from its stationary
equilibrium, in which all conditional variances from learning have reached their deterministic steady state and the coefficients in prices and policies are time homogeneous.

We begin, as in the main text, by conjecturing a linear equilibrium price function:

$$P_t = p_v \hat{v}_{t+1}^M + p_G \hat{G}_{t+1}^M + p_v (v_{t+1} - \hat{v}_{t+1}^M) + p_G (G_{t+1} - \hat{G}_{t+1}^M) + p_g G_t + p_N N_t.$$  

Importantly, we recognize that it must be the case that $p_v = 1/R_f$, since a unit shift in $v_t$ must raise the discounted present value of future cash flows by $1/R_f$.

We now construct the equilibrium in several steps. We first solve for the learning processes of the government and investors, which begin with an intermediate step of deriving the beliefs from the perspective of the market that has access to only public information. Given the market’s beliefs, which we can define recursively with the Kalman Filter, we can construct the conditional posterior beliefs of the government, and the posterior beliefs of each investor by applying Bayes’ Rule to the market’s beliefs given the private signal of each investor. We then solve for the optimal trading and information acquisition policies of the investors. Imposing market clearing, we can then express the government’s objective in terms of the equilibrium objects we derive from learning.

**Appendix C.1 Equilibrium Beliefs**

In this subsection, we characterize the learning processes of the government and the investors. As we will see, it will be convenient to first derive the market’s posterior beliefs about $v_{t+1}$, $N_t$, and $G_{t+1}$, respectively, which are Gaussian with conditional mean $\left(\hat{v}_{t+1}^M, \hat{N}_t^M, \hat{G}_{t+1}^M\right)$ and conditional variance $\Sigma_t^M = \text{Var} \left[\begin{bmatrix} v_{t+1} \\ N_t \\ G_{t+1} \end{bmatrix} | \mathcal{F}_t \right]$. Importantly, the market faces strategic uncertainty over the government’s action due to the noise in the government’s trading. As such, one must form expectations about this noise both for extracting information from prices and for understanding price dynamics and portfolio choice.

To solve for the market beliefs, we first construct the innovation process $\eta_t^M$ for the asset price from the perspective of the market

$$\eta_t^M = P_t - (p_v - p_v) \hat{v}_{t+1}^M - (p_G - p_G) \hat{G}_{t+1}^M - p_g G_t = p_v v_{t+1} + p_G G_{t+1} + p_N N_t.$$  

Given that the investors and the government do not observe $G_{t+1}$ (the next-period government noise), they must account for it in their learning.

Importantly, the asset price $P_t$ and the innovation process $\eta_t^M$ contain the same information, so that $\mathcal{F}_t^M = \sigma \left(\{D_s, \eta_s^M, G_t\}_{s \leq t}\right)$. Since the market’s posterior about $v_{t+1}$ will be Gaussian, we need only specify the laws of motion for the conditional expectation $\left(\hat{v}_{t+1}^M, \hat{N}_t^M, \hat{G}_{t+1}^M\right)$ and the conditional variance $\Sigma_t^M$. As is standard with a Gaussian information structure, these estimates are governed by the Kalman Filter. As a result of learning
from prices, the beliefs of the market about \( v_{t+1}, N_t, \) and \( G_{t+1} \) will be correlated ex-post after observing the asset price. We summarize this result in the following proposition.

**Proposition A3** Given the normal prior \( (v_0, N_0) \sim \mathcal{N}((\bar{v}, \bar{N}), \Sigma_0) \) and \( G_0 \sim \mathcal{N}(0, \sigma_0^2) \), the posterior market beliefs are Gaussian \( (v_{t+1}, N_t, G_{t+1}) \mid \mathcal{F}_t^M \sim \mathcal{N}((\hat{v}_{t+1}^M, \hat{N}_t^M, \hat{G}_{t+1}^M), \Sigma^M_t) \), where the filtered estimates \( (\hat{v}_{t+1}^M, \hat{N}_t^M, \hat{G}_{t+1}^M) \) follow the stochastic difference equations

\[
\begin{bmatrix}
\hat{v}_{t+1}^M \\
\hat{N}_t^M \\
\hat{G}_{t+1}^M \\
\end{bmatrix} = \begin{bmatrix}
\rho_v \hat{v}_t^M & 0 \\
0 & \hat{G}_{t|t-1}^M \\
\end{bmatrix} + \begin{bmatrix}
D_t - \hat{v}_t^M \\
\eta_t^M - \rho_v \hat{v}_t^M \\
G_t - G_{t|t-1} \\
\end{bmatrix},
\]

and the conditional variance \( \Sigma^M_t \) follows a deterministic induction equation. The market’s posterior expectations of \( v_{t+1}, N_t, \) and \( G_{t+1} \) are related through

\[
p_v v_{t+1} + p_G G_{t+1} + p_N N_t = p_v \hat{v}_{t+1}^M + p_G \hat{G}_{t+1}^M + p_N \hat{N}_t^M.
\]

Importantly, when the market tries to extract information from the price, market participants realize that the price innovations \( \eta_t^M \) contain the government noise \( G_{t+1} \). As such, they must take into account the information content in the government noise when learning from the price, and must form expectations about \( G_{t+1} \). Through this channel, the path dependence of the government noise feeds into the market’s beliefs and the market has incentives to forecast the future government noise.

Since investors learn through Bayesian updating, we can update their beliefs sequentially by beginning with the market beliefs, based on the coarser information set \( \mathcal{F}_t^M \), and then updating the market beliefs with the private signals of investor \( i \), \( (s_i^t, g_i^t) \). Given that the market posterior beliefs and investor private signals are Gaussian, this second updating process again takes the form of a linear updating rule. We summarize these steps in the following proposition.

**Proposition A4** Given the market beliefs, the conditional beliefs of investor \( i \) are also Gaussian \( (v_{t+1}, N_t, G_{t+1}) \mid \mathcal{F}_t^i \sim \mathcal{N}((\hat{v}_{t+1}^i, \hat{N}_t^i, \hat{G}_{t+1}^i), \Sigma^s_t(i)) \), where

\[
\begin{bmatrix}
\hat{v}_{t+1}^i \\
\hat{N}_t^i \\
\hat{G}_{t+1}^i \\
\end{bmatrix} = \begin{bmatrix}
\hat{v}_{t+1}^M \\
\hat{N}_t^M \\
\hat{G}_{t+1}^M \\
\end{bmatrix} + \Gamma_t^i \begin{bmatrix}
\eta_t^M - \hat{v}_{t+1}^M \\
g_t^M - \hat{G}_{t+1}^M \\
\end{bmatrix},
\]

and \( \Sigma^s_t(i) \) is related to \( \Sigma^M_t \) through a linear updating rule.

Since the government does not observe any private information, its conditional posterior beliefs align with those of the market. In what follows, we focus on the covariance-stationary limit of the Kalman Filter, after initial conditions have diminished and the conditional variances of beliefs have converged to their deterministic, steady state. The following corollary establishes that such a steady state exists.
Corollary 1 There exists a covariance-stationary stationary equilibrium, in which the conditional variance of the market beliefs has a deterministic steady state. Given this steady state, the beliefs of investors are also covariance-stationary.

Having characterized learning by investors and the government in this economy, we now turn to the optimal policies of investors.

Appendix C.2 Investment and Information Acquisition Policies

We now examine the optimal policies of an individual investor $i$ at time $t$ who takes the intervention policy of the government as given. Given the CARA-normal structure of each investor’s problem, the separation principle applies and we can separate the investor’s learning process about $(v_{t+1}, N_t, G_{t+1})$ from his optimal trading policy. To derive the optimal investment policy, it is convenient to decompose the excess asset return as

$$R_{t+1} = E\left[R_{t+1} \mid F_t^M\right] + \phi' z_{t+1} = \psi_t + \phi' z_{t+1},$$

where

$$z_{t+1} = \begin{bmatrix} D_{t+1} - \hat{v}_{t+1}^M \\ \eta_{t+1} - p_c \rho_v v_{t+1} - p_g \hat{G}_{t+1}^M \\ G_{t+1} - \hat{G}_{t+1}^M \end{bmatrix},$$

and $z_{t+1} \sim N(0_{3 \times 1}, \Omega^M)$ from Proposition A3. We can then decompose the excess return based on the information set of the investor:

$$R_{t+1} = E\left[R_{t+1} \mid F_t^i\right] + \phi' s_{t+1},$$

where we can update $E\left[R_{t+1} \mid F_t^i\right]$ from $E\left[R_{t+1} \mid F_t^M\right]$ by the Bayes’ Rule according to

$$E\left[R_{t+1} \mid F_t^i, a_i^i s_t + (1 - a_i^s) g_t^i\right] = E\left[R_{t+1} \mid F_t^M\right] + \text{Cov}\left[R_{t+1}, \begin{bmatrix} s_t^i - E\left[s_t^i \mid F_t^M\right] \\ g_t^i - E\left[g_t^i | F_t^M\right] \end{bmatrix}' \right]_{F_t^M}$$

$$\times \text{Var}\left[\begin{bmatrix} s_t^i - \hat{v}_{t+1}^M \\ g_t^i - \hat{G}_{t+1}^M \end{bmatrix} \mid F_t^M\right]^{-1} \begin{bmatrix} s_t^i - E\left[s_t^i \mid F_t^M\right] \\ g_t^i - E\left[g_t^i | F_t^M\right] \end{bmatrix}$$

$$= \psi_t + \phi' \omega \begin{bmatrix} (1 - a^i) \tau_g^i \Sigma_{M,G_1} \Sigma_{M,vv} + (a^s \tau_s)^{-1} & -\Sigma_{M,vG_1} \\ -\Sigma_{M,vG_1} & \Sigma_{M,vv} + (a^s \tau_s)^{-1} \end{bmatrix}^{-1} \begin{bmatrix} s_t^i - \hat{v}_{t+1}^M \\ g_t^i - \hat{G}_{t+1}^M \end{bmatrix}.$$

This expression shows that the investor’s private information in either $s_t^i$ or $g_t^i$ can help him to better predict the excess asset return relative to the market information. Since the investor is myopic, his optimal trading strategy is to acquire a mean-variance efficient portfolio based on his beliefs. This is summarized in the following proposition.
Proposition A5 Given the state vector $\Psi_t = [\hat{v}_t^{M}, \hat{N}_t^{M}, G_t, \hat{G}_t^{M}]$ and investor $i$’s signals $s_i^t$ and $g_i^t$, investor $i$’s optimal investment policy $X_i^t$ takes the following form:

$$X_i^t = \frac{1}{\gamma} \phi \omega \left[ \frac{\Sigma^{M,G_1}G_1 + [(1 - a^i) \tau_g]^{-1} - \Sigma^{M,v}G_1}{\Sigma^{M,v} + (a^i \tau_s)^{-1}} \right] \left[ \frac{\Sigma^{M,v} + (a^i \tau_s)^{-1}}{\Sigma^{M,v} + (a^i \tau_s)^{-1} - \Sigma^{M,v}G_1} \right] \left[ s_i^t - \hat{v}_t^{M} \right]$$

with the coefficients $\zeta, \phi$, and $\omega$ given in the online Appendix.

This proposition shows that both signals $s_i^t$ and $g_i^t$ help the investor in predicting the asset return over the public information, because they can be used to form better predictions of $u_{t+1}$ and $G_{t+1}$, which determine the asset return in the subsequent period. The investor needs to choose acquiring either $s_i^t$ or $g_i^t$ based on the ex ante market information:

$$E \left[ U_i^t \mid \mathcal{F}_{t-1}^M \right] = \sup_{a_i^t \in \{0, 1\}} \left[ \frac{\phi'}{\phi ' \Omega^{M} \phi} E \left\{ \exp \left( -\gamma R^i W - \frac{1}{2} \frac{E \left[ R_{t+1} \mid \mathcal{F}_t^i \right]^2}{\text{Var} \left[ R_{t+1} \mid \mathcal{F}_t^i \right]} \right) \mid \mathcal{F}_{t-1}^M \right\} \right]$$

where

$$M \left( a^i \right) = \frac{\omega \left[ \Sigma^{M,G_1}G_1 + [(1 - a^i) \tau_g]^{-1} - \Sigma^{M,v}G_1}{\Sigma^{M,v} + (a^i \tau_s)^{-1} - \Sigma^{M,v}G_1} \right] \left[ s_i^t - \hat{v}_t^{M} \right]$$

This is the expected utility of investor $i$ based on the public information from the previous period. Importantly, we recognize that the investor’s information acquisition choice is independent of the expectation with respect to $\mathcal{F}_{t-1}^M$. Intuitively, second moments are deterministic in a Gaussian framework, so the investor can perfectly anticipate the level of uncertainty he will face without knowing the specific realization of the common knowledge information vector $\Psi_t$ tomorrow. We can further derive the objective to

$$a^i = \arg \sup_{a^i \in \{0, 1\}} - \log \left\{ \phi ' \left[ \Omega^{M} - M \left( a^i \right) \right] \phi \right\}.$$  

Since the optimization objective involves only variances, which are covariance-stationary, the signal choice faced by the investors is time invariant. Intuitively, given the Gaussian price distribution and exponential utility for the investors, the benefit of more precise private information lies with the reduction in uncertainty over the excess asset return.

By substituting $M \left( a^i \right)$ into the optimization objective, we arrive at the following result.
Proposition A6  Investor $i$ chooses to acquire information about the asset fundamental $v_{t+1}$ (i.e., $a^i = 1$) with probability $\lambda$:

$$
\lambda = \begin{cases} 
1, & \text{if } Q < 0 \\
(0, 1), & \text{if } Q = 0 \\
0, & \text{if } Q > 0,
\end{cases}
$$

where

$$
Q = \frac{\text{Cov} [R_{t+1}, G_{t+1} | \mathcal{F}^M_t]^2}{\Sigma M G_1 G_1 + \tau^{-1}_g} - \frac{\text{Cov} [R_{t+1}, v_{t+1} | \mathcal{F}^M_t]^2}{\Sigma M v v + \tau^{-1}_s}
$$

is given explicitly in the Appendix, and $\lambda \in (0, 1)$ is the mixing probability when the investor is indifferent between acquiring information about the asset fundamental or the government noise.

This proposition states that the investor chooses his signal to maximize his informational advantage over the market beliefs, based on the extent to which the signal reduces the conditional variance of the excess asset return. Importantly, this need not imply a preference for learning about $v_{t+1}$ directly, since the government’s future noise $G_{t+1}$ also contributes to the overall variance of the excess asset return. The more government’s noise covaries with the unpredictable component of the asset return from the market’s perspective, the more valuable is this information to the investors.\textsuperscript{26} This is the partial equilibrium decision of each investor taking prices as given.

In the special case that the fundamental $v$ is i.i.d., or $\rho_v = 0$, we can establish a necessary and sufficient condition for all investors to choose to acquire information about the noise in future government trading, fixing the government’s trading policy $\vartheta_N$. This is summarized in the following proposition.

Proposition A7 Suppose $\rho_v = 0$, and fix a government trading policy $\vartheta_N$. It is necessary and sufficient that $\{\sigma_v, \sigma_N, \sigma_D\}$ satisfy:

\begin{align*}
\sqrt{\frac{\sigma^2_v + \tau^{-1}_g}{\sigma^2_v}} \left( \frac{1}{2\sigma_N c (1 - \vartheta_N)} \right)^{-1} & \sqrt{\left( \frac{1}{2\sigma_N c (1 - \vartheta_N)} \right)^{-1} - \frac{\sigma^2_v + \sigma^2_D}{c}} \\
& \geq (1 + x) \sqrt{\left( \sigma^2_G + (1 + x) \tau^{-1}_g \right) \left( \frac{1}{\sigma^2_G - R^f \frac{x}{1 - \vartheta_N}} \right)^2}, \quad \text{(A4)}
\end{align*}

where $x$ satisfies:

$$
x (1 + x)^3 = \left( \frac{\vartheta_N \sigma^3_G}{R^f \sigma^3_G} \right)^2,
$$

\textsuperscript{26}Since a higher signal precision will reduce the conditional variance of the excess asset return but impact the expected return symmetrically because the signal is unbiased, the channel through which information acquisition affects portfolio returns is through reduction in uncertainty. Given that investors can take long or short positions without limit, the direction of the news surprise does not impact the information acquisition decision.
and \( c \) is a nonnegative function of \( \{ \vartheta_N, R^I, \sigma_G \} \), given in the Internet Appendix, for all investors to acquire private information about future noise in government trading. Furthermore, such an equilibrium is more likely to exist the higher are \( \sigma_N \) and \( \sigma_D \), and always exists for \( \sigma_v \) sufficiently small.

If prices aggregate only private information about the future noise in government trading, \( G_{t+1} \), then all investors are also willing to acquire that information if it reduces their conditional uncertainty about the future price, \( P_{t+1} \), which contains \( G_{t+1} \), more than learning about the fundamental reduces their conditional uncertainty about next period’s dividend, \( D_{t+1} \). This can occur when the noise in the price from noise trading, \( p_N N_t \), sufficiently hides the aggregated private information about \( G_{t+1} \). Consistent with this logic, the left-hand side of the necessary and sufficient condition in Proposition A7 can be rewritten

\[
\vartheta = \frac{\sigma^2 + \tau^2}{\sigma^2} p_N \sigma_N.
\]

A higher \( \sigma_N \), which increases \(-p_N \sigma_N\), increases the noise in prices, and consequently uncertainty about \( G_{t+1} \). Similarly, a higher \( \sigma^2_D \), which reduces the aggressiveness with which investors trade on their private information, also lowers how informative are prices about \( G_{t+1} \). As a result, the higher are \( \sigma_N^2 \) and \( \sigma_D^2 \), the more motivated investors are to acquire private information about \( G_{t+1} \).

Finally, the proposition also reveals that, for sufficiently small \( \sigma_v \), an equilibrium in which all investors learn about the future noise in government trading always exists. The more that next period’s dividend is driven by its unlearnable shock \( \varepsilon^D_{t+1} \), the less is the benefit to investors learning about the fundamental \( v \), as compared to learning about \( G_{t+1} \). As such, when \( \sigma_v \) is sufficiently small, and investors face minimal uncertainty about the fundamental, they will always find it optimal to instead learn about the future noise in government trading.

### Appendix C.3 Market-Clearing

Given the optimal policy for each investor from Proposition A6 and the government’s trading policy in (3), imposing market clearing in the asset market leads to

\[
N_t = \lambda \frac{\varsigma \Psi_t + \frac{\phi' \omega}{\sum M, v + \tau^2} \begin{bmatrix} 1 \\ 0 \end{bmatrix} (v_{t+1} - \hat{v}_t^M)}{\gamma \phi' \left( \Omega^M - \omega \begin{bmatrix} \sum M, v + \tau^2 \\ 0 \end{bmatrix} \omega' \right) \phi} + \frac{\varsigma \Psi_t + \frac{\phi' \omega}{\sum M, g_1 + \tau^2} \begin{bmatrix} 0 \\ 1 \end{bmatrix} (G_{t+1} - \hat{G}_{t+1})}{\gamma \phi' \left( \Omega^M - \omega \begin{bmatrix} 0 \\ \sum M, g_1 + \tau^2 \end{bmatrix} \omega' \right) \phi} + \vartheta N_t^M + \sqrt{\vartheta' K^M \Omega^M K^M} \vartheta G_t,
\]

where \( \vartheta = [0 \quad \vartheta_N \quad 0 \quad 0]' \) and we have applied the weak Law of Large Numbers that \( \int_X s_i' d\psi = v_{t+1} \) and \( \int_X g_i' d\psi = G_{t+1} \) over the arbitrary subset of the unit interval \( X \). In addition, we have recognized that \( Var \left[ \vartheta_N \hat{N}_t^M \mid \mathcal{F}_{t+1}^M, \{ a_i^t \} \right] = \vartheta' \Omega^M \vartheta \). Following the insights of He and Wang (1995), we can express the market clearing condition with a smaller, auxiliary
state space given that expectations about \( v_{t+1} \) and \( N_t \) are linked through the stock price \( p \).

We now recognize that

\[
\hat{N}_t^M = N_t + \frac{p_v}{p_N} (v_{t+1} - \hat{v}_{t+1}^M) + \frac{p_G}{p_N} (G_{t+1} - \hat{G}_{t+1}^M),
\]

(A6)

from Proposition A3. This allows us to rewrite \( \Psi_t \) as the state vector

\[
\tilde{\Psi}_t = [\hat{v}_{t+1}^M, \hat{G}_{t+1}^M, v_{t+1}, N_t, G_t, G_{t+1}].
\]

Matching coefficients with our conjectured price function pins down the coefficients and confirms the linear equilibrium. Importantly, the coefficients are matched to the basis \( \{\hat{v}_{t+1}^M, v_{t+1} - \hat{v}_{t+1}^M, G_{t+1} - \hat{G}_{t+1}^M, G_t, N_t\} \) in accordance with our conjecture on the functional form of the asset price. This yields three conditions:

\[
0 = -A \left( 1 + p_v (\rho_v - R^f) \right),
\]

\[
\vartheta_N = 1 + Ap_N R^f,
\]

\[
p_G = \frac{1}{R^f p_g},
\]

where

\[
A = \frac{\lambda}{\gamma \phi'} \left( \Omega^M - \omega \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \omega' \right) + \frac{1 - \lambda}{\gamma \phi'} \left( \Omega^M - \omega \begin{bmatrix} 0 & 0 \\ 0 & \frac{1}{\Sigma M \vartheta g_{t+1}} \end{bmatrix} \omega' \right)
\]

These conditions pin down the relationship between the government’s trading policy and the price coefficients, and

\[
-AR^f p_g + \sqrt{\vartheta^T K^M \Omega^M K^M \vartheta} = 0,
\]

(A7)

\[
\frac{p_v}{p_N} + \lambda \frac{\vartheta^T \omega}{\Sigma M \vartheta + \tau_g} \begin{bmatrix} 1 \\ 0 \end{bmatrix} \phi = 0,
\]

(A8)

\[
\frac{p_G}{p_N} + (1 - \lambda) \frac{\vartheta^T \omega}{\Sigma M \vartheta + \tau_g} \begin{bmatrix} 0 \\ 1 \end{bmatrix} \phi = 0,
\]

(A9)

which pin down \( p_g, p_v, \) and \( p_G \) and, consequently, the informativeness of the asset price given the loading on the noise trading \( p_N \). As one can see above, since the investors always take a neutral position on \( \hat{v}_{t+1}^M \) (as it is common knowledge), the government also takes a neutral position by market-clearing. The market-clearing condition (A7) reflects that the investors take an offsetting position to the noise \( G_t \) in the government’s trading.

Since the investors determine the extent to which their private information about \( v_{t+1} \) and \( G_{t+1} \) is aggregated into the asset price, the government is limited in how it can impact
price informativeness. This is reflected in the last two market-clearing conditions, (A8) and (A9). The second terms in these conditions are the intensities with which the investors trade on their private information about $v_{t+1}$ and $G_{t+1}$, respectively. The first terms, $\frac{p_v}{p_N}$ and $\frac{p_G}{p_N}$, are the correlations of $v_{t+1}$ and $G_{t+1}$ with the perceived level of noise-trading $\tilde{N}_t^M$, as can be seen from equation (A6). Since the government trades based on $\tilde{N}_t^M$, it cannot completely separate its impact on the true level of noise-trading $N_t$ in prices from its impact on $v_{t+1}$ and $G_{t+1}$.

Given that the government internalizes its impact on prices when choosing its trading strategy $\vartheta_N$, we can view its optimization problem as being over the choice of price coefficients $\{p_g, p_v, p_G, p_N\}$ in the price functional $P_t = p(\tilde{\Psi}_t)$, subject to the market-clearing conditions.

### Appendix C.4 Optimal Government Policy

Lastly, we turn to the problem faced by the government at time $t$. Given that it holds the market beliefs, the government will choose a coefficient $\vartheta_N$ for its intervention strategy to maximize its objective, taking as given the information acquisition decision of the investors. These results are summarized in the following proposition.

**Proposition A8** The optimal choice of $\vartheta_N$ solves the steady-state optimization problem:

$$U^G = \sup_{\vartheta_N} -\eta_\sigma \left( \phi - \begin{bmatrix} 1 \\ \mathbf{0} \\ \mathbf{0} \end{bmatrix} \right) \Omega^M \left( \phi - \begin{bmatrix} 1 \\ \mathbf{0} \\ \mathbf{0} \end{bmatrix} \right) - \gamma_v F,$$

where $H$ and $F$ are given in the online Appendix.

Given that the government internalizes its direct impact on the asset price, we can treat its optimization as being over the parameter $\vartheta_N$, with the government internalizing the information acquisition, expectations, and trading policies of investors through its impact on prices.

An equilibrium is then a fixed point for $\lambda$ that satisfies Proposition A6.

### Appendix C.5 Computation of the Equilibrium

To compute equilibrium numerically, we follow the Kalman filter algorithm for the market beliefs outlined in Proposition A3 to find the stationary equilibrium. We then solve for the portfolio choice of each investor and impose the market-clearing condition, and optimize the government’s objective in choosing $\vartheta_N$. Finally, we check each investor’s information acquisition decision by computing the $Q$ statistic to verify that the conjectured equilibrium is an equilibrium. We perform this optimization to search for both fundamental-centric ($\lambda = 1$) and government-centric ($\lambda = 0$) equilibria, as well as mixing equilibria ($\lambda \in (0, 1)$).