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Abstract

Announcing a large fiscal stimulus may signal the government's pessimism about the severity of a recession to the private sector, impairing the stabilizing effects of the policy. Using a theoretical model, we show that these signaling effects occur when the stimulus exceeds expectations and are more noticeable during periods of high economic uncertainty. Analysis of a new dataset of daily stock prices and fiscal news in Japan supports these predictions. We introduce a method to identify fiscal news with different degrees of signaling effects and find that such effects weaken or, in extreme cases, even completely undermine the stabilizing impact of fiscal policy.

Keywords: Fiscal policy; Macroeconomic stabilization; Macroeconomic uncertainty; Stock prices; Japan; Asymmetric information

JEL classification: E62, E32, D83

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1. Introduction

Fiscal policy is often regarded as a key tool for stabilizing business cycles. During the pandemic, for instance, many countries implemented substantial fiscal packages to support their economies amidst the widespread crisis. However, estimating the effectiveness of these stabilization policies is challenging because they are designed to respond to endogenous events, such as a recession. Consequently, the size of these interventions likely reflects policymakers' assessments of the economic outlook. This means that the announcement of a large fiscal stimulus may be interpreted by the private sector as an indication that the government views the recession as particularly severe. Such an interpretation can worsen private sector expectations about the economic outlook, possibly diminishing the stabilizing effects of the fiscal intervention. The objective of this paper is to assess whether these signaling effects are supported by a newly constructed dataset of fiscal news in Japan, and to provide the first quantification of these effects for fiscal policy.

We first develop a stylized model to illustrate the theory of signaling effects from economic policies. This model provides critical insights into designing our empirical analysis of fiscal policy's signaling effects. Four important predictions of this theory emerge from the model. First, signaling effects arise when policymakers and the private sector have asymmetric information, and when policy actions are understood by the private sector as responses to ongoing economic developments. Second, the greater the private sector's prior uncertainty, the stronger the signaling effects. Third, signaling effects dampen (or magnify) the impact of a policy action if the private sector expected a smaller (or larger) intervention before the government reveals the fiscal intervention's size. Fourth, signaling effects do not necessarily reverse the impact of economic policies. A fiscal expansion can still increase output, even if signaling effects dampen these impacts.

We construct a novel dataset that combines the daily Nikkei 225 stock index with narrative records from press releases about thirty-four supplementary fiscal packages announced by the Japanese government from 1992 to 2022. These fiscal news were introduced in response to events that threatened to worsen the economic outlook, such as the 2011 earthquake or the COVID-19 pandemic. We use articles of the *Nikkei newspaper* – the major real-time economic and business outlet in Japan – to identify the timing of public announcements for each fiscal package.

We focus on Japan because its legislative process for spending bills is orderly and predictable. Crucially, the size of a spending bill is disclosed at a specific stage in the legislative process and is not renegotiated afterward. This institutional feature allows us to pinpoint exactly when the size of fiscal packages is first made public. Identifying this moment is crucial for our analysis because any signaling effects from economic policies can only occur when the government announces the size of the stimulus. Therefore, we examine changes in stock prices on the day the size of the fiscal packages is announced.

An important preliminary step is to establish how stock prices respond to fiscal news, absent signaling effects. We show that the stock market generally reacts positively to this fiscal news in Japan. Bullish responses to fiscal news are not obvious, as such news might lead to expectations of future tax increases – such as taxes on dividends or capital gains – or heightened sovereign default risk. We find that the stock market reacts positively to announcements of large fiscal spending, which are arguably unrelated to the business cycle and thus cannot convey any signal about the government's view of the economic outlook.[1] Moreover, we find that daily changes in stock prices following the news that a spending bill has passed into law (ratification phase) generally result in a rise in stock prices.[2] The ratification of a spending bill is the final step in the process and, in Japan, almost never introduces new information about the size of the fiscal package being ratified.[3] Thus, the ratification stage does not give rise to signaling effects.

[1]We focus on the following large exogenous fiscal shocks: the announcement that Tokyo was selected to host the 2020 Olympic Games, the choice of Osaka as the host city for the 2025 Universal Exposition, which was accompanied by significant urban regeneration plans and infrastructure spending, and the victory of the Liberal Democratic Party led by Shinzo Abe in the general election, marking the beginning of a pro-government spending economic policy ("Abenomics" policies).

[2]The positive response is significant when stock market volatility is higher than its sample average, reflecting stronger sensitivity of market expectations when uncertainty is high, consistently with Bayesian updating.

[3]This information is provided earlier in the process by the Prime Minister's Office and is not revised for the fiscal interventions considered in our sample.

The positive response of stock prices to fiscal news, in the absence of signaling effects, implies that these effects might have a negative impact on the stock market. According to our stylized model, signaling effects tend to reduce the effectiveness of fiscal policy in stabilizing the business cycle, particularly when the private sector is more uncertain about the economic outlook. We find evidence supporting these predictions by analyzing changes in stock prices on days when news about the size of supplementary fiscal packages is released. Our results show that when stock market volatility (measured by the Nikkei 225 VI) is above its average level, news about the size of fiscal stimulus packages depresses stock prices, consistently with the theory of signaling effects.

The Japanese government bond volatility index – a measure of sovereign default risk – does not significantly respond to the fiscal news considered in this study. Hence, the negative response of stock prices to the fiscal news in periods of high uncertainty cannot be explained by a change in the perceived risk of sovereign default. Moreover, the positive response of stock prices to news about the ratification of a spending bill makes it hard to argue that these bearish stock market response to news regarding the size of fiscal stimuli is driven by expectations of higher taxes.

We then turn to the quantification of fiscal policy's signaling effects on economic activity by estimating a vector autoregression (VAR) model. We develop a novel methodology to identify the strength of signaling effects conveyed by fiscal news. The methodology rests on the comovement between stock prices and *revisions* to the private sector's forecast about government spending on the day when the Prime Minister's Office announces the size of the fiscal packages to the public. Consistently with the predictions of the stylized model, we impose that signaling effects are strong when we observe *negative* comovement between the response of stock prices and the revisions to the private sector's forecast. Conversely, fiscal news that generates *positive* comovement between stock prices and the revisions to the private sector's forecast arguably give rise to signaling effects of smaller magnitude.

We find that fiscal news with significant signaling effects leading to a 10 basis-point upward revision to the private sector's forecast of the annual growth rate of government expenditure lowers real GDP growth by 20 basis points at the peak and lasts for half a year. In contrast, fiscal news with minor or no signaling effects has expansionary effects on output. These findings suggest that signaling effects from fiscal policies considerably weaken policymakers' ability to stabilize the economy and, in extreme cases, offset or even reverse the expansionary impact of an announced fiscal stimulus.

It is important to emphasize that the proposed identification strategy aims to distinguish the magnitude of signaling effects associated with fiscal news. By doing so, we can compare the macroeconomic impacts of fiscal news due to these varying degrees of signaling effects. This differential approach addresses a key limitation in the existing literature on signaling effects – e.g. Campbell et al., 2012, 2017; Nakamura and Steinsson, 2018; Bauer and Swanson, 2023 – which has sought to identify these effects by examining whether private sector expectations react with the "wrong sign," meaning a sign not explained by standard economic models. However, as shown in the stylized model, this definition of signaling effects is overly restrictive because these effects may just moderate, rather than reverse, the impact of economic policy.

We include tax revenues in our VAR model because they are essential for accurately capturing the signaling effects associated with fiscal news. If agents are forward-looking, the negative correlation between spending and stock prices – key to our identification strategy – as well as the decline in output following fiscal news with significant signaling effects, could be attributed to the anticipation of higher taxes resulting from increased government spending. However, tax revenue responds similarly to both types of fiscal news.

Our analysis is chiefly related to studies that investigate the signaling effects of economic policies. In this realm of research, several studies focus on the signaling effect of announcements about monetary policy, studying the role of incomplete information (Vickers, 1986; Romer and Romer, 2000), inflation expectations (Melosi, 2017; Nakamura and Steinsson, 2018; Miranda-Agrippino and Ricco, 2021; Andrade and Ferroni, 2021), unconventional monetary policies (Campbell et al., 2012, 2017; D'Amico and King, 2013), and monetary and non-monetary news of monetary announcements (Cieslak and Schrimpf, 2019; Gáti, 2023;

Gáti and Handlan, 2024). Bauer and Swanson (2023) challenge the relevance of signaling effects in monetary policy, suggesting that what is often labeled as "Fed information effects" might actually be the result of simultaneous responses from both the Fed and the markets to macroeconomic news. Their critique does not directly apply to our methodology, as we measure signaling effects by analyzing high-frequency changes in stock prices rather than month-over-month shifts in private sector expectations about real activity. Additionally, our approach involves identifying various degrees of signaling effects conveyed by fiscal news and evaluating the implications of these different degrees for the impact of fiscal news on output – an approach that we call differential identification of signaling effects. Melosi (2017) develops and estimates a structural model in which monetary policy can have signaling effects.

The paper is connected to an extensive literature seeking to measure the efficacy of fiscal policy using various identification strategies and relying on different fiscal instruments. Blanchard and Perotti (2002) and Mountford and Uhlig (2009) pioneered new methods to identify fiscal shocks in VAR models. Rotemberg and Woodford (1992), Ramey and Shapiro (1998), Edelberg et al. (1999), Burnside et al. (2004) use military spending to capture variation in fiscal policy which is arguably exogenous to the business cycle. Fisher and Peters (2010), Ramey (2011), Owyang et al. (2013), Ben Zeev and Pappa (2017), Ramey and Zubairy (2018), Ghassibe and Zanetti (2022), and Jo and Zubairy (2024) focus on military news shocks. Romer and Romer (2010) rely on narrative methods to identify tax shocks. Their work spurred a number of papers that considerably expanded our understanding of the effects of tax shocks on the economy – see e.g., Favero and Giavazzi (2012) and Mertens and Ravn (2011, 2012, 2013, 2014). Oh and Reis (2012) study the multipliers associated with government transfers. Hausman (2016) investigates the effects of the large veteran's bonus of 1936 on consumption spending. Romer and Romer (2016) look at the macroeconomic effects of changes in Social Security benefit payments. Perotti (2011), Forni and Gambetti (2014), and Ascari et al. (2023) include series of fiscal news or changes in expectations about future fiscal variables in a VAR to study the economic effects of these events. All these papers focus on exogenous changes in fiscal policy, which do not give rise to signaling effects.

Our analysis is related to Ricco et al. (2016), who argue that the government's ability to clearly communicate the future path of fiscal spending to market participants critically affects the efficacy of certain fiscal policies. They propose a new measure of the coordination effects of fiscal communication using the *Survey of Professional Forecasters* and show that with elevated disagreement the output response is muted. Nevertheless, this study does not consider the signaling effects of fiscal policy, which is the main object of the present analysis. De Fiore et al. (2024) study the role of households' expectations in shaping the macroeconomic effects of a fiscal stimulus.

We finally relate to the large literature that studies the role of imperfect information in the formation of expectations in the context of monetary policy. Woodford (2002), Adam (2007), Gorodnichenko (2008), Nimark (2008), Lorenzoni (2009), Blanchard et al. (2013), Melosi (2014), Okuda et al. (2021), Gambetti et al. (2022), and several other studies show that imperfect information is critical to the formation of expectations about inflation and the conduct of monetary policy. Different from the aforementioned studies, we study one of the implications of imperfect information for the effects of fiscal policy.

The remainder of the paper is organized as follows. In Section 2 we develop a stylized model from which we derive a few key predictions of the theory of signaling effects from economic policy. In Section 3, we introduce the dataset of supplementary fiscal announcements compiled from narrative records of press releases of the Japanese government. In Section 4, we show the differential response of stock prices between the fiscal announcements geared towards economic stabilization and those that are *exogenous* to economic conditions. In Section 5, we show formally that stock prices react differently to fiscal news depending on the signaling effects associated with each announcement. Consistently with our theory, we document a significant interplay between the private sector's prior economic uncertainty and signaling effects of fiscal announcements. In section 6 we estimate a VAR model that identifies the impact of signaling effects on real activity using the restrictions consistent with the theory laid down in Section 2. In Section 7, we conclude.

2. A Stylized Model of Signaling Effects

In this section, we present a stylized model to outline the key properties of the theory regarding the signaling effects of economic policies. This model will provide critical insights for designing our empirical analysis of fiscal policy's signaling effects, which we will explore in Sections 4 and 5.[4] The model incorporates asymmetric information between the private sector and the policymaker, who takes policy actions based on beliefs about an economic shock that is not perfectly observed by anyone in the economy. The policy action impacts the state of the economy and is perfectly observed by the private sector, which is aware of the policymaker's reaction function. Note that we do not assume that the policymaker has superior information as this assumption is not essential for signaling effects to arise.

The model has two periods; however, the results can be straightforwardly extended to the multi-period case. In the first period, nature draws an i.i.d. Gaussian shock ε to the state of the economy, X_1. Concomitantly, the private sector observes the signal s^p regarding the state of the economy, X_1. In the second period, the policymaker observes its own signal, s^g, regarding the state of the economy in the previous period, X_1. This signal is not observed by the private sector and only affects the policymaker's beliefs about the state of the economy, X_1, which, in turn, affect, its policy action, a, taken in the second period. Information is asymmetric since the signals observed by the private sector (s^p) and that received by the policymaker (s^g) are privately observed. For tractability, we assume that the private sector correctly observe the precision of the signal received by the policymaker (s^g).

The two-period structure of the model allows us to consider lags between changes in the economic outlook and the policy response. This time structure captures the idea that policymakers react to an economic shock – e.g. a recession – with a lag. Lags are particularly relevant for discretionary fiscal stabilization policies, which will be the focus of our empirical analysis. Moreover, this time protocol facilitates the illustration of the key property of the

[4] Appendix A presents a version of our stylized model that allows a policymaker to take simultaneous policy actions, demonstrating that the results discussed in this section remain consistent regardless of the timing of the policy action. The analysis of the signaling effects theory within a general equilibrium model is provided by Melosi (2017).

theory of signaling effects.

The first period can be interpreted as a period when an unexpected change in the economic outlook, X_1, may occur. This change can be a recession, whose severity is unknown to private agents and the policymaker. The private sector relies on the signal, s^p, to form their beliefs about the economic outlook X_1 in the first period. Formally,

$$X_1 = \varepsilon, \tag{1}$$

$$s^p = X^1 + \xi, \tag{2}$$

where $\varepsilon \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ denotes the economic shock affecting the outlook in the first period. The second equation describes the noisy signal, s^p, received by the private sector before the policymaker announces its policy action. The random variable $\xi \sim \mathcal{N}(0, \sigma_\xi^2)$ indicates that the noise of the private sector's signal is drawn from a normal distribution.

The policymaker observes a signal regarding the shock that hit the economy in the previous period: $s^g = X_1 + \xi^g$ with noise $\xi^g \sim \mathcal{N}(0, \sigma_{\xi,g}^2)$. The policymaker's beliefs about the economic outlook in the first period will shape its action, a. These beliefs – denoted by $E(X_1|s^g)$ – are the solution to a standard signal extraction problem.

The state of the economy and the policy action in the second period are defined as follows:

$$X_2 = X_1 + \gamma a + \lambda E(X_1|s^p, a), \tag{3}$$

$$a = \delta E(X_1|s^g) + \varepsilon_a. \tag{4}$$

Starting from the first equation, the parameter γ captures the effects of policy actions on the economic variable. The policymaker can stimulate the economy in period 2, X_2, by maneuvering its policy tool, a. The larger the parameter γ, the stronger the effect of a policy action, a, on the state of the economy in the second period, X_2. To make the analysis more intuitive and without loss of generality, throughout this section, we assume that γ is strictly positive, as government spending increases output, X_2.

We assume that agents' expectations conditional on observing both the private signal s^p in the first period, and the policy action a in the second period, may have *feedback effects* on the economic variable, X_2. These expectations are denoted by $E(X_1|s^p, a)$ and the parameter λ controls the magnitude of these feedback effects. If $\lambda > 0$, expectations can be regarded as self-reinforcing.[5]

Equation (4) is the policymaker's reaction function. We set $\delta < 0$, implying that the policy action is intended to be *countercyclical*; that is, a falls, cooling down economic activity, X_2, if the government expects period 1's output to have increased. In this case, the government takes action a with the objective of stabilizing the economy represented by the random variable X_2. We assume that policymakers respond to the economic condition observed before their intervention – i.e. X_1. This assumptions is made for tractability as well as to capture delays in fiscal responses.[6] The policy shock is drawn from a mean-zero Gaussian distribution, $\varepsilon_a \sim \mathcal{N}(0, \sigma^2_{\varepsilon,a})$. It is assumed that the private sector knows the reaction parameter, δ and the quality of the policymaker's signal – i.e., the volatility of the noise $\sigma_{\xi,g}$. However, the private sector does not observe the government signal's noise, ξ^g, and the policy shock, ε_a.

Agents' prior beliefs about state of the economy X_1 ahead of the policy response can be pinned down by solving a straightforward signal extraction problem – equations (1)-(2). Solving this problem yields $E(X_1|s^p) = k_1 \cdot s^p$ where $k_1 \equiv \frac{\sigma^2_\varepsilon}{\sigma^2_\varepsilon + \sigma^2_\xi}$ and the uncertainty $VAR(X_1|s^p) = \sigma^2_\varepsilon \cdot (1 - k)$.

Similarly, the solution to the signal extraction faced by the government is $E(X_1|s^g) = k_g s^g$, where $k_g \in (0, 1)$ is the Kalman gain reflecting how sensitive the policymaker's beliefs are to the signal, s^g. This gain is given by $k_g = \frac{\sigma^2_\varepsilon}{(\sigma^2_\varepsilon + \sigma^2_{\xi,g})}$. Thus, the policymaker's reaction function can be written as $a = \delta \cdot k_g s^g + \varepsilon_a$. Without loss of generality, we rescale the policy response $\delta \equiv \frac{\alpha}{k_g}$, where the parameter $\alpha < 0$ represents the reaction of the government to the

[5]We could assume that feedback effects are not delayed and occur already in the first period. However, this would complicate our analysis without adding anything important to the main point we want to make in this section. A model where feedback effects and learning occur simultaneously with policy actions is described in the appendix.

[6]Appendix A develops a model in which policymakers take simultaneous policy actions. Our main conclusions extend to that environment.

signal it receives, s^g. Thus, the policy reaction function (4) can be equivalently expressed as

$$a = \alpha \left(X_1 + \xi^g \right) + \varepsilon_a. \tag{5}$$

The policy action expected by the private sector at the end of the first period is: $E(a|s^p) = \alpha E(X_1|s^p)$. After observing the policy action, a, the private sector optimally updates its expectations regarding X_t^1 as follows:

$$E(X_1|s^p, a) \;\; = \;\; E(X_1|s^p) + k_2(a - E(a|s^p)), \tag{6}$$

where $k_2 \equiv \frac{\alpha VAR(X_1|s^p)}{VAR(X_1|s^p)\alpha^2 + \alpha^2\sigma^2_{\xi,g} + \sigma^2_{\varepsilon,a}}$. Note that this gain is negative because $\alpha < 0$ as the private sector understands policy actions to be countercyclical.

A negative gain k_2 implies that if the magnitude of the policy action, a, exceeds the private sector's ex-ante expectations $E(a|s^p)$, the private sector will revise its expectations about the state of the economy downward, such that $E(X_1|s^p, a) < E(X_1|s^p)$. This adjustment in the private sector's expectations arises from the signaling effects associated with the policy action. Importantly, the revision to expectations in equation (6) depends on the policy surprise captured by $a - E(a|s^p)$.

The time structure of this simple model allows us to precisely pin down the signaling effects of policy actions, a. Formally, signaling effects are defined as the revision to private sector's expectations after the policymaker announces its policy action, a. Formally, $E(X_1|s^p, a) - E(X_1|s^p)$, which can be shown from equation (6) to be as follows:

$$E(X_1|s^p, a) - E(X_1|s^p) \;\; = \;\; k_2(a - E(a|s^p)). \tag{7}$$

The term $k_2(a - E(a|s^p))$ in equation (7) captures the signaling effects and illustrates the importance of controlling for the private sector's beliefs before observing the policy action when evaluating the signaling effects of policy. The mere policy action being positive or negative in and of itself does not capture the signaling effects. What matters to evaluate signaling effects is whether the size of the policy action surprises the private sector negatively or positively.

As we will show through a numerical exercise later in this section, a negative surprise – a fiscal package smaller than what the private sector expected based on its assessment of the state of the economy, $a < E(a|s^p)$, – will deliver good news to the private sector. A smaller than expected policy action is interpreted by the private sector as evidence that the policymaker expects the economy to be in a better shape than what the private sector thought before observing the policy action. As a result, the private sector will review its expectations positively.

2.1. A Few Numerical Exercises

We will now perform a few numerical exercises to illustrate the fundamental properties of signaling effects theory. First, to accurately assess the presence of signaling effects from an economic policy, it is essential to consider the prior beliefs of economic agents regarding the scale of the policy action. If the fiscal package exceeds expectations, the private sector may interpret this as an indication that the economy is in worse shape than anticipated, potentially leading to negative signaling effects on economic activity.

Second, increased uncertainty in the private sector about the state of the economy amplifies signaling effects. Third, signaling effects do not necessarily reverse the impact of economic policies. Often, signaling effects only dampen the overall impact of a policy intervention, making it more complex to determine their existence than what the literature has typically done – e.g. Campbell et al. (2012). This feature aligns with our approach, which focuses on the differential effects of policy shocks with varying degrees of signaling. Finally, policy actions perceived as unrelated to changes in economic conditions do not produce signaling effects.

We set the policymaker's response to economic condition, $\alpha = -2$. The effect of a unitary change in the policy action, a, on the economic activity in the second period is given by the parameter $\gamma = 0.5$. In the baseline case, the standard deviation of the fundamental shock σ_ε is equal to one. The standard deviation of the noise in the policymaker's signal shock, $\sigma_{\xi,g}$ is set to 0.05 and the standard deviation of the noise in the signal received by the private sector in the first period, σ_ξ, is set to 0.25.

We assume that the realized noise in the private signal is zero; that is, $\xi = 0$. We also shut down the policy shock, $\sigma_{\varepsilon,a} = 0$, in all the exercises where we want to focus on policies with signaling effects. In the last exercise (Section 2.5), we will consider "exogenous" policy actions that do not have signaling effects and so we will consider that shock.

These numbers are not intended to match any moment in the data given the admittedly very abstract nature of the model. These values are chosen to illustrate properties of signaling effects of economic policies that will turn out to be useful to design the empirical exercises of the paper.

2.2. Prior Beliefs and Signaling Effects

We assume that a unitary negative shock ($\varepsilon = -1$) in the first period causes the value of the fundamentals to fall ($X_1 = \varepsilon = -1$). Agents expect this deterioration of the outlook to trigger a response from the government in the second period. Their prior beliefs – called prior because they are formed before the government takes its perfectly observed action a in the second period – are denoted by $E(a|s^p)$. As shown in the previous section, these prior beliefs are based on the knowledge of the policy reaction function – specifically the parameter α –, and agents' beliefs about the state of the economy in the first period, $E(X_1|s^p)$.

The left chart of Figure 1 shows the signaling effects $(E(X_1|s^p, a) - E(X_t|s^p))$, as a function of the policy surprise $(a - E(a|s^p))$. To obtain this graph we assume a set of positive and negative noise shocks to policymaker's signal (ξ^g) to generate an array of policy surprises $(a - E(a|s^p))$. These policy surprises are shown in the horizontal axis. The vertical axis reports the signaling effects (i.e. $E(X_1|s^p, a) - E(X_1|s^p)$) associated with these policy surprises. The slope of the solid blue line is the gain k_g, defined in the previous section – see equation (7).

A negative (positive) policy surprise means that, based on its prior beliefs, the private sector expected a larger (smaller) policy action than what is actually taken by the government in period 2. The announcement of a smaller (larger) than expected policy action is good (bad)

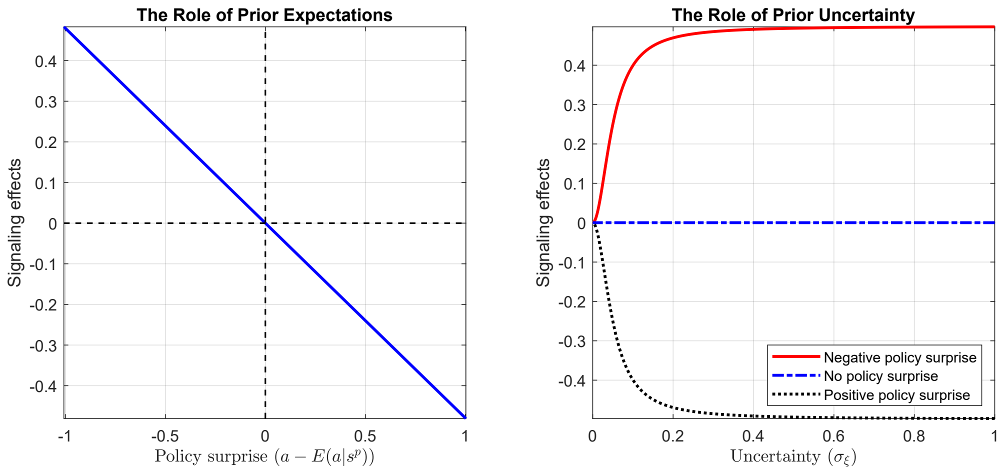

Figure 1: **Signaling Effects of Economic Policy.** The *left chart* shows how signaling effects (i.e., the revision to economic agents' expectations about the state of the economy after observing the policy action – $E(X_1|s^p, a) - E(X_1|s^p)$) as a function of the policy surprise $(a - E(a|s^p))$. The policy surprises are obtained by choosing a set of noise shocks ξ^g to the policymaker's signal for a given fundamental shock $\varepsilon = -1$. The *right chart* shows the signaling effects of policy actions triggering a negative surprise (the red solid line), no surprise (the blue dotted-dashed line), and a positive surprise (the the black dotted line) as economic agents' uncertainty varies. Uncertainty varies as a result of changes in the precision of the signal (σ_ξ) observed by the private sector. The three policy surprises are obtained by setting the noise ξ^g in the policymaker's signal equals to -1 (negative policy surprise), 0 (no policy surprise), and 1 (positive policy surprise).

news about the state of the economy, leading the private sector to review their expectations $(E(X_1|s^p, a) - E(X_t|s^p))$ accordingly.

Importantly, in the left chart of Figure 1, the blue line crosses the point (0,0), suggesting that signaling effects arise only if the private sector is surprised by the size of the policy action. If agents' prior beliefs correctly anticipate the size of a policy package, there is no signaling effects.

To sum up, this exercise underscores the importance of taking into account the revision to private sector's expectations about the size of the policy intervention when assessing signaling effects of policy actions. The size of the policy action, a, in and of itself is not decisive for the sign of the signaling effects.

2.3. Uncertainty and Signaling Effects

We now show that signaling effects become more pronounced when the private sector is more uncertain about the fundamentals. To illustrate this, we vary the level of uncertainty regarding the state of the economy by selecting a range of values for the precision of the private sector's signal noise, denoted by ξ. Specifically, as the standard deviation σ_ξ increases, the precision of the signal decreases, leading to greater uncertainty about the state of the economy X_1. Consequently, as we will show, the signaling effects become larger. We assume that no fundamental shock impacts the economy in the first period ($\varepsilon = 0$).

The right chart of Figure 1 illustrates how the size of the signaling effects (on the vertical axis) – i.e. $E(X_1|s^p, a) - E(X_1|s^p)$ – varies in response to a more uncertain outlook from the perspective of the private sector (on the horizontal axis). Uncertainty and the size of the signaling effects interact. Specifically, signaling effects increase with the private sector's uncertainty about the state of the economy. When (prior) uncertainty is large, the private sector relies more on the policy action to learn about the state of the economy, boosting the signaling effects. This is a theoretical prediction that we will test to prove the existence of signaling effects of fiscal announcements in Japan.

Not surprisingly, as indicated by the analysis in the previous exercise (left chart), the sign of the signaling effects depends on whether the private sector is surprised by the size of the policy action, a, from the downside or the upside. A smaller (larger) than expected policy action – a negative (positive) policy surprise – leads to an improvement (deterioration) of the private sector's beliefs regarding the state of the economy; that is positive (negative) signaling effects. If the private sector correctly anticipates the policy action, there are no signaling effects. See the dashed-dotted blue line on the right chart of Figure 1. This result is in line with what we showed in the first exercise.

2.4. Signaling Does Not Necessarily Reverse the Impact of Policies

In this third exercise, we assume that no fundamental shock affects the economy in the first subsample ($\varepsilon = 0$). As in the first exercise, a set of positive and negative noise shocks to the policymaker's signal, ξ^g provide us with a range of values for policy action, a, which are shown on the horizontal axis of the two charts in Figure 2.[7]

We examine two factors that could dampen the effects of policy actions. First, we consider different degrees of feedback effects: no feedback ($\lambda = 0.0$), minimal feedback ($\lambda = 0.5$), and substantial feedback ($\lambda = 1.5$). Based on these assumptions regarding feedback effects, we compute the state of the economy in the second period, X_2, which is shown on the vertical axis of the left chart in Figure 2. The state of the economy in the second period reflects both the effects of the policy action on the economy, γa, and the feedback effects from the private sector's beliefs about the economy, $\lambda E(X_1|s^p, a)$.[8] These feedback effects are the channel through which the signaling effects of policy actions influence the state of the economy in the second period, X_2.

The left chart of Figure 2 illustrates the effect of a policy action a on the state of the economy in the second period, X_2 under different levels of feedback to the economy. The black dotted line represents the state of the economy for a given policy surprise under the assumption of no feedback effects (i.e., $\lambda = 0$). When there is no feedback, the effects of the policy action on the economy are the largest because signaling effects do not influence the state of the economy, X_2, through the feedback channel. As feedback effects become stronger, signaling effects play a more significant role in dampening the impact of the policy on output, X_2. This is evident by moving from the black dotted line (no feedback effects, $\lambda = 0$) to the dashed-dotted red line (with feedback effects, $\lambda = 0.5$). Feedback effects can become so pronounced ($\lambda = 1.5$) that signaling effects might even overturn the conventional impact of policy action on the state of the economy ($\gamma > 0$). This is reflected in the blue

[7] We could display the policy surprises, $a - E(a|s^p)$, on the x-axis. However, this would not affect our analysis because we assume that no fundamental shock impacts the economy in the first subsample ($\varepsilon = 0$) and that the realization of the noise in the private sector's signal is zero ($\xi = 0$). Consequently, $E(a|s^p) = 0$.

[8] Since we assume that no economic shock affects the economy in the first period ($\varepsilon = 0$), $X_1 = 0$, and therefore, the first term on the right-hand side of equation (3) defining X_2 is zero.

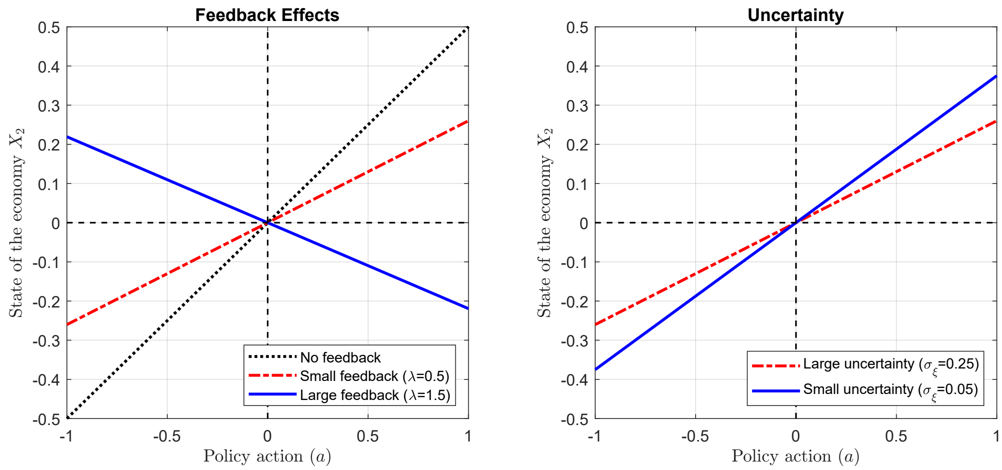

Figure 2: **Effectiveness of Economic Policies with Signaling Effects.** In the *left chart*, economic activity (X_2) is plotted as a function of the policy surprise, $a - E(a|s^p)$ for three levels of feedback from beliefs to economic activity. The black dotted line denotes the case with no feedback effects ($\lambda = 0.0$). The cases of small feedback effects ($\lambda = 0.5$) and large feedback effects ($\lambda = 1.5$) are denoted by the red dashed dotted line and the solid blue line, respectively. In the *right chart*, economic activity (X_2) is plotted as a function of the policy surprise, $a - E(a|s^p)$, for two levels of uncertainty of the private sector. The red dashed-dotted line denotes the case of large uncertainty, in which the noise standard deviation of the private sector's signal is relatively large ($\sigma_\xi = 0.25$). The blue solid line denotes the case of small uncertainty, in which the noise standard deviation of the private sector's signal is relatively small ($\sigma_\xi = 0.05$). In both cases the parameter controlling the feedback, λ is equal to 0.5. In both charts, policy actions on the horizontal axis are obtained by varying the realized noise in the policymaker's signal (ξ^g).

line sloping downward on the left chart, indicating that stimulative policies may ultimately contract the economy.

The right chart of Figure 2 illustrates how private sector's uncertainty affects the strength of signaling effects and hence the efficacy of policy actions, a, on the economy, X_2 . The red dashed-dotted line represents the high-uncertainty scenario, where the volatility of the noise in the private sector's signal, σ_ξ, is 0.25. The blue solid line denotes the low-uncertainty scenario, with $\sigma_\xi = 0.05$. The red dashed-dotted line is flatter than the blue solid line, implying that when the private sector faces greater uncertainty about the state of the economy, signaling effects are stronger, resulting in smaller effects of policy actions on the economy, X_2.[9] When the signal observed by the private sector is more imprecise (higher uncertainty),

[9]Recall that because of signaling effects, positive (negative) policy surprises cause the private sector to revise downward (upward) their expectations on the state of the economy, X_1 –i.e., $E(X_1|s^p, a) < E(X_1|s^p)$ if policy surprises are positive and vice versa. See the right chart of Figure 1. As shown in equation (3),

agents rely more on the information conveyed by the policy action, amplifying the signaling effects. It can be shown that, for sufficiently large levels of uncertainty, signaling effects become so strong that can reverse the effects of policy on output, X_2.

These exercises show that while a contraction in output following an expansionary economic policy may be explained by signaling effects, finding an increase in output does not disprove the existence of signaling effects as often assumed in the literature – e.g Campbell et al. (2012). Signaling effects *dampen* the impact of a policy on economic outcomes but they do not necessarily reverse the sign of its impact.

2.5. "Exogenous" Policy Actions

By "exogenous" policy actions, we mean policy actions that are not aimed at stabilizing economic conditions. These actions are captured by our stylized model by setting the policy reaction parameter δ equal to zero and by considering the case in which the policy action is entirely driven by the policy shock ε_a. If the private sector understands that the policy action is not triggered by any changes to the economic conditions, X_1, expected by the policymaker, they will not update their beliefs after observing the policy action a. The signal is exogenous because $\delta = 0$ and, therefore, does not convey any information about the state of the economy, X_1. Hence, it is obvious that $E(X_1|s^p) = E(X_1|s^p, a)$, implying zero signaling effects – defined in equation (7).

To sum up, this simple signal-extraction model highlights the key properties of the theory of signaling effects. First, to correctly assess the existence of signaling effects of an economic policy, it is critical to control for economic agents' prior beliefs about the size of the policy. Second, the larger the private sector's prior uncertainty, the more sizable the signaling effects. Third, signaling effects do not necessarily reverse the effect of economic policies. A fiscal expansion can still boost output even though signaling effects are at play. Signaling effects only dampen the expansionary effects of a fiscal stimulus. It is also important to underscore

expectations $E(X_1|s^p, a)$ positively affect the state of the economy in period 2 through the feedback channel.

that a critical feature for an economic policy to have signaling effects is that the policy is understood to respond to economic conditions. If an economic policy is fully autonomous ($\delta = 0$), it does not give rise to signaling effects.

3. Construction of the Data Set

To evaluate the signaling effects of fiscal policy, we have created a new dataset that combines daily stock price data (the Nikkei 225 average stock price index) with narrative records of fiscal announcements from Japanese press releases. Japan is a crucial choice for our study. To assess the presence of potential signaling effects, it is essential to pinpoint the exact moment when the government credibly releases information about the size of the fiscal intervention to the stock markets.

The legislative process for approving a fiscal measure varies greatly across countries and is typically complex and uncertain, involving many parties that can influence a spending bill in unpredictable ways at every step of the process. A key challenge for us is, therefore, to identify the precise moment when news about the size of the fiscal package is released and no longer subject to parliamentary negotiation. In this regard, Japanese institutions follow a clear and transparent process. The details of a fiscal package are established and definitively announced to the markets at a specific moment. After this announcement, market participants do not expect significant changes in the size of the package, providing us with a crucial time reference to estimate the signaling effects of fiscal policy.

Looking at these institutional details more closely, the Prime Minister's Office of Japan announced thirty-four stimulus packages of supplementary budgets from August 28, 1992, to October 28, 2022. Table 1 provides the main details of each of these packages.[10] Supplementary fiscal packages are issued irregularly, sometimes outside the opening hours of the stock market, with a posthumous formal ratification. To identify the moment of the public announcement of each fiscal package, we use the *Nikkei* newspaper – the major, real-time,

[10] Fiscal spending excludes the loans from government-affiliated financial institutions and tax deferrals from the total size of the fiscal package.

Table 1: Dates of Fiscal Announcements: 1992–2022

(1) Dates	(2) Indicators	(3) Fiscal spending	(4) Total size	(5) Disclosure event
(a) *Countermeasures against the collapse of bubble economy*				
08/28/1992	$\mathbb{I}\{A_{1,t}\}$	n.a.	10.7 trn.	Meeting of relevant ministers
04/13/1993	$\mathbb{I}\{A_{2,t}\}$	n.a.	13.2 trn.	Meeting of relevant ministers
09/16/1993	$\mathbb{I}\{A_{3,t}\}$	n.a.	6.15 trn.	Government and ruling coalition agreement
02/09/1994	$\mathbb{I}\{A_{4,t}\}$	n.a.	15.25 trn.	Cabinet decision
09/20/1995	$\mathbb{I}\{A_{5,t}\}$	n.a.	14.22 trn.	Meeting of relevant ministers
(b) *Countermeasures against financial crisis in Japan*				
04/24/1998	$\mathbb{I}\{A_{6,t}\}$	n.a.	16.65 trn.	Meeting of relevant ministers
11/16/1998	$\mathbb{I}\{A_{7,t}\}$	n.a.	23.9 trn.	Meeting of relevant ministers
11/11/1999	$\mathbb{I}\{A_{8,t}\}$	n.a.	18 trn.	Meeting of relevant ministers
10/19/2000	$\mathbb{I}\{A_{9,t}\}$	n.a.	11 trn.	Meeting of relevant ministers
(c) *Countermeasures against global financial crisis*				
08/29/2008	$\mathbb{I}\{A_{10,t}\}$	2 trn.	11.5 trn.	Government and ruling parties' agreement
10/31/2008	$\mathbb{I}\{A_{11,t}\}$	5 trn.	26.9 trn.	Press conference by PM
12/19/2008	$\mathbb{I}\{A_{12,t}\}$	10 trn.	43 trn.	Meeting of relevant ministers
04/09/2009	$\mathbb{I}\{A_{13,t}\}$	15.4 trn.	56.8 trn.	LDP approval
12/08/2009	$\mathbb{I}\{A_{14,t}\}$	7.2 trn.	24.4 trn.	Cabinet decision
08/31/2010	$\mathbb{I}\{A_{15,t}\}$	915 bn.	9.8 trn.	Committee of relevant ministers
10/08/2010	$\mathbb{I}\{A_{16,t}\}$	4.9 trn.	20.8 trn.	Government and ruling parties' agreement
(d) *Supplementary budgets for recovery from Great East Japan Earthquake*				
04/18/2011	$\mathbb{I}\{A_{17,t}\}$	4 trn.	n.a.	Ruling parties' agreement
06/30/2011	$\mathbb{I}\{A_{18,t}\}$	2 trn.	n.a.	Government final plan
10/15/2011	$\mathbb{I}\{A_{19,t}\}$	12 trn.	n.a.	Ruling and opposition parties' agreement
(e) *Countermeasures against yen appreciation*				
10/25/2012	$\mathbb{I}\{A_{20,t}\}$	400 bn.	750 bn.	Government final plan
11/27/2012	$\mathbb{I}\{A_{21,t}\}$	880 bn.	1.2 trn.	Government final plan
(f) *Abenomics policy*				
01/11/2013	$\mathbb{I}\{A_{22,t}\}$	10.3 trn.	20.2 trn.	Press conference by PM
12/05/2013	$\mathbb{I}\{A_{23,t}\}$	5.5 trn.	18.6 trn.	Meeting of Government and ruling parties
12/29/2014	$\mathbb{I}\{A_{24,t}\}$	3.5 trn.	n.a.	Meeting of government and ruling parties
08/02/2016	$\mathbb{I}\{A_{25,t}\}$	13.5 trn.	28.1 trn.	Meeting of government and ruling parties
12/05/2019	$\mathbb{I}\{A_{26,t}\}$	13.2 trn.	26.0 trn.	Meeting of government and ruling parties
(g) *Countermeasures against COVID-19 pandemic*				
02/14/2020	$\mathbb{I}\{A_{27,t}\}$	15.3 bn.	500 bn.	Novel Coronavirus Response Headquarters
03/11/2020	$\mathbb{I}\{A_{28,t}\}$	430 bn.	1.6 trn.	Novel Coronavirus Response Headquarters
04/07/2020	$\mathbb{I}\{A_{29,t}\}$	39.5 trn.	108.2 trn.	Meeting of government and ruling parties
05/27/2020	$\mathbb{I}\{A_{30,t}\}$	72.7 trn.	117.1 trn.	Meeting of government and ruling parties
12/08/2020	$\mathbb{I}\{A_{31,t}\}$	40.7 trn.	73.6 trn.	Meeting of government and ruling parties
11/19/2021	$\mathbb{I}\{A_{32,t}\}$	55.7 trn.	78.9 trn.	Meeting of government and ruling parties
(h) *Countermeasures against price increases*				
04/27/2022	$\mathbb{I}\{A_{33,t}\}$	6.2 trn.	13.2 trn.	Press conference by PM
10/28/2022	$\mathbb{I}\{A_{34,t}\}$	39 trn.	71.6 trn.	Meeting of government and ruling parties

Notes: The table summarizes information about fiscal announcements in Japan for the period 1992-2022. It provides the date (column 1), the indicator variables (column 2), the amount of fiscal spending (column 3) the total size of fiscal packages (column 4), and the event where the final scale of the package was disclosed (column 5). The timing of each announcement is identified from the *Nikkei* newspaper. Fiscal spending consists of national and local government actual spending and fiscal investment and loans. The total size comprises loans from government financial institutions in addition to fiscal spending. In the fiscal packages before 2000, only the total size is reported. Only fiscal spending was released in the series of supplementary budgets in 2011 (the total size was not disclosed).

economic and business outlet in Japan. Since we are interested in fiscal announcements, we select news releases that report the statement of the Prime Minister and the size of the government intervention.

In Japan, the legislative process for approving a fiscal measure comprises three main orderly phases. In the first phase (the order stage), the Prime Minister instructs the Cabinet ministers to prepare a proposal for the supplementary budget or fiscal package. In the second phase (the announcement stage), a public discussion between the government and the ruling parties reveals the approximate content of the fiscal package but leaves uncertainty around the scale. This second phase ends with a public announcement by the Prime Minister (or government official) on the most likely scale of the fiscal package, which is endorsed by the official approval by the Cabinet. In the third phase (the ratification stage), the fiscal package is formally ratified by the Diet, typically without revisions since the measures have already gained support from the ruling parties and the Cabinet.[11] Our analysis, therefore, will mostly focus on the second phase, which entails the first official announcement regarding the scale of the fiscal packages, to assess the existence of signaling effects.

To study the effect of fiscal announcements on stock prices, we create a set of indicator variables that account for the days of information release in each of the three phases of the announcement – see the second column of Table 1.[12] Consequently, we denote with the indicator variable $\mathbb{I}\{A_t^{\text{order}}\}$ the dates when the PM orders the preparation of a proposal for the fiscal package, with the indicator variable $\mathbb{I}\{A_t^{\text{size}}\}$ the dates of the announcements on the size of the final fiscal packages, and with the indicator variable $\mathbb{I}\{A_t^{\text{ratify}}\}$ the dates of ratification by the Diet. Table C.1 in Appendix C.1 reports the dates for the three distinct

[11] In fact, we have been confirmed by the Cabinet Office of Japan that all budgets during our sample period were approved by the Diet as proposed by the government.

[12] We set the indicator variable equal to one on the day in which the news is published either in the evening edition or in the morning edition. The news can in fact be released as flash news in the evening edition before the stock market closure. When the important news of finalizing the scale of fiscal packages is announced in the afternoon of a given day, the news is first released in the evening edition of that day, and then in the morning edition of the following day with detailed information. In such cases, we assign one to the indicator variable for the date when the news appeared in the evening edition, as freshness is more important than the detail of the news. As a robustness check on the exact time of the announcements, we also use the *Nikkei Quick News* (NQN) section from *Nikkei* newspaper, which provides the title and content of each news with the timing of the release in one-minute increments. We find that results are consistent across specifications.

phases associated with each fiscal announcement for the sample period 1992-2022.

As we will show, the announcements in the second phase, which are informative about the size of the fiscal packages, are the most relevant to evaluate the signaling effects of fiscal policy. On the contrary, the information released during the first phase does not seem to be very relevant for the stock market. The ratification stage (third phase) seems to convey information regarding the timing of the implementation of the announced fiscal intervention. However, at this late stage, no changes in the size of the fiscal package is announced by government officials and, hence, no signaling effects can be detected at this time. As shown in Section 2, signaling effects rest upon the revelation of the actual size of the stimulus from which the private sector can learn about the government's view on the state of the economy.

4. Fiscal Announcements and the Stock Market

We first construct a benchmark to evaluate the role of signaling effects of fiscal measures. To this end, we consider three announcements of large increase in government spending that do not give rise to signaling effects since they are "exogenous" with respect to the business cycle. As discussed in Section 2, if the policy action is not taken in response to a change in the economic conditions, signaling effects do not arise.

The three large "exogenous" fiscal spending episodes are:

1. The victory of the Liberal Democratic Party led by Shinzo Abe in the general election, marking the beginning of a pro-government spending agenda ("Abenomics" policies) on December 16, 2012.

2. The successful bid to host the 2020 Olympics with the announcement of large public investment projects on September 8, 2013.

3. The choice of Osaka as the host city for the 2025 Universal Exposition, which was accompanied by significant urban regeneration plans and infrastructure spending on November 24, 2018.

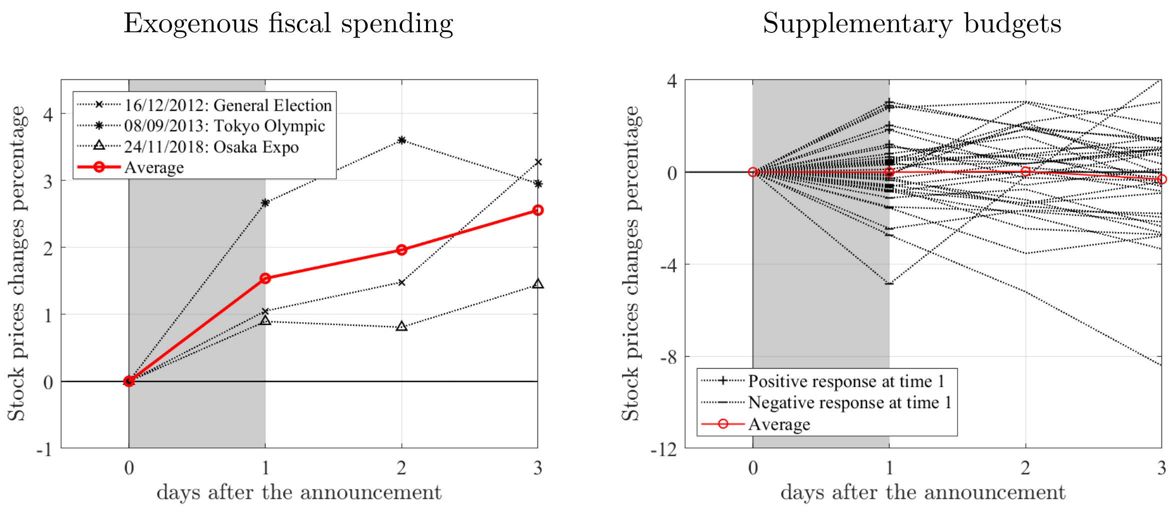

Figure 3: **Effects of fiscal spending news on stock prices.** The figure shows the responses of stock prices to fiscal announcements of three large exogenous fiscal stimulus described in the text (left panel) and thirty-four supplementary fiscal packages listed in Table 1 (right panel). Responses are the cumulative sum of residuals obtained by regressing the percentage change in stock prices on several control variables. We normalize the response to zero on the day before the announcement. The shaded areas highlight the time of the announcement. The y-axes are in percentage changes. The red-solid line with a circle markers shows the average value of responses. In the right panel the markers + and − indicate positive and negative change in stock prices on the day of the announcement. More details are provided in Appendix C.3.

The left chart of Figure 3 shows the percentage responses of the Nikkei 225 index for the three subsequent days to the fiscal announcements. Specifically, we plot the cumulative sum of the residuals obtained by regressing the percentage change in stock prices on several control variables, normalizing the response on the day before the announcement to zero.[13] In our exercise the fiscal announcement occurs between time zero and one (the shaded area in the figure), and the change in stock prices at time one represents the immediate response of stock prices that cannot be explained by changes in the control variables. The effect of the three expansionary fiscal announcements is positive on stock prices on average (red-solid line with circle markers), and differences in the responses of stock prices to the separate

[13]In Appendix C.3, we provide a detailed description of the regression we run. The data and the estimated equations are described in the next section, equation (8). We use the series of residuals from the regression to purge the response of stock prices from the effect of other factors that could affect stock prices. The explanatory variables in the regression are those in our benchmark specification in the next section, excluding the volatility index and fiscal indicator indexes. Note that we here estimate equation (8) by varying the daily horizon of the regressand from 0 to 3 days in order to obtain the dynamic responses.

announcements are sizeable, ranging from around 2.5% in response to the winning bid of the 2020 Olympics to around 1% in the case of the Universal Exposition. These responses represent a preliminary benchmark, showing that stock markets responded positively to the announcements of "exogenous" fiscal packages, which are arguably free of signaling effects according to theory.

A more formal and comprehensive analysis supporting the view that the short-run response of stock prices to fiscal shocks, absent signaling effects, is positive will be presented in the next section. Specifically, we will show that stock prices significantly increase during the ratification phase (the third phase) of the thirty-four supplementary fiscal packages described in Table 1. As previously noted, the ratification of fiscal measures does not provide new information about the size of the fiscal package beyond what was already disclosed in the second phase. Consequently, there are no signaling effects at the ratification stage.

We compare these three benchmark responses of stock prices against those of the thirty-four supplementary fiscal policy measures that the Prime Minister's Office announced outside the regular budget cycles over the period $1992 - 2022$ aimed at counteracting economic difficulties. A list of these measures has been provided in Table 1. We consider the days when the Prime Minister's office announces the size of the package (the second phase). These fiscal packages are not "exogenous" and their effects on the economy may be dampened or reversed by signaling effects according to the theory highlighted in Section 2.

The right chart of Figure 3 shows that the percentage change in stock prices to the supplementary fiscal announcements covers a wide range of values, comprising positive and negative responses, and resulting in an average response of stock prices close to zero, as can be seen by looking at the red-solid line with circle markers. On the first day after the announcement of the size of the packages, the response of stock prices is equally split between negative responses and positive responses. A similar finding emerges if one looks at the responses of stock prices on the days the fiscal announcements.

Unlike the three large "exogenous" fiscal announcements, these thirty-four supplementary budget measures are intended to stabilize the economy in the face of a looming recession, potentially signaling the government's expectations regarding the severity of the economic outlook to the private sector. Consequently, the impact of these fiscal measures could potentially offset the positive response of stock prices that is observed with the three large "exogenous" fiscal news.

While these findings only suggest the possibility of signaling effects, this preliminary analysis is helpful for identifying whether any evidence of such effects might be present in the data. The varying responses between the two charts indicate that a more formal investigation could provide clearer insights into the existence and quantitative significance of these effects.

5. Empirical Investigation of Signaling Effects

In this section, we formally examine whether the supplementary stimulus packages announced by the Prime Minister's Office from 1992 to 2022 (Table 1) had signaling effects. These fiscal measures were intended to address adverse and uncertain economic conditions. As discussed in Section 2, the countercyclical nature of these packages could theoretically generate signaling effects. We also investigate whether these effects are more pronounced during periods of increased uncertainty. The quantification of the signaling effects of fiscal shocks on economic activity is deferred to the VAR analysis in Section 6.

5.1. Evidence of Signaling Effects of Fiscal Policy

To detect the existence of potential signaling effects of fiscal policy, we use the regression analysis as follows. We implement our analysis on the changes in the daily index of stock prices by using the log difference of the average of the Nikkei 225 Index in each period (Δs_t). The sample size after removing missing values includes 7,679 observations over the sample period. We estimate the response of stock prices to fiscal announcements using the following benchmark specification:

$$\Delta s_t = \alpha \mathbb{I}\{A_t^{\text{size}}\} + \beta \mathbb{I}\{A_t^{\text{size}}\} \times VI_{t-1} + Z_{t-1}\gamma' + \delta + e_t \tag{8}$$

where Δs_t is the response of the change in stock prices to fiscal announcements, $\mathbb{I}\{A_t^{\text{size}}\}$ is an indicator variable taking a value equal to unity when one of the thirty-four supplementary fiscal packages is finalized and announced (the second phase) – see Table 1. VI_t denotes the Nikkei 225 Volatility Index, normalized so as to have zero mean and unit variance. This index reflects the stock market's uncertainty regarding the near-term economic outlook. Note that VI_t is included in the regression with a lag, as we want to capture the effect of fiscal announcements in periods of high uncertainty. On the contrary, we do not want to capture the impact of fiscal announcements on the volatility of the stock market, which is what we might measure if we included VI_t contemporaneously. The coefficient δ is a time fixed-effect. The estimated value of $\alpha + \beta \cdot VI_{t-1}$ can then be interpreted as the impulse response function of the deviations of stock prices from their average movement to announcements regarding the magnitude of the thirty-four supplementary fiscal packages.

The parameter β captures the importance of the interactions between stock market volatility and the fiscal announcement's effect on stock prices. According to the theory of signaling effects (Section 2), these interactions are critical as signaling effects are predicted to become more pronounced when there is greater uncertainty in the private sector.

As it will be later verified, the stock market generally reacts positively to news of future fiscal expansion, assuming that no signaling effects are involved. Markets' bullish responses to fiscal news is not obvious, as such news might lead to expectations of future tax increases – e.g. taxes on dividends or capital gains – and heightened sovereign default risk, which typically provokes negative stock market's reactions. Therefore, if, as predicted by the theory, signaling effects are stronger when stock market volatility is high, we would expect the estimated β to be significant and negative. This is a key test for identifying the existence of signaling effects.

Finally, the variable Z_{t-1} denotes the vector of control variables, which include: the lagged change in the volatility index (ΔVI_{t-1}), the lagged change in stock prices (Δs_{t-1}), the Dow Jones Industrial Average for the US Stock Market at trading closure in the preceding day ($\Delta DJIA_{t-1}$), the change in the yen—dollar exchange rate ($\Delta EXCH_{t-1}$), and the ten-year Japanese Government Bond (JGB) yields ($BOND_{t-1}$). These control variables account for possible serial correlation in the errors, changes in domestic stock prices originated by movements in the US stock market, and more broadly the credit supply and financial conditions. Chen and Rogoff (2003) show a strong correlation between movements in the US and Japanese stock prices. The exchange rate is a well-known factor affecting share prices in Japan, where a large proportion of companies are exporters.

Column (1) in Table 2 shows the estimation coefficients for our benchmark specification in equation (8), based on the indicator variable $\mathbb{I}\{A_t^{\text{size}}\}$ that records the dates of the announcements of the final size of the fiscal packages to the public (the second phase). The coefficient β on the interaction term $\mathbb{I}\{A_t^{\text{size}}\} \times VI_{t-1}$ is statistically significant and equal to -0.458. As explained earlier in this section, the significance and sign of this coefficient provide critical evidence in favor of the theory of signaling effects.

The negative coefficient β indicates that when stock market volatility is below the sample average, fiscal news from the Prime Minister's Office boosts stock prices. This finding is consistent with the stylized model (Section 2.4). When uncertainty is low, the signal observed by the private sector, s^p, is quite accurate. Consequently, the size of policy actions provides little additional information to economic agents about the state of the economy. As a result, signaling effects are minimal, and stock prices rise in response to fiscal news, similar to their reaction to the three major "exogenous" fiscal news events and other news, such as the ratification news, as we will show later in this section.

The coefficient α on the indicator variable $\mathbb{I}\{A_t^{\text{size}}\}$ is statistically insignificant, implying that the effect of fiscal announcements on stock prices is negligible under average volatility. It is important to note that this lack of significance is not at odds with the theory of signaling effects. In the stylized model of Section 2, we showed that signaling effects dampen the conventional expansionary effects of fiscal policy (as indicated by the blue solid line in the left chart of Figure 2) and do not necessarily reverse the sign of the effects of fiscal news on economic activity (as shown by the blue solid line of Figure 2). Moreover, this finding is consistent with the average response of stock prices to the thirty-four supplementary fiscal

Table 2: Impact effects of fiscal announcements on stock prices: 1992–2022

VARIABLES	(1)	(2)	Δs_t (3)	(4)	(5)
$\mathbb{I}\left\{A_t^{\text{size}}\right\}$	0.023	−0.209	0.026	0.022	0.025
	(0.268)	(0.320)	(0.268)	(0.268)	(0.268)
$\mathbb{I}\left\{A_t^{\text{size}}\right\} \times VI_{t-1}$	−0.458**		−0.455**	−0.456**	−0.454**
	(0.258)		(0.259)	(0.258)	(0.259)
$\mathbb{I}\left\{A_t^{\text{order}}\right\}$			0.418**		0.418**
			(0.231)		(0.231)
$\mathbb{I}\left\{A_t^{\text{order}}\right\} \times VI_{t-1}$			0.197		0.198
			(0.220)		(0.220)
$\mathbb{I}\left\{A_t^{\text{ratify}}\right\}$				−0.279*	−0.276
				(0.215)	(0.215)
$\mathbb{I}\left\{A_t^{\text{ratify}}\right\} \times VI_{t-1}$				0.570**	0.573**
				(0.316)	(0.316)
VI_{t-1}	0.047*	0.042*	0.044*	0.046*	0.042*
	(0.030)	(0.028)	(0.031)	(0.030)	(0.031)
Δs_{t-1}	−0.067***	−0.069***	−0.066***	−0.066***	−0.066***
	(0.017)	(0.016)	(0.017)	(0.017)	(0.017)
$\Delta DJIA_{t-1}$	0.504***	0.504***	0.504***	0.505***	0.504***
	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)
$\Delta EXCH_{t-1}$	0.065**	0.064***	0.068***	0.064**	0.067***
	(0.029)	(0.028)	(0.029)	(0.029)	(0.029)
$BOND_{t-1}$	−0.022**	−0.022**	−0.022**	−0.022**	−0.022**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Constant	0.027	0.027	0.024	0.028	0.025
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Observation	7,679	7,679	7,679	7,679	7,679
Adj. R-squared	0.174	0.173	0.175	0.174	0.175

Notes: This table shows the estimates of regressing the change in stock prices on the indicator variables and control variables for the sample period from 1990 to 2022. We show the results by changing the timings of indicator variables, i.e., $\mathbb{I}\left\{A_t^{\text{size}}\right\}$, $\mathbb{I}\left\{A_t^{\text{order}}\right\}$, and $\mathbb{I}\left\{A_t^{\text{ratify}}\right\}$. The control variables includes the lagged change in the volatility index (ΔVI_{t-1}), the Dow Jones Industrial Average for the US Stock Market at trading closure in the preceding day ($\Delta DJIA_{t-1}$), the yen–dollar nominal exchange rate ($\Delta EXCH_{t-1}$), the ten-year Japanese Government Bond (JGB) yields ($BOND_{t-1}$), and one lag in the change in stock prices (Δs_{t-1}). Newey-West HAC standard errors are in parentheses. The 1%, 5% and 10% significant levels are denoted by $***$, $**$ and $*$, respectively. The estimates refer to the model with $h = 0$.

announcements, shown by the red line in the right plot of Figure 3.

In Columns (3) through (5) of Table 2, we add time dummies for the early preparation of the proposal of the fiscal package, $\mathbb{I}\{A_t^{\text{order}}\}$, (column 3), and for the formal ratification of the fiscal package by the Diet, $\mathbb{I}\{A_t^{\text{ratify}}\}$, (column 4). We also consider both time dummies together in our regression model (column 5).

Importantly, the significance, the sign, and the magnitude of the interaction term β, which provides a critical test to the theory of signaling effects, remain unchanged across the robustness exercises. The first phase in the legislative procedure does not appear to influence stock prices. However, stock prices respond significantly and positively to the announcements of fiscal package ratification (the third phase) when market volatility is high. When markets are more uncertain, their beliefs are more responsive to news – a finding that is consistent with standard Bayesian updating.

The sign of the response of stock prices to the announcement that a spending bill is finally passed into law. As explained in Section 3, at the ratification stage, there is no additional information regarding the size of the fiscal package in Japan, ruling out the existence of signaling effects. The ratification stage confirms that a supplementary fiscal stimulus will soon be enacted and stock markets react only to this news. As shown in Section 2, signaling effects arise when policymakers provide information about the size of the fiscal package, which the private sector can use to infer the government's view on the outlook. Additional information, such as the timing of ratification and implementation, does not give rise to effects of signaling. Therefore, the positive response of stock prices following the announcement that a fiscal stimulus is ratified by the Diet is not inconsistent with the existence of signaling effects.

Rather, the finding shown in column (5) reinforces the idea of bullish stock market's reactions to expansionary fiscal news, absent signaling effects. As already pointed out in few occasions, this positive response is an important benchmark for our analysis. In addition, this finding corroborates the preliminary evidence provided in Section 4 where we look at the response of stock prices to the announcement of three massive "exogenous" fiscal packages.

In Appendix C.2, we show that that periods of high uncertainty, as measured by values of Nikkei VI above the sample average or by households' and firms' disagreement about the economic outlook, are positively correlated with a negative response of the stock market to fiscal announcements. These findings also support the results shown in this section that signaling effects are stronger when uncertainty is higher. Households' disagreement is measured by using the *Consumer Confidence Survey* that has been administered monthly by the Japanese Cabinet Office since 2004 and covers 8,400 households. We measure firms' disagreement by using the Short-Term Economic Survey of Enterprises in Japan, known as the *Tankan Survey*, administered by the Bank of Japan on a quarterly frequency since 1974. More details about these surveys are provided in Appendix C.2.2. The Survey encompasses 220,000 firms and 10,000 enterprises.

5.2. Risk of Government's Default and Stock Prices Indexes

We have interpreted financial markets' negative response to fiscal announcements as evidence of signaling effects from fiscal policy. However, it could be argued that this negative response might reflect agents' concerns about the financial solvency of the government in a country where public debt-to-GDP ratio is very large. In particular, market participants might become worried that a debt-financed fiscal stimulus might lead to higher default risk. To rule out this hypothesis, we estimate our baseline regression using a measure of the riskiness of Japanese government bonds as our dependent variable. The measure that we use is the change in the Japanese government bond volatility index. In Appendix C.4, we show that this index does not change in any significant way in response to the supplementary fiscal announcements. This finding suggests that the supplementary fiscal stimuli considered in our analysis did not cause any appreciable increase in the Japanese government's default risk. Thus, the negative response of stock prices to news regarding the size of supplementary fiscal packages does not seem to be driven by changes in the risk of sovereign default.

One might also be concerned that our findings may depend on the specific stock market index that we used, which might overweight firms in some specific industries. Appendix C.4 shows that our results supporting the existence of signaling effects are robust to using alternative indexes of stock market prices. In particular, we replace Nikkei 225 with TOPIX (Tokyo Stock Price Index)[14] and show that the significant and negative coefficient on the

[14] Nikkei 225 is an average stock price index of 225 stocks selected from the first section of the Tokyo Stock Exchange (TSE), while TOPIX is an alternative index of stock prices obtained from averaging the price

interaction term, β, is robust to changes in how we measure the response of stock prices, corroborating the key result of this section.

6. Quantifying Signaling Effects on Economic Activity

The empirical results in Section 5 support the view that signaling effects of fiscal policy exist and are significant in Japan. These effects are more pronounced on stock prices during periods of market uncertainty, aligning with the theory highlighted in Section 2. However, the analysis in the previous section did not consider the size of the supplementary fiscal packages, so it could not provide insights into the quantitative relevance of the signaling effects of fiscal policy.

Additionally, to draw quantitative conclusions, one needs to take into account the private sector's revisions to expectations about government spending owing to the fiscal news. As shown in the stylized model of Section 2, these revisions to expectations about the size of the stimulus determine the size of signaling effects. The mere size of the fiscal stimulus is not sufficient to inform how signaling effects would alter the efficacy of fiscal policies. Therefore, considering the revisions to expectations about the size of a fiscal stimulus is crucial for making quantitative predictions about the signaling effects of economic policies.

So far, we have not considered the potentially important issue of how the supplementary spending packages were expected to be financed. We include tax revenue in the model studied in this section to take this into account.

We use a VAR model to analyze the impact of fiscal news on economic activity. Our aim is to determine the strength of the signaling effects associated with each of the thirty-four fiscal packages. To achieve this, we examine the co-movement between stock prices and month-over-month revisions in the private sector's forecast of the annual growth rate of government expenditure at the time the size of these packages is announced. For the revisions, we use forecast data on government spending from *JCER ESP Forecasts*, published by the *Japan Center for Economic Research*, which gathers professional economists' forecasts of various

index of all stocks listed in the first section of TSE.

economic variables.[15] Expectations about public spending are available on a monthly basis, enabling us to observe revisions only in the month the fiscal stimulus size is announced. Since the size of supplementary fiscal packages is not subject to later revisions, timing differences are not an issue. A potential complication could arise if two packages were announced in the same month; however, this scenario does not occur in our sample.

Fiscal news with significant signaling effects is identified when private sector expectations about public spending and stock prices move in opposite directions. Conversely, *fiscal news with minor signaling effects* occurs when these variables move in the same direction. We assess these co-movements when the Prime Minister's Office announces the size of the fiscal package (second stage), as detailed in Table 1.

Both types of fiscal news can be interpreted through the lens of the simple model of signaling effects introduced in Section 2. Fiscal news are either policy shocks, ε_a, – i.e., a non-systematic deviation from the usual way the government respond to a downturn – or noise shock in the policy maker's signal, ξ^g, – i.e. a changes in unanticipated changes to policy maker's assessment of the economic outlook. In the stylized model, both shocks give rise to a policy surprise from the perspective of the private sector, $a - E(a|s^p) \neq 0$. The different level of signaling effects carried by the two shocks can be captured by varying the accuracy of the signal received by the private sector, σ_ξ. When the private signal is less (more) precise, uncertainty is higher (lower), implying that the private sector will try to extract more (less) information regarding the state of the economy from the policy action, making signaling effects of fiscal news stronger (weaker).[16] See the exercise performed in Section 2.4, where we show that fiscal news with significant signaling effects are less expansionary than fiscal policy shocks, and, might, in fact, be even contractionary.

To ensure that our identifying restrictions are consistent with the conventional effects of fiscal policy expansions, we restrict the response of government spending to be zero on impact – to reflect the often significant implementation lags in fiscal policy – and be positive

[15]Appendix C.5 describes how these revisions are constructed.

[16]Reducing the accuracy of the private signal is tantamount to increasing the private sector's uncertainty in the stylized model.

Table 3: Identifying restrictions

Variables	Shock: News with minor signaling	Shock: News with significant signaling	Shock: Other shocks
Change in expectations of fiscal spending	+	+	0
Daily change in stock prices	+	−	0
Government spending	≈ 0 at impact > 0 for 4–12 mos.	≈ 0 at impact > 0 for 4–12 mos.	Unrestricted
Output	Unrestricted	Unrestricted	Unrestricted
Tax revenues	Unrestricted	Unrestricted	Unrestricted

Notes: The marks, +, −, and 0 denote positive, negative and zero restrictions on contemporaneous responses of variables to each shock, respectively. In addition, sign restrictions over a number of months are imposed on the responses of actual government spending.

in the four-to-twelve months after the policy announcement. Finally, shocks other than two identified fiscal shocks are assumed to have no effect on both the revisions to expected government expenditure and stock prices in the days when the Japanese governments announce the size of the supplementary fiscal stimuli. Table 3 summarizes the sign restrictions used in our identification.

Our empirical specification is based on Jarocinski and Karadi (2020):

$$\begin{pmatrix} f_t \\ y_t \end{pmatrix} = \begin{pmatrix} 0 \\ c_y \end{pmatrix} + \sum_{p=1}^{P} \begin{pmatrix} 0 & 0 \\ B^p_{YF} & B^p_{YY} \end{pmatrix} \begin{pmatrix} f_{t-p} \\ y_{t-p} \end{pmatrix} + \begin{pmatrix} u^f_t \\ u^y_t \end{pmatrix}, \quad \text{where} \quad \begin{pmatrix} u^f_t \\ u^y_t \end{pmatrix} \sim \mathcal{N}(0, \Sigma), \tag{9}$$

where the vector f_t comprises the revisions to government expenditure and the changes in the stock prices the days when the fiscal announcements are made (second phase). In those months when no fiscal announcements are made, we set these two variables to zero, $f_t = 0$. We normalize the variables in the vector f_t to have zero mean and we assume that they do not have lag dependence. The vector y_t comprises a set of monthly macroeconomic variables: government expenditure, real GDP, and tax revenue.[17] We estimate the model on monthly data covering the period June 2009-December 2022. This sample period is shorter than that used earlier in the exercise carried out in Section 5 because the expectations of government expenditures become available only from June 2009.[18]

[17]The monthly series of government spending and real GDP is obtained from the *JCER Monthly GDP Estimate*, and tax revenue is collected from the *Ministry of Finance Statistics Monthly*. Appendix C.5 outlines the construction of our series.

[18]Our estimation approach is based on sign restrictions as in Uhlig (2005) leaving some series unconstrained, thus imposing minimal structure, as in Mumtaz and Zanetti (2012, 2015) and Bai et al. (2024).

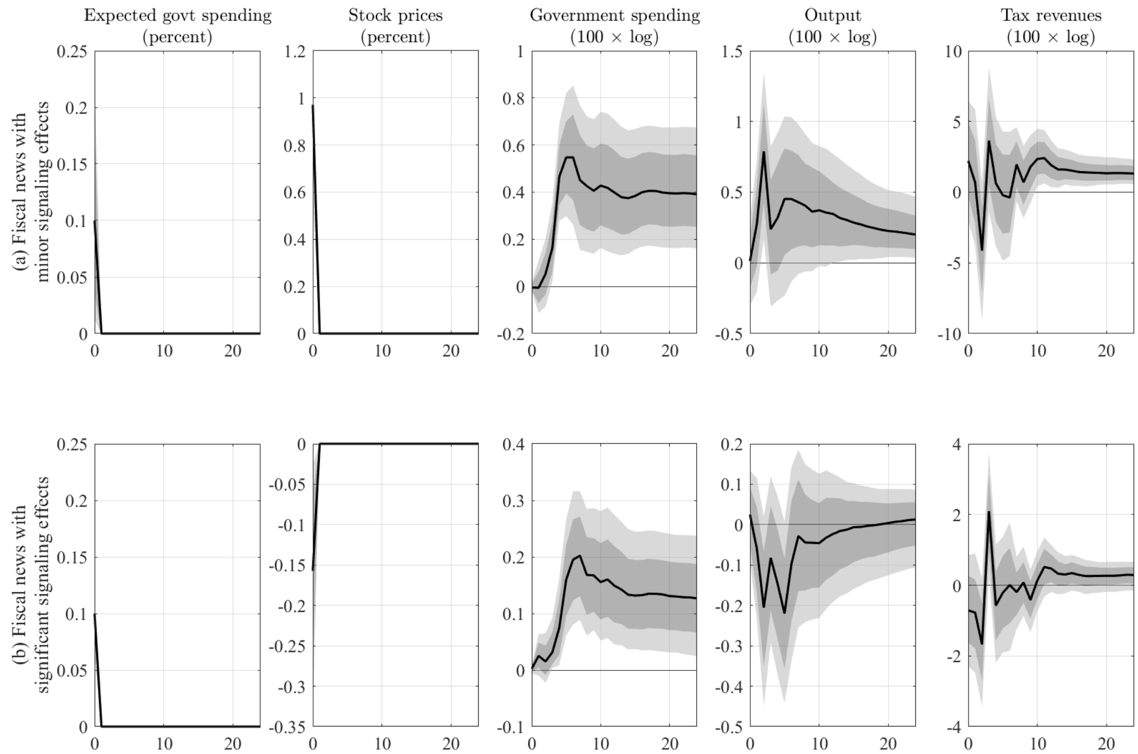

Figure 4: **Impulse response functions.** The black line indicates the median impulse response. The dark and light-shaded areas correspond to 68% and 90% confidence bands, respectively. The scale of the shocks are normalized so as to be 10 basis point of impact median responses in the revision to expectations about future government spending. The x-axis shows months.

Figure 4 shows the IRFs to fiscal news with minor signaling effects (top panels) and fiscal news with significant signaling effects (bottom panels), respectively. The responses are normalized so that the median revision to private sector's expectations about future government spending, $\Delta E_t G_{t+1}$, at period 0 is 10 basis points. These responses confirm the key predictions of the theory of signaling effects highlighted in the stylized model presented in Section 2. The response of output, which we left unconstrained, is significant and positive for the fiscal news with minor signaling effects, while it is negative (within the 68% confidence band) for the fiscal news with significant signaling effects.

We include tax revenues in our VAR model. If agents are forward looking, one could argue that the output contraction in response to the fiscal news with significant signaling effects might be due to rational agents anticipating an increase in taxes following the rise in government spending. Yet, tax revenue responds fairly similarly across the two types of fiscal shocks. To the extent that markets are able to anticipate the response of tax revenue to the fiscal stimuli considered in this exercise, we can rule out that the negative response of output in both panels is due to how government spending is financed. In addition, in Appendix C.6 we show that the results shown in Figure 4 are robust to including the 10-year Japanese government bond yields, capturing the risk of sovereign default, in the model.

7. Conclusion

Our study presents a novel theoretical framework to analyze the signaling effects of fiscal announcements. This theory underscores the importance of accounting for economic agents' prior beliefs regarding policy size to accurately evaluate signaling effects. Moreover, the theory suggests that increased private sector uncertainty intensifies these effects. While signaling effects may not completely offset the efficacy of fiscal policies, they might considerably impair fiscal authorities' ability to stabilize their economy.

We construct a new dataset of narrative records from Japan to test the key predictions of the theory. Our empirical analysis confirms that these key predictions of signaling theory are valid for Japanese fiscal policy. Fiscal announcements exhibit negligible signaling effects when macroeconomic uncertainty is low. However, as uncertainty rises, these effects can undermine somewhat the government's capacity to stabilize the economy. We provide the first quantification of fiscal policy's signaling effects on real activity using a novel identification strategy to identify these effects in a VAR model.

Our findings open several important avenues for future research. For instance, examining whether fiscal authorities can strategically use signaling effects to influence agent expectations without undermining policy credibility would be valuable. Additionally, extending the analysis to include alternative fiscal tools, such as debt issuance or tax announcements, could reveal different signaling effects. Lastly, exploring the impact of communication in fiscal announcements on signaling effects, and if strategic information disclosure can mitigate adverse outcomes, would be insightful. We intend to explore some of these areas in future work.

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Online Appendices

The Signaling Effects of Fiscal Announcements

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Contents

A. Extension to the Simple Model of Signaling Effects

This section presents an alternative version of the simple model described in Section 2, where policymakers respond with no lag to the realization of the economic shock. The key properties of the model introduced in Section 2 are retained also under this alternative assumption.

A.1. The model

As in the baseline model of Section 2, the behavior of the economy is summarized by a univariate process driving a scalar, X_t, which we call the economic variable, economic conditions, or the economy. We assume that agents do not observe this variable and have to track it using two sources of information: (i) a non-policy source of information, captured by the signal s_t about X_t, which is perfectly observed by every agent and (ii) the policy actions taken by the government or policymaker in response to the economic variable X_t. Differently from the baseline model, though, the government aims at contemporaneously stabilizing its dynamics by taking contemporaneous action a. The action is perfectly observed by every agent of the economy. Agent know the model structure (i.e., the equation and the parameter values), which is formalized below.

We assume that agents' expectations, $X_{t|t}$, have feedback effects on the economic variable, X_t. The policymaker can stimulate the economic variable, X_t, by increasing its policy tool a. The economic variable is also affected by an i.i.d. Gaussian shock, ε_t. More formally,[1]

$$X_t = \gamma a_t + \lambda X_{t|t} + \varepsilon_t, \quad \gamma > 0 \text{ and } \lambda \neq 0, \tag{A.1}$$

where $\varepsilon_t \sim \mathcal{N}\left(0, \sigma_\varepsilon^2\right)$. The parameter $\gamma > 0$ encapsulates the positive effects of policy on the economic variable. The parameter λ controls the feedback effect of agents' beliefs. If $\lambda > 0$, expectations can be regarded to some extent as self-fulfilling. We make this assumption throughout this section.

The government takes action a in every period t with the objective of stabilizing the dynamics of the economic variable X_t.

$$a_t = \alpha E_t^g X_t + \tau_t, \quad \alpha \leq 0, \tag{A.2}$$

where $\tau_t \sim \mathcal{N}\left(0, \sigma_\tau^2\right)$ is an exogenous policy shock and $E_t^g(\cdot)$ denotes the expectations of the government, which are defined as follows:

$$E_t^g\left(X_t\right) = X_t + \mu_t, \tag{A.3}$$

where $\mu_t \sim \mathcal{N}\left(0, \sigma_\mu^2\right)$ is a measurement error.

[1] Since all the shocks in the model are i.i.d. and, for simplicity, there is no inertia in the model equation (A.1), agents' expectations about future realizations of the economic variable $X_{t+h|t}$ are always equal to zero and thereby do not affect the dynamics of the economic variable, X_t.

The non-policy signal is defined as follows:

$$s_t = X_t + \xi_t, \tag{A.4}$$

where $\xi_t \sim \mathcal{N}(0, \sigma_\xi^2)$ is the noise.

Private agents receive the same information and perfectly know the structure of the model. Their beliefs, $X_{t|t}$, and signals are common knowledge, so that their information set is $I_t^p = \left\{a_t, s_t, X_{t|t}\right\}$.[2] The government, instead, acquires different information from the private agents. It observes X_t with a measurement error (as in equation (A.3)) in addition to receiving the same common signal s_t observed by private agents. Therefore, the expectations of the government differ from those of the private agents, i.e., $E_t^g(X_t) \neq X_{t|t}$. The difference in the information acquired by the private agents and the government is critical to allow the government's actions to transfer non-redundant information to private agents for the the emergence of signaling effects.[3] The system can be written as follows:

$$\begin{aligned} X_t &= \gamma a_t + \lambda X_{t|t} + \varepsilon_t, && \text{(A.5)} \\ a_t &= \alpha X_t + u_t, && \text{(A.6)} \\ s_t &= X_t + \xi_t, && \text{(A.7)} \end{aligned}$$

where $u_t \equiv \tau_t + \alpha\mu_t$. Note that if $\alpha = 0$ (i.e., the policy action is unrelated to the government's expectations on the state of the economy), the shock u_t is simply the exogenous policy shock (i.e., $u_t = \tau_t$). If $\alpha < 0$ such that the policy action is related to the government's expectations and is countercyclical, the shock u_t is also affected by autonomous changes in beliefs of the government driven by the measurement error (μ_t).

A.2. Signal Extraction Problem

Notice that agents know their expectations (i.e., $X_{t|t} \in I_t^p$.) Hence, after plugging the policy function into the law of motion of the economic variable, we obtain the following state-space model for the signal extraction problem:[4]

$$\begin{aligned} \tilde{X}_t &= \frac{\gamma}{1-\alpha\gamma} u_t + \frac{1}{1-\alpha\gamma} \varepsilon_t, && \text{(A.8)} \\ \tilde{a}_t &= \alpha \tilde{X}_t + u_t, && \text{(A.9)} \\ \tilde{s}_t &= \tilde{X}_t + \xi_t, && \text{(A.10)} \end{aligned}$$

[2] See Melosi (2017) for a case in which agents acquire different information about the economy and optimally respond to their forecasts of the forecasts of other agents. Our results are robust to this assumption.

[3] As we shall see, the other important feature for signaling effects to arise is that government actions respond to the economic variable (i.e., $\alpha \neq 0$).

[4] Unlike Nimark (2008) and Melosi (2017), agents do not have private information and, thereby, have the same expectations about the economic variable, X_t.

where $\tilde{X}_t \equiv X_t - \lambda/(1-\alpha\gamma)X_{t|t}$, $\tilde{a}_t \equiv a_t - \alpha\lambda/(1-\alpha\gamma)X_{t|t}$, and $\tilde{s}_t \equiv s_t - \lambda/(1-\alpha\gamma)X_{t|t}$. Notice that $\{\tilde{a}_t, \tilde{s}_t\} \in I_t^p$.

This can be written in matrix form as follows:

$$\tilde{X}_t = \mathbf{R}\mathbf{z}_t, \tag{A.11}$$

$$\mathbf{y}_t = \mathbf{D}\tilde{X}_t + \mathbf{e}_t, \tag{A.12}$$

where $\mathbf{z}_t = [u_t \quad \varepsilon_t]'$, $\mathbf{e}_t = [u_t \quad \xi_t]'$, $\mathbf{y}_t = [\tilde{a}_t \quad \tilde{s}_t]'$, $\mathbf{D} = [\alpha \quad 1]'$,

$$\mathbf{R} = \left[\frac{\gamma}{(1-\alpha\gamma)} \quad \frac{1}{(1-\alpha\gamma)} \right]. \tag{A.13}$$

The Kalman gain vector, $\mathbf{K}$, can be shown to be given by

$$\mathbf{K} = \left(\mathbf{R}\Sigma_z\mathbf{R}'\mathbf{D}' + \mathbf{R}\mathbf{V}\right)\mathbf{F}^{-1}, \tag{A.14}$$

where

$$\Sigma_z = \begin{bmatrix} \sigma_u^2 & 0 \\ 0 & \sigma_\varepsilon^2 \end{bmatrix}, \tag{A.15}$$

$$\mathbf{V} = E\left(\mathbf{z}_t\mathbf{e}_t'\right) = \begin{bmatrix} \sigma_u^2 & 0 \\ 0 & 0 \end{bmatrix}, \tag{A.16}$$

$$\mathbf{F} = E\left(y_t y_t'\right) = \mathbf{D}\left(\mathbf{R}\Sigma_z\mathbf{R}'\right)\mathbf{D}' + \Sigma_e + \mathbf{DRV} + \left(\mathbf{DRV}\right)', \tag{A.17}$$

$$\Sigma_e = \begin{bmatrix} \sigma_u^2 & 0 \\ 0 & \sigma_\xi^2 \end{bmatrix}, \tag{A.18}$$

and the law of motion of the private sector's expectations, $X_{t|t} \equiv E\left(X_t | I_t^p\right)$, can be, thereby, expressed as follows:

$$\tilde{X}_{t|t} = \mathbf{K}\begin{bmatrix} \tilde{a}_t \\ \tilde{s}_t \end{bmatrix} = \mathbf{K}\begin{bmatrix} \left[\frac{\alpha\gamma}{1-\alpha\gamma} + 1\right] u_t + \frac{\alpha}{1-\alpha\gamma}\varepsilon_t \\ \frac{\gamma}{1-\alpha\gamma}u_t + \frac{1}{1-\alpha\gamma}\varepsilon_t + \xi_t \end{bmatrix}. \tag{A.19}$$

From the definition of $\tilde{X}_{t|t}$, we obtain

$$X_t = \tilde{X}_t + \frac{\lambda}{1-\alpha\gamma}X_{t|t} \tag{A.20}$$

Applying the expectation operator on both sides of the equation yields

$$X_{t|t} = \tilde{X}_{t|t} + \frac{\lambda}{1-\alpha\gamma}X_{t|t} \tag{A.21}$$

and after re-arranging

$$X_{t|t} = \frac{1-\alpha\gamma}{1-\alpha\gamma-\lambda}\tilde{X}_{t|t} \tag{A.22}$$

By plugging equation (A.22) into equation (A.20) we obtain

$$X_t = \tilde{X}_t + \frac{\lambda}{1-\alpha\gamma-\lambda}\tilde{X}_{t|t} \tag{A.23}$$

The system of equations (A.11), (A.19), (A.22), and (A.23) is the solution to the model and can be written more compactly as:

$$X_{t|t} = \left(\frac{1-\alpha\gamma}{1-\alpha\gamma-\lambda}\right) \cdot \mathbf{K} \begin{bmatrix} \left[\frac{\alpha\gamma}{1-\alpha\gamma}+1\right] u_t + \frac{\alpha}{1-\alpha\gamma}\varepsilon_t \\ \frac{\gamma}{1-\alpha\gamma}u_t + \frac{1}{1-\alpha\gamma}\varepsilon_t + \xi_t \end{bmatrix}. \tag{A.24}$$

A.3. Signaling Effects and Private Sector's Uncertainty

In this section, we conduct numerical exercises to show the basic properties of the theory of signaling effects. Specifically, we show that the magnitude of signaling effects varies with the government's degree of responsiveness to economic conditions (α). In the case of no response ($\alpha = 0$), there is no signaling effects because the government does not respond to the economy, X_t, and, consequently, its action, a_t, is driven by the exogenous policy shock τ_t and does not convey any information about the economy. When the government responds to the economy ($\alpha < 0$), signaling effects kick in and affect agents' beliefs about the economy ($X_{t|t}$) and – provided that there is feedback from agents' beliefs to the economic variable ($\lambda \neq 0$) – economic outcomes as well. In particular, we want to focus on how the private agents' uncertainty about the non-policy signal on the state of the economy (represented by σ_ξ) prior to observing the policy signal influences the size of signaling effects.

Parameter Values

	No Response	Weak Response	Strong Response
α	0.00	-1.00	-2.00
γ	0.50	0.50	0.50
λ	0.75	0.75	0.75
σ_ε	1.00	1.00	1.00
σ_u	0.10	0.10	0.10

Table A.4: **Parameter values.** Each column shows the parameter values used in three numerical exercises. The three cases only differ in how strongly the government responds to the economic variable (α).

Table A.4 reports the parameter values used in the numerical exercises. Figure A.5 shows the response of the economy (X_t, dashed-dotted red line) and the private agents expectations

($X_{t|t}$, solid-blue line) to an autonomous unitarty change in the policy actions driven by u_t for different values of the private agents' prior uncertainty (σ_ξ). We consider three policy actions: no government response to the economy ($\alpha = 0$, left panel), a weak government's response to the economy ($\alpha = -1$, middle panel), and a strong government's response to the economy ($\alpha = -2$, right panel). The signaling effects are defined as the deviation of the economic variable from the value it would have assumed if agents were perfectly informed by receiving a perfectly accurate signal such that their prior uncertainty is zero ($\sigma_\xi = 0$).

We first examine the case in which the government does not respond to the economic variable ($\alpha = 0$), and so signaling effects is absent by construction. The left panel in Figure A.5 shows the private agents expectations ($X_{t|t}$) in solid-blue line, and the state of the economy (X_t) in dashed-dotted red line. The two lines perfectly overlaps for different values of the uncertainty prior to observing the economic signal (σ_ξ), evincing that beliefs of agents perfectly reflect the state of the economy when the action of the government does not respond to the economic variable. In the case of no response of fiscal policy to the economic condition, the change in the policy action is uniquely driven by the independent policy shock (τ_t) whose magnitude is perfectly observed by agents. In the literature on fiscal multipliers, these shocks are the closest counterpart of discretionary changes in government spending, which are exogenous to the state of the economy and therefore do not give rise to signaling effects. The private agents recover the exact state of the economy from the signal in the policy action. Since the action of the government (a_t) is unrelated to the economic condition (X_t), private beliefs ($X_{t|t}$) perfectly track the economic condition for any given level of noise in the common signal received by agents (σ_ξ). In this case, neither beliefs nor the economic conditions are affected by variations in private sector's prior uncertainty, as evinced by the perfect overlapping of the two lines in the figure.

As a second and third exercise, we consider the government that maneuvers its policy action (a_t) to respond to *perceived* changes in the economic variable $E_t^g(X_t)$, encapsulated by the parameter α in equation (A.2). We assume that these changes in the government's beliefs also reflect some noise/error (μ_t), as defined in equation (A.3). Since the parameter $\alpha \neq 0$, agents do not know if the observed changes in the policy action are driven by a policy shock (τ_t), or noise (μ_t), or a change in the unobserved economic condition (X_t). Since the private sector cannot rule out the possibility that the policy action is driven by the unobserved economic condition, the policy action transfers non-redundant information about the economy to agents.

To establish whether signaling effects increase if the government is more proactive in stabilizing the economy, we consider two subcases: one case of a weak policy response ($\alpha = -1$) and one of a strong policy response ($\alpha = -2$). The middle panel in Figure A.5 shows the case of the government action (a_t) that weakly responds to changes in the economic environment ($\alpha = -1$). In this case, both agents' beliefs about the economy and the economy are affected by signaling effects. This can be seen by observing how beliefs ($X_{t|t}$, the blue solid line) and economic conditions (X_t, the red dashed-dotted line) fall as the private sector's prior uncertainty rises. For positive values of the prior uncertainty ($\sigma_\xi > 0$) both variables ($X_{t|t}$ and X_t) are lower than their perfect information values with no prior uncertainty

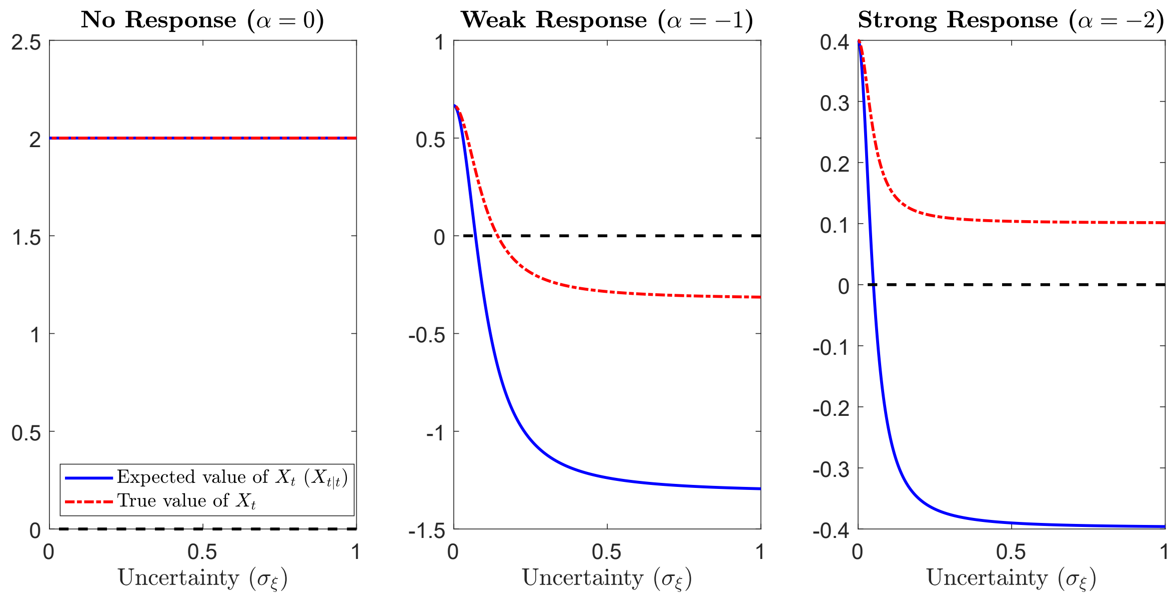

Figure A.5: **Signaling Effects of Economic Policy.** The response of agents' expectations, $X_{t|t}$, (blue solid line) and the economy, X_t, (red dotted-dashed line) to an autonomous unitary increase in the policy action ($u_t > 0$) as the private sector's prior uncertainty, σ_ξ, varies on the horizontal axis. On the left, the case of weaker policy response ($\alpha = -1$). On the right, the case of stringer policy response ($\alpha = -2$)

($\sigma_\xi = 0$). But why do signaling effects lower beliefs and harm the economy? Because in the presence of uncertainty, the policy actions have the dual nature of economic policy and signal about the economy. The duality implies that if the government raises its instrument a_t, rational agents that face uncertainty on the state of the economy perceive that the policy action may have been executed in response to deteriorating economic conditions ($X_t < 0$).

Furthermore, and critical for the empirical analysis that follows, as agents' prior uncertainty (σ_ξ) increases, agents' expectations about the economic variable ($X_{t|t}$) are more responsive to policy signaling and consequently signaling effects become stronger, as exemplified by the solid-blue line in the middle and the right panels. Signaling effects grow with the private sector's prior uncertainty because as the private signal becomes more inaccurate, agents rely more on the public signal to learn about the economic condition X_t. Since rational agents know that the government increases its policy action a_t when the economic condition deteriorates, agents will lower their expectations of the economic conditions. Since the private sector's expectations simultaneously feed into economic conditions, X_t, the economy deteriorates as a result of signaling effects.

With the increase in uncertainty in the signal received on the state of the economy, the private agents increase the importance of the policy action to signal the state of the economy. With sufficiently high uncertainty, signaling effects are so strong that agents' beliefs *worsen* ($X_{t|t} < 0$, the blue solid line) in response to an *expansionary* policy action, ($a_t > 0$). Since agents' beliefs feed back to the economic conditions, X_t, large signaling effects can even imply a perverse *negative* response of the economy (X_t, the red dashed-dotted line) to the *expansionary* policy action ($a_t > 0$).

The right panel in Figure A.5 shows the case of the government action that strongly responds to changes in the economic environment ($\alpha = -2$). Comparing the middle and right panels in the figure, there is yet another prediction of our theory of signaling effects of fiscal policy. As the government becomes more proactive in using its policy tools (a_t) to stabilize the economy (X_t), signaling effects become smaller. The degree of government's pro-activity is controlled by the parameter α. You can see that when this parameter is twice as big (right panel), the economy does not contract in the aftermath of an expansionary policy shock regardless of the level of prior uncertainty, σ_ξ. The stronger stabilization effort by the government reduces the volatility of the economic variable X_t and, hence, for a given level of prior uncertainty, agents' expectations, $X_{t|t}$, are less sensitivity to signaling effects. As agents' expectations fall less, the economy, X_t, does not shrink following the fiscal intervention.

B. A Microfounded Model of Signaling Effects

Our simple model in Section 2 retains minimal parametric restrictions for fiscal announcements to have signaling effects but lacks theoretical foundations. In this section, we develop a microfounded, two-period, New-Keynesian model that shows that *stock prices* are the key factor reflecting the signaling effects of fiscal announcements, which motivates our empirical strategy of extracting the signaling effects from the response of stock prices to fiscal announcements. The microfounded model shows that the main results from the simple model – i.e., the critical role of the uncertainty of the private sector prior to the fiscal announcement, the relevance of cyclicality in the systematic response of fiscal policy, and the dampening and not necessarily a reversal in the effect of economic policy – hold in the more sophisticated environment. The theoretical model shows that the strength of the signaling effects depends on the structure of the economy (it increases with the degree of nominal rigidities and agents' risk aversion), and numerical simulations show that signaling effects can be quantitatively sizeable for economic activity, as shown in the section on numerical simulations in this Appendix B.

Economic Environment

Time is discrete and comprises two periods, such that $t = 1, 2$. The economy is populated by a continuum of households, a production sector with a continuum of firms indexed by $j \in [0, 1]$ and a fiscal authority. Households maximize utility, consume perishable goods and earn labor income. Production is determined by exogenous productivity and firms manufacture goods. Each firm j maximizes profits in a monopolistically competitive market and sells output to households for a set price that is subject to nominal rigidities à la Calvo, which prevent firms from resetting prices in each period. Thus, the expectations about productivity in the next period are important for the firm's maximization of profits. The

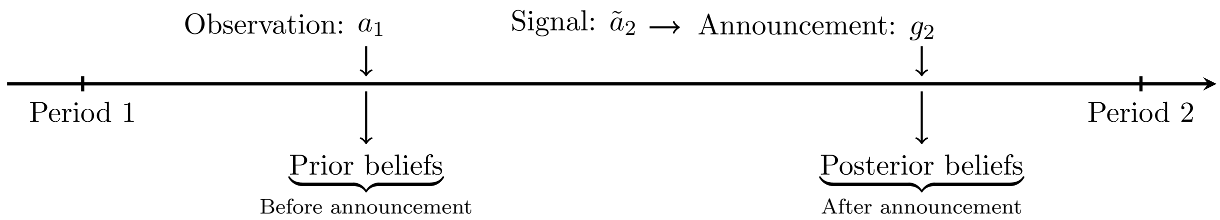

Figure B.6: **The acquisition, release, and processing of information.**
In period 1, agents observe current productivity (a_1) and have prior uncertainty on the state of the economy. The government receives a signal about productivity in period 2 ($\tilde{a}_2$), sets the plan for government spending for period 2 (g_2) and announces the fiscal plan before the end of period 1. Agents form posterior beliefs based on the fiscal announcement.

fiscal authority sets public spending according to a counter-cyclical fiscal rule that is known to the private sector.

We assume the government and the private sector acquire different information about labor productivity, and firms use Bayesian learning to infer the realization of future productivity from the announcement of fiscal spending by the government. In period 1, the private sector observes current productivity (a_1) and the fiscal authority receives a noisy signal about the realization of productivity in period 2 ($\tilde{a}_2$). Based on the signal received in period 1, the government sets the amount of public spending for period 2 (g_2) and discloses the fiscal spending plan to the private sector immediately before period 1 ends. The firms optimally set prices based on the expectations about productivity and may use the fiscal announcement to update their belief on the state of the economy and infer productivity in the next period. Stock prices – equal to the present discounted value of expected profits over the two periods – reflect the effect of the fiscal announcement.

Figure B.6 summarizes the timing of the acquisition, release, and processing of information. Our main focus is on the effect of the announcement of government spending for the formation of the posterior beliefs of the firms about productivity, which are critical to the optimal price setting of the firms and asset prices, which we focus on in the next section.

Information Structure

In period 1, the private sector and the government observe the current level of productivity a_1. At the end of period 1, the government receives a noisy signal about productivity in period 2 (a_2) and issues a public announcement about the spending plan that reflects the signal of productivity observed by the government. In period 2, the private sector decides the optimal levels of consumption, labor, and the price based on the (posterior) beliefs about productivity in period 2 (a_2) while the government implements the plan for fiscal spending (g_2) announced at the end of period 1.

Private sector's posterior beliefs

The private sector's prior beliefs on productivity in period 2 follow the random walk:

$$a_2 = a_1 + u, \tag{B.1}$$

where $u \sim N(0, \sigma_u^2)$ is a white-noise shock with variance σ_u^2. The variance of the error (σ_u^2) represents the private sector's prior uncertainty. For future reference, we denote with $\pi(a_2)$ the private sector's prior beliefs (formed in period 1) about the level of productivity in period 2. From equation (B.1), the private sector expects productivity in period 2 to be equal to the realized productivity in period 1 (a_1), and σ_u^2 encapsulates the prior uncertainty of the private sector.

In period 1, the fiscal authority receives a noisy signal on the realization of productivity in the next period 2 ($\tilde{a}_2$) and, based on the signal, announces the spending plan for period 2 using a fiscal rule known to the private sector (defined below). The signal on productivity received by the government is noisy, as described by the following process:

$$\tilde{a}_2 = a_2 + v, \tag{B.2}$$

where $v \sim N(0, \sigma_v^2)$ is a white-noise shock on the realization of productivity with variance σ_v^2. We interpret the inverse of the variance ($1/\sigma_v^2$) as the precision of the information received by the government.

In period 1, the government announces the spending plan for the second period (g_2), which reflects the signal about productivity received, $\tilde{a}_2$. Since private agents are rational and know the policy function of the government, they use the announced spending plan (g_2) to recover the exact signal ($\tilde{a}_2$) received by the government. The private sector form posterior beliefs on productivity in period 2 (denoted by $\pi(a_2 \mid g_2)$) with Bayesian learning by combining the information contained in the fiscal announcement with the prior beliefs, according to the Bayes' rule:

$$\pi(a_2 \mid g_2) \propto f(g_2 \mid a_2)\pi(a_2), \tag{B.3}$$

where $f(g_2 \mid a_2)$ is the conditional distribution of the government-spending plan for a given technology in period 2, and $\pi(a_2)$ is the private sector's prior beliefs on technology in period 2. Given the prior beliefs and the signal on productivity inherent to the fiscal announcement, the posterior mean and standard deviation of the private sector's beliefs conditional on the fiscal announcement are equal to:[5]

$$a_2 \mid g_2 \sim N(\hat{a}_2, \hat{\sigma}^2), \tag{B.4}$$

[5] Appendix B.1 shows the derivation of the mean ($\hat{a}_2$) and variance ($\hat{\sigma}^2$) of the posterior distribution resulting from equations (B.1) and (B.2).

where

$$\hat{a}_2 = E_1(a_2 \mid g_2) = \frac{\hat{\sigma}^2}{\sigma_u^2} a_1 + \frac{\hat{\sigma}^2}{\sigma_v^2} \tilde{a}_2, \quad \text{and} \quad \hat{\sigma}^2 = \left(\frac{1}{\sigma_u^2} + \frac{1}{\sigma_v^2} \right)^{-1}. \tag{B.5}$$

Proposition 1. *Given the announcement of the fiscal plan (g_2) and the precision of the signal received by the fiscal authority ($1/\sigma_v^2$), the expected level of productivity in period 2 ($\hat{a}_2$) positively comoves with the signal on productivity ($\tilde{a}_2$), and the comovement increases with the prior uncertainty of the private sector (σ_u^2).*

Proof. See Appendix B.1. □

Proposition 1 links the expectations of the private sector to the fiscal announcement that discloses the signal of productivity received by the government. Central to our analysis, the strength in the relation increases with the prior uncertainty of the private sector and the precision of the signal received by the government. This result stems directly from Bayesian updating: the more uncertain is the private sector about productivity, the less relevant are the prior beliefs, and the more important is the information contained in the announcement of the fiscal plan for the formation of the private sector's expectations, consistent with our results in the simple model of Section 2.

Households and Firms

During each period $t = 1, 2$, the representative household gains utility from consumption c_t and disutility from supplying labor n_t to the firm. The two-period utility function is:

$$E_1 \left[\left(\frac{c_1^{1-\gamma}}{1-\gamma} - \chi n_1 \right) + \beta \left(\frac{c_2^{1-\gamma}}{1-\gamma} - \chi n_2 \right) \right], \tag{B.6}$$

where the parameters $\beta \in (0, 1)$, and $\gamma \geq 0$ represent the discount factor and risk aversion, respectively, the free parameter $\chi \geq 0$ determines the steady-state value for the supply of labor, and E_1 is the expectations operator for period 1. The budget constraints for each period $t = 1, 2$ are:

$$P_1 c_1 + \frac{B_1}{R_1} = W_1 n_1 + D_1 - P_1 \tau_1 \quad \text{and} \quad P_2 c_2 = W_2 n_2 + B_1 + D_2 - P_2 \tau_2, \tag{B.7}$$

respectively, where P_t is the price level, W_t is the nominal wage, D_t is nominal dividends, τ_t is real lump-sum taxes in each period t, and B_1 and R_1 are the nominal bonds and the gross nominal interest rate in period 1. Households choose consumption and labor supply to maximize (B.6) subject to the intertemporal budget constraint:

$$P_1 c_1 + \frac{P_2 c_2}{R_1} = W_1 n_1 + \frac{W_2 n_2}{R_1} + D_1 + \frac{D_2}{R_1} - P_1 \tau_1 - \frac{P_2 \tau_2}{R_1}. \tag{B.8}$$

The consumption c_t comprises a continuum of differentiated goods $c_t(j)$, each produced by firm $j \in [0,1]$, bundled together by the constant-elasticity-of-substitution (CES) aggregator:

$$c_t = \left(\int_0^1 c_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{B.9}$$

where ε is the elasticity of substitution between goods. Each firm $j \in [0,1]$ manufactures the good j using the production function:

$$y_t(j) = e^{a_t} n_t(j)^{\alpha}, \tag{B.10}$$

where $n_t(j)$ is labor input for the firm j, a_t is aggregate productivity, and $0 < \alpha < 1$ encapsulates diminishing returns to the labor input. In each period t, a fraction $1-\zeta$ of firms reset the price optimally, while the remaining fraction ζ maintains the price unchanged. We assume that each firm sets the price $P_t(j)$ one period in advance before observing productivity in the next period. In our two-period economy, this assumption leads the fraction $1-\zeta$ of firms to set $P_2^*(j)$ in period 1 to maximize the present expected value of profits in period 2, weighted by the marginal utility of consumption $(1/c_2^{\gamma})$:

$$\max_{P_2^*(j)} E_1 \left[(1/c_2^{\gamma}) \left\{ P_2^*(j) y_2(j) - W_2 n_2(j) \right\} \right] \tag{B.11}$$

subject to the demand function

$$y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon} y_t, \tag{B.12}$$

and the production function (B.10), where the price level for the composite good is obtained by substituting equation (B.12) into equation (B.9) and it is equal to:

$$P_t = \left(\int_0^1 P_t(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}. \tag{B.13}$$

The optimal price in period 2 (P_2^*) is equal to:

$$P_2^* = \frac{\varepsilon}{\varepsilon - 1} E_1 \frac{W_2}{\alpha e^{a_2} n_2^{\alpha-1}}. \tag{B.14}$$

Using the price level in equation (B.13), the aggregate price in period 2 is:

$$P_2^{1-\varepsilon} = \zeta P_1^{1-\varepsilon} + (1-\zeta)(P_2^*)^{1-\varepsilon}. \tag{B.15}$$

Similar to the optimal price for period 2 in equation (B.14), the optimal price in period 1

(P_1) is equal to:

$$P_1 = \frac{\varepsilon}{\varepsilon - 1} E_0 \frac{W_1}{\alpha e^{a_1} n_1^{\alpha-1}}. \quad \text{(B.16)}$$

The Fiscal Authority

In each period $t = 1, 2$, the fiscal authority sets government spending (g_t) in response to the noisy signal on aggregate productivity $(\tilde{a}_t)$ according to the fiscal rule:

$$(g_t/g_{ss}) = \left(e^{\tilde{a}_t}\right)^{\psi}, \quad \text{(B.17)}$$

where $\psi < 0$ captures the degree of counter-cyclical adjustment of government spending to the signal of productivity $(\tilde{a}_t)$, and the parameter g_{ss} is the steady-state level of government expenditures. The fiscal rule (B.17) is known to the private sector. At the end of period 1, the fiscal authority receives the noisy signal about productivity in period 2 $(\tilde{a}_2)$, described in equation (B.2), and it announces the fiscal plan for period 2 (g_2) immediately —before the end of period 1— to the private sector. The fiscal authority balances the budget in each period using lump-sum taxes, such that $g_t = \tau_t$.

Equilibrium Conditions

In each period $t = 1, 2$, the equilibrium conditions in the goods and labor markets are:

$$y_t = c_t + g_t, \quad \text{and} \quad n_t = \int_0^1 n_t(j)dj, \quad \text{(B.18)}$$

respectively, and the aggregate production function $y_t = e^{a_t} n_t^{\alpha}$ holds. In period 1, the gross inflation rate is normalized to one, $\Pi_1 = P_1/P_0 = 1$, and the nominal interest rate is at the steady-state level R, such that $R_1 = R$.[6] We define the government-spending-to-output ratio as $\theta = g/y$.

Stock Prices, Beliefs, and Fiscal Announcements

This section shows that stock prices are central to our theory of signaling effects since the *expectations* on the dividends in period 2 encompass the effect of the fiscal announcement on the beliefs of the private sector.

Before the fiscal authority announces the plan for government spending for period 2, the stock prices reflect the agents' prior beliefs on productivity in period 2, which are based on the observed productivity in period 1 given the random walk process in equation (B.1) that

[6]We assume that the economy is at the steady state in period 1. The constant interest rate is consistent with a Taylor rule with strict inflation targeting and the gross rate of inflation equal to one.

determines the private sector's prior beliefs, such that:

$$Q \mid a_1 = D_1 + \frac{E_1[D_2 \mid a_1]}{R}, \tag{B.19}$$

where $D_1 = P_1 y_1 - W_1 n_1$, and $E_1[D_2 \mid a_1] = D_1$.[7] The private sector uses the information inherent in the fiscal announcement to update beliefs on productivity in period 2, and the resulting posterior beliefs on the stock prices after the fiscal announcement are equal to:

$$Q \mid g_2 = D_1 + \frac{E_1[D_2 \mid g_2]}{R}, \tag{B.20}$$

where $E_1[D_2 \mid g_2] = P_2 E_1[y_2 \mid g_2] - E_1[W_2 \mid g_2] E_1[n_2 \mid g_2]$. Equation (B.20) shows that the announcement of the spending plan for period 2 (g_2) influences the private sector's *expectations* on dividends in period 2. Thus, the stock prices encapsulate the effect of the fiscal announcement on the private sector's posterior beliefs. This result motivates our use of stock prices to study and test empirically the theory of signaling effects of fiscal policy.

Analytical Results

Our microfounded model is sufficiently simple to derive analytical solutions. We simplify the analysis by linearizing the system around the steady state and we ease notation by using a caret symbol on a variable to denote the deviation of the variable from the steady state. The next proposition establishes the impact of the fiscal announcement on dividends and stock prices.[8]

Proposition 2. *The response of expected dividends in period 2 ($\hat{D}_2$) and current stock prices ($\hat{Q}$) to the announcement of government spending for period 2 ($\hat{g}_2$) are equal to:*

$$\hat{D}_2 = \frac{1}{\Psi} \left\{ \kappa^{No\ Signal} + \kappa^{Signal} \right\} \hat{g}_2, \tag{B.21}$$

$$\hat{Q} = \frac{\beta}{1+\beta} \hat{D}_2, \tag{B.22}$$

where:

$$\Psi = \{\varepsilon + (1-\varepsilon)\alpha\}\{(1-\theta)(1-\alpha)(1-\zeta) + \alpha\gamma\} > 0, \tag{B.23}$$

$$\kappa^{No\ Signal} = \gamma\theta \left\{ (1-\alpha)(1-\zeta)\varepsilon + \alpha \right\} > 0, \tag{B.24}$$

$$\kappa^{Signal} = \underbrace{\{(1-\theta)(1-\zeta)[\varepsilon + (1-\varepsilon)\alpha] + \gamma[(\varepsilon-1)\alpha - \varepsilon(1-\zeta)]\}}_{Sign} \cdot \underbrace{\frac{\omega}{(1+\omega)\psi}}_{Magnitude} \gtreqless 0, \tag{B.25}$$

[7] Under the assumption of no uncertainty in period 1's productivity (i.e., $E_0[a_1] = a_1$), equation (B.16) can be rewritten as $W_1 n_1 = \alpha(\varepsilon - 1) P_1 y_1 / \varepsilon$. Using this equation with equation (B.10) for the production function into the definition of $D_1 \equiv P_1 y_1 - W_1 n_1$, it yields: $D_1 = \{\varepsilon - \alpha(\varepsilon-1)/\varepsilon\} P_1 e^{a_1} n_1^{\alpha} = \{\varepsilon - \alpha(\varepsilon-1)/\varepsilon\} e^{a_1}$. Since P_1 and n_1 are normalized and equal to one in the steady state. Thus, a_1 determines the level for D_1.

[8] Appendices B.2 and B.3 show the analytical solutions for the two-period model and the steady state of the model, respectively, and Appendix B.4 derives the linear system.

and $\omega = \sigma_u^2/\sigma_v^2$ is the private sector's prior uncertainty relative the imprecision of the signal received by the government.

Proof. See Appendix B.4. □

Proposition 2 shows that the effect of government spending on dividends and stock prices is determined by two forces. On the one hand, the announcement involves the standard expansionary effect of government spending, encapsulated by the parameter $\kappa^{No\ Signal}$ in equation (B.21), which leads to an increase in expected dividends and stock prices consequent to the fiscal announcement. On the other hand, the fiscal announcement entails the signaling effect, encapsulated by the parameter κ^{Signal} whose *sign* is determined by the elasticity of substitution between goods (ε) and the *magnitude* depends on the term $\omega/[(1 + \omega)\psi]$, as shown in equation (B.25). As in our simple model in Section 2, the signaling effect can have either positive or negative impact of stock prices, depending on the private sector's expectations. The sign of the signaling effect is determined by the elasticity of substitution between goods that is critical to the sensitivity of prices to changes in expected productivity. Since dividends and stock prices are jointly determined by the response of output and prices, the sensitivity of prices to future productivity plays a major role in the response of stock prices. A low elasticity of substitution (i.e., a small value for ε) entails a high markup of prices over marginal costs, and increases the sensitivity of prices to changes in expected productivity. An announcement of an expansionary fiscal policy that signals a fall in future productivity generates contractionary expectations for output while it increases the expectations for prices. Thus, the overall effect of the fiscal announcement on dividends and stock prices depends on which of these countervailing effects dominates. For a sufficiently high elasticity of substitution that limits the sensitivity of prices to productivity, the increase in prices to the fall in expected productivity is limited and together with the fall in output lead to a decrease in stock prices fall. As we show in the next subsection, for a plausible calibration of the elasticity of substitution (and the markup) that limits the sensitivity of prices to productivity, the signaling effect is driven by the expectations of the fall in output that dampens the response of dividends and stock prices, potentially generating a negative response of stock prices. The overall impact of the signaling effect on stock prices is jointly determined by κ^{Signal} and $\kappa^{No\ Signal}$, as shown in equation (B.21). The signaling effect results in a negative response of stock prices if κ^{Signal} is negative and larger than $\kappa^{No\ Signal}$, otherwise stock prices increase despite the negative influence of the signaling effect. An important result from the microfounded model is that fiscal policy may encompass signaling effects despite the response of stock prices is positive to the fiscal announcement, consistent with the result in our simple model.

The magnitude of the signaling effect, encapsulated by the term $\omega/[(1+\omega)\psi]$ in equation (B.25), is proportional to the prior uncertainty of the agents before the fiscal announcements, represented by the parameter ω. When the prior uncertainty about future productivity is high, the fiscal announcement provides non-redundant information about productivity, and therefore the signaling effect is stronger. Similarly, a low systematic response of fiscal policy (ψ) magnifies the power of the signaling effect brought about by an increase of government spending. These results corroborate the findings from the simple model in Section 2.

The next proposition summarizes the forces that determine the magnitude of the signaling effect.

Proposition 3. *The magnitude of the signaling effect of fiscal policy:*

(i) increases with the prior uncertainty of the private sector for given precision of the information received by the government ($\omega = \sigma_u^2/\sigma_v^2$); and

(ii) decreases with the size of the systematic response of fiscal policy (ψ).

Proof. Direct implication from equation (B.25). □

The next lemma shows that the structure of the economy is relevant to the size of the signaling effect.

Lemma 1. *The signaling effects of fiscal policy increase in the degree of nominal rigidities (ζ) and risk aversion (γ).*

Proof. See Appendix B.5. □

As established by Lemma 1, the strength of the signaling effects of fiscal policy is proportional to the degree of nominal rigidities. If prices are fully flexible and firms re-optimize in each period, the signal on the future economic conditions encompassed in the fiscal announcement becomes irrelevant for the maximization problem of the firms, since they can adjust prices after observing current productivity, making the information in the fiscal announcement redundant. However, if prices are rigid and firms cannot optimally adjust them in each period, firms rely on the fiscal announcement to infer future productivity to set prices optimally. In other words, the strength of the signaling effect is proportional to the degree of nominal price rigidities.

The degree of risk aversion magnifies the signaling effect of fiscal policy. If households have a high degree of risk aversion (γ), they dislike swings in consumption between periods and information about future productivity becomes important to smooth consumption over time. The relevance of the information inherent in the fiscal announcement is proportional to the degree of risk aversion.[9]

Numerical simulations

We study the quantitative relevance of our theoretical results by simulating the model numerically, calibrated on Japanese data. The exercise shows that signaling effects can be quantitatively significant and are amplified by the prior uncertainty of the private sector, the imprecision of the signal received by the government, and they interact with the structure of the economy (the signaling effect increases with the degree of nominal rigidities and the agents' risk aversion).

[9] Zanetti (2014) studies the interplay between risk aversion and asset prices in consumption-based models.

Table B.5: Parameter values

Parameter	Description	Value
α	Labor share	0.55
β	Discount rate	0.99
γ	Risk aversion parameter	2.00
ϵ	Elasticity of substitution in production	6.00
ζ	Degree of price stickiness	0.50
θ	Share of government spending in steady state	0.25
P_1	Price level in period 1	1.00
σ_v^2	Variance of noise in the signal	1.00

Notes: The values for parameters α, β, γ, ϵ, and ζ are set to be consistent with the data and estimates reported in the literature. The parameter θ is the government-spending-to-GDP ratio from National Account Data from Japan.

While we calibrate most of the parameters to standard values in the literature, we estimate the parameter ψ that determines the cyclical response of government spending to productivity in the fiscal rule using Japanese data.[10] We aim to provide an initial quantitative assessment of the signaling effect of fiscal announcements. Table B.5 summarizes the calibration of parameters.

We set the labor share (α) equal to 0.55 and the discount rate (β) equal to 0.99. We set the parameter of risk aversion (γ) equal to 2 and we will conduct extensive robustness analysis on this parameter. We set the elasticity of substitution across goods (ϵ) equal to 6, consistent with a 20% price markup, and we set the degree of price rigidities (ζ) equal to 0.5, consistent with the average price update of two quarters. We set the government-spending-to-GDP ratio (θ) equal to 25%, consistent with Japanese data, and we calibrate the fiscal spending shock to 5% of GDP, consistent with the fiscal expansion in Japan in 2020 relative to the long-run government-spending-to-GDP ratio from the National Account Data for the years 2014-2019. We normalize the price in period 1 (P_1) and the variance of noise in the signal (σ_v^2) to one. With this normalization, in the rest of the analysis the parameter σ_u^2 represents the prior uncertainty of agents relative to the normalized degree of precision in the signal.

We estimate the elasticity of government spending to productivity (ψ) that determines the systematic response of fiscal policy to changes in expected productivity using data on aggregate technology from the Penn World Table (version 10.0), and data on government spending from the Annual Report on National Account in Japan for the period 1980–2019.[11] Since government spending comprises several categories, we use the three most representative classes of fiscal spending, represented by total government spending, government consumption, and public investment. We estimate our parameter of interest ψ by regressing each

[10] Appendix B.6 describes the data of total factor productivity and government spending for Japan.

[11] The data from Penn World Table (version 10.0) is available at https://www.rug.nl/ggdc/productivity.

Table B.6: Systematic response of fiscal policy

	Total Spending	Government Consumption	Public Investment
	(1)	(2)	(3)
Estimated value of ψ	-0.33^{**}	-0.11^{*}	-0.96^{*}
	(0.14)	(0.06)	(0.49)
No. of lagged regressand	4	4	4
Observations	34	34	34

Notes: The data is from Penn World Table and the Annual Report on National Account in Japan for the period 1980-2019. Newey-West HAC standard errors are in parentheses. The lagged independent variables are set based on the Akaike information criterion. The 5% and 10% significant levels are denoted by $**$ and $*$, respectively.

alternative categories of government spending on productivity using the equation:

$$\tilde{g}_t = \psi \hat{x}_t + \sum_{i=1}^{p} \rho_i \tilde{g}_{t-i} + c + u_t, \tag{B.26}$$

where $\tilde{g}_t$ and $\hat{x}_t$ are the detrended series of government spending and total factor productivity, respectively, and the lagged dependent variables control for serial correlation in the error. The series are detrended using the Hamilton's (2018) regression filter, and the lag lengths, denoted by p in equation (B.26), are selected based on the Akaike information criterion.[12] Table B.6 shows the estimation results. The alternative estimates for ψ, shown in columns (1)–(3), are negative, ranging within values -0.11 and -0.96, and they are statistically significant. We use the value of -0.33 associated with total government spending as our benchmark values, and we conduct extensive robustness analysis on the value of this parameter.

Figure B.7 shows the effect of the private sector's prior uncertainty (σ_u^2) on the percentage deviation of stock prices response to the fiscal announcement ($Q|g_2$) for alternative calibrations to the countercyclical response of fiscal policy. The solid line shows the benchmark calibration $\psi = -0.33$, and the shaded area shows responses of fiscal policy within -20% ($\psi = -0.264$, dotted line) and $+20\%$ ($\psi = -0.396$, dashed line). The figure shows that the role of prior uncertainty is quantitatively relevant in the response of stock prices to the fiscal announcement across two dimensions. First, the strength of the signaling effect increases with the spread of beliefs. When the private sector has no prior uncertainty, the response of the stock market is positive and equal to 0.5 percent from the long-run equilibrium, while when the prior uncertainty is the same as the variance of the noise (i.e., $\sigma_u^2 = 1$) stock prices fall by 1 percent from their long-run value, and the negative response increases non-linearly

[12] In the Hamilton's regression filter, the variable is regressed on its two-years lagged value and the residuals of the regression are regarded as the detrended series. While we use the Hamilton's regression filter as our benchmark, the results are robust to the alternative detrending methods of Hodrick-Prescott (HP) filter and the band pass filter. An appendix with robustness analysis is available on request to the authors.

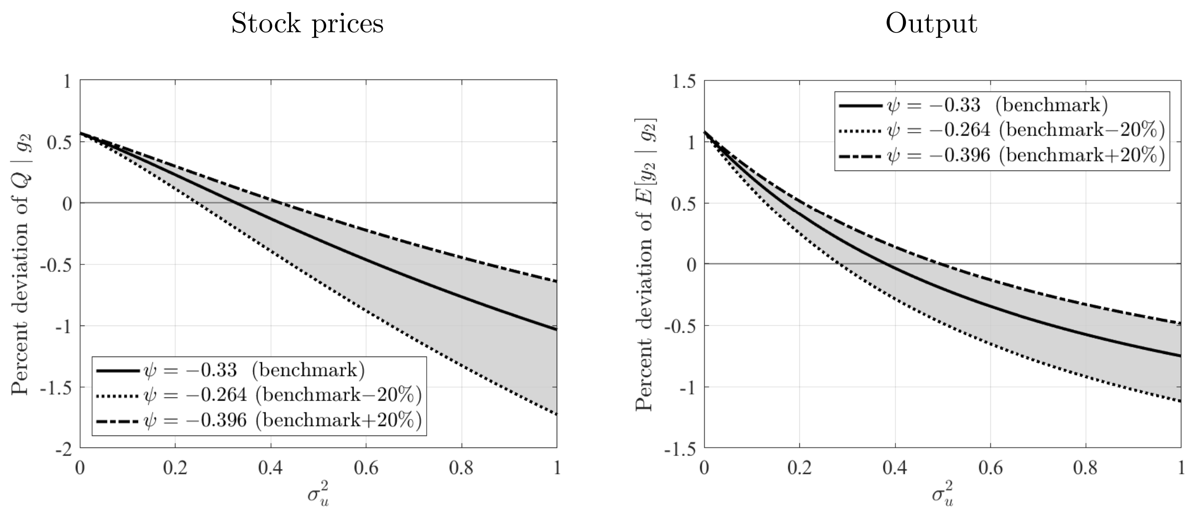

Figure B.7: **Stock prices, signaling effects, and systematic response of fiscal policy.** The figures illustrate the relationship between the stock price and expected output responses to the announcement of fiscal spending for period 2 and the agents' prior belief, respectively. These responses are measured by the percentage deviation from the steady-state value. The solid line shows the responses in the benchmark calibration of the system in Table B.5 with $\psi = -0.33$, shown in Table B.6. The dashed and dotted lines show the responses in the alternative calibrations for ψ 20% above and below the benchmark calibration, respectively.

with the private sector's prior uncertainty.

Second, the signaling effect significantly diminishes with the degree in the countercyclical response of fiscal policy. As shows in Figure B.7, the percentage response of stock prices to the fiscal announcement is lower when the coefficient ψ is +20% ($\psi = -0.264$, dashed line) than the benchmark calibration ($\psi = -0.33$, solid line) and the opposite realizes when the coefficient ψ is −20% than the benchmark calibration. Those differences significantly increase with the variance of prior beliefs, encapsulated by the parameter σ_u^2.

Finally, we show the quantitative importance of the degree of price rigidities (ζ) and risk aversion (γ) for the signaling effects of fiscal policy, as established by Lemma 1. Figure B.8 shows the combinations of values for parameters ζ and γ that generates negative (dark-shaded area) and positive (light-shaded area) signaling effects to the expansionary fiscal announcement.[13] The marker $*$ represents the combination of ζ and γ in the benchmark calibration.

Overall, the numerical simulations show that the signaling effect has a sizeable impact on stock prices and output and the magnitude depends on the prior uncertainty, the systematic response of fiscal policy to productivity and the structure of the economy, as discussed earlier in the section.

To summarize, our theoretical model shows that the key properties of signaling effects

[13] We calibrate the system with the benchmark values in Table B.6 and normalize the prior uncertainty of agents to one ($\sigma_u^2 = 1$).

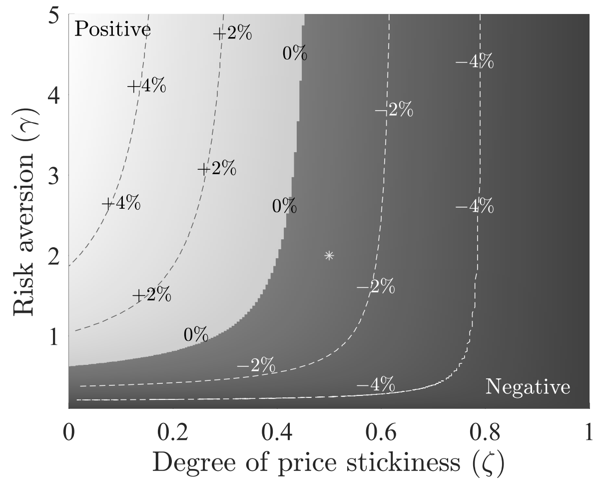

Figure B.8: **Signaling effects, risk aversion (γ) and price stickiness (ζ).** The dark-shaded (light-shaded) area shows values for ζ and γ that generate negative (positive) signaling effects on stock prices. The other parameters in the model are set to baseline values in Table B.5, and the prior uncertainty σ_u^2 is set equal to one. And, the marker $*$ represents the combination of ζ and γ in the benchmark calibration.

outlined by the simple model in Section (2) hold in the microfounded environment. Central to our empirical analysis, the theoretical model shows that stock prices encompass the signaling effects of fiscal announcements and that signaling effects heighten with uncertainty and do not necessarily reverse the effect of economic policy. We will use these important results to study empirically the signaling effect of fiscal announcements in the rest of our analysis.

B.1. Derivation of the posterior distribution for a_2

This Appendix derives the posterior distribution of productivity in period 2 using the Bayes' rule, that is, $\pi(a_2 \mid g_2) \propto f(g_2 \mid a_2)\pi(a_2)$. From equations (B.1) and (B.2), the prior density function and the likelihood function are respectively given by:

$$\pi(a_2) = \frac{1}{\sqrt{2\pi\sigma_f^2}} \exp\left\{-\frac{(a_2 - a_1)^2}{2\sigma_u^2}\right\},$$

and

$$f(g_2 \mid a_2) \equiv f(\tilde{a}_2 \mid a_2) = \frac{1}{\sqrt{2\pi\sigma_v^2}} \left\{\frac{(\tilde{a}_2 - a_2)^2}{2\sigma_v^2}\right\},$$

where we note that the likelihood function of g_2 conditioning on a_2 is equivalent to that of $\tilde{a}_2$ because private agents perfectly infer the signal $\tilde{a}_2$ from g_2. We apply the Bayes' theorem to calculate the conditional posterior density function of a_2, which yields:[14]

$$\begin{aligned}
\pi(a_2 \mid g_2) &\equiv \pi(a_2 \mid \tilde{a}_2) \\
&\propto f(\tilde{a}_2 \mid a_2)\pi(a_2) \\
&\propto \exp\left\{-\frac{1}{2}\left[\frac{(a_2-a_1)^2}{\sigma_u^2}+\frac{(\tilde{a}_2-a_2)^2}{\sigma_v^2}\right]\right\} \\
&\propto \exp\left\{-\frac{1}{2}\left[\frac{(a_2-(1/\sigma_u^2+1/\sigma_v^2)^{-1}(\sigma_f^{-2}a_1+\sigma_g^{-2}\tilde{a}_2))^2}{(1/\sigma_u^2+1/\sigma_v^2)^{-1}}\right]\right\} \\
&= \exp\left\{-\frac{(a_2-\hat{a}_2)^2}{2\hat{\sigma}^2}\right\},
\end{aligned}$$

where

$$\hat{a}_2 = \frac{\hat{\sigma}^2}{\sigma_u^2}a_1 + \frac{\hat{\sigma}^2}{\sigma_v^2}\tilde{a}_2, \quad \text{and} \quad \hat{\sigma}^2 = \left(\frac{1}{\sigma_u^2}+\frac{1}{\sigma_v^2}\right)^{-1}.$$

Therefore, the posterior distribution is a normal distribution with mean $\hat{a}_2$ and variance $\hat{\sigma}_2$, as outlined in equations (B.4) and (B.5).

B.2. Model solution

The Euler and labor-supply equations from the household maximization problem are:

$$\left(\frac{1}{c_1}\right)^{\gamma} = \beta R_1 E_1 \frac{P_1}{P_2}\left(\frac{1}{c_2}\right)^{\gamma}, \tag{B.27}$$

$$\frac{W_t}{P_t} = \chi c_t^{\gamma}. \tag{B.28}$$

Given a_1 and P_1, the fiscal authority sets public expenditure equal to $g_1 = g_{ss}\left(\exp\{a_1\}\right)^{\psi}$. From equations (B.28), (B.16), (B.18) and (B.10) we derive the equations for the labor supply, consumption and nominal wages in period 1:

$$W_1 = \chi c_1^{\gamma}, \tag{B.29}$$

$$W_1 = \frac{\varepsilon-1}{\varepsilon}\alpha e^{E_0[a_1]} n_1^{\alpha-1}, \tag{B.30}$$

$$c_1 = e^{a_1} n_1^{\alpha} - g_1. \tag{B.31}$$

After updating the beliefs on period 2's productivity to $E_1[a_2 \mid g_2]$, intermediate goods

[14] Here, we transform the third equality to the fourth equality using the following identity:

$$\frac{(z-\alpha_1)^2}{\beta_1}+\frac{(z-\alpha_2)^2}{\beta_2} = \frac{(z-\chi)^2}{\delta}+\frac{(\alpha_1-\alpha_2)^2}{\beta_1+\beta_2},$$

where $\delta^{-1} = \beta_1^{-1}+\beta^{-1}$ and $\chi = \delta(\beta_1^{-1}\alpha_1+\beta_2^{-1}\alpha_2)$.

firms sets P_2^* to satisfy the following system of equations:

$$
\begin{aligned}
P_2^* &= \frac{\varepsilon}{\varepsilon - 1} \frac{E_1[W_2 \mid g_2]}{\alpha e^{E_1[a_2|g_2]} E_1[n_2 \mid g_2]^{\alpha-1}}, && \text{(B.32)}\\
P_2^{1-\varepsilon} &= (1-\zeta) P_1^{1-\varepsilon} + \zeta (P_2^*)^{1-\varepsilon}, && \text{(B.33)}\\
\frac{E_1[W_2 \mid g_2]}{P_2} &= \chi (E_1[c_2 \mid g_2])^{\gamma}, && \text{(B.34)}\\
E_1[c_2 \mid g_2] &= e^{E_1[a_2|g_2]} (E_1[n_2 \mid g_2])^{\alpha} - g_2, && \text{(B.35)}\\
E_1[W_2 \mid g_2] &= W_1. && \text{(B.36)}
\end{aligned}
$$

Finally, after observing the realization of a_2 in period 2, the labor supply, consumption and nominal wage at period 2 is determined as in equations (B.29)-(B.31).

B.3. Model steady state

Given the steady-state values for $n_{ss} = \bar{n}$, $P_{ss} = 1$, $a_{ss} = 0$ and $g_{ss} = \theta y_{ss}$, we derive the steady-state value of consumption from the market clearing condition and production function as:

$$c_{ss} = (1-\theta) n_{ss}^{\alpha}. \tag{B.37}$$

The free parameter χ is determined by the optimal pricing rule and intra-temporal optimal condition:

$$0 = \left(\frac{\varepsilon - 1}{\varepsilon}\right) \alpha n_{ss}^{\alpha-1} - \chi c_{ss}^{\gamma}. \tag{B.38}$$

The intra-temporal optimal condition gives us the steady-state value of nominal wage as $W_{ss} = \chi c_{ss}^{\gamma}$. Finally, the nominal interest rate in this economy becomes $R = 1/\beta$ from the Euler equation evaluated in the steady-state.

B.4. Linear system and the response of stock prices to the fiscal announcement

This section derives the response of stock prices to the fiscal announcement. To derive the analytical properties of the response of stock prices to the fiscal announcement, we log-linearize the equilibrium conditions around the steady state. Under the assumption that the economy is in the steady state in period 1, the log-linearized version of equilibrium conditions

(B.27), (B.28), (B.14), (B.15), (B.18) and government spending rule (B.17) are the following:

$$\begin{aligned}\hat{P}_2 &= -\gamma\hat{c}_2^g,\\ \hat{W}_2^g &= \gamma\hat{c}_2^g,\\ \hat{P}_2^* &= \hat{W}_2^g - \hat{a}_2 + (1-\alpha)\hat{n}_2^g,\\ \hat{P}_2 &= (1-\zeta)\hat{P}_2^*,\\ \hat{c}_2^g &= \frac{1}{1-\theta}\hat{a}_2^g + \frac{\alpha}{1-\theta}\hat{a}_2 - \frac{\theta}{1-\theta}\hat{g}_2,\\ \hat{g}_2 &= \psi\tilde{a}_2.\end{aligned} \tag{B.39}$$

where we define $\hat{X}_2 \equiv \ln(X_2/X_{ss})$ and $X_2^g \equiv E_1[X_2 \mid g_2]$ except for the signal and posterior beliefs of productivity in period 2, denoted by $\tilde{a}_2$ and $\hat{a}_2$. Those productivity variables are originally measured as the deviation from the steady state since $a_{ss} = 0$. Thus, equation (B.5) can be regarded as the deviation of the posterior beliefs on productivity in period 2 from its steady state. By the assumption of being in the steady state at period 1, equation (B.5) can be represented as:

$$\hat{a}_2 = \frac{\omega}{1+\omega}\tilde{a}_2 \tag{B.40}$$

where $\omega \equiv \sigma_u^2/\sigma_v^2$. The log-linearized version of expected dividends and stock prices conditional on g_2 are given by:

$$\begin{aligned}\hat{D}_2^g &= \frac{\varepsilon}{\varepsilon-(\varepsilon-1)\alpha}\left(\hat{P}_2 + \hat{y}_2^g\right) - \frac{(\varepsilon-1)\alpha}{\varepsilon-(\varepsilon-1)\alpha}\left(\hat{W}_2^g + \hat{n}_2^g\right)\\ \hat{Q}^g &= \frac{\beta}{1+\beta}\hat{D}_2^g\end{aligned} \tag{B.41}$$

After some algebraic manipulation, we can derive $\hat{n}_2^g$, $\hat{P}_2$, and $\hat{y}_2^g$ as a function of $\hat{g}_2$ as follows:

$$\begin{aligned}\hat{n}_2^g &= \left[\frac{1}{(1-\alpha)(1-\theta)(1-\zeta)+\alpha\gamma}\left\{\theta\gamma + \frac{((1-\theta)(1-\zeta)-\gamma)\omega}{(1+\omega)\psi}\right\}\right]\hat{g}_2,\\ \hat{P}_2 &= \left[\frac{1}{(1-\alpha)(1-\theta)(1-\zeta)+\alpha\gamma}\left\{(1-\alpha)(1-\zeta)\theta\gamma + \frac{\gamma(1-\zeta)\omega}{(1+\omega)\psi}\right\}\right]\hat{g}_2,\\ \hat{y}_2^g &= \left[\frac{1}{(1-\alpha)(1-\theta)(1-\zeta)+\alpha\gamma}\left\{\alpha\gamma\theta + \frac{(1-\theta)(1-\zeta)}{(1+\omega)\psi}\right\}\right]\hat{g}_2,\end{aligned} \tag{B.42}$$

and $\hat{W}_2^g = 0$. Substituting equation (B.42) into equation (B.41), the analytical solution of expected dividends in period 2 is given by:

$$\begin{aligned}\hat{D}_2^g \;=\; & \frac{\gamma\theta\{(1-\alpha)(1-\zeta)\varepsilon+\alpha\}}{\{\alpha+(1-\alpha)\varepsilon\}\{(1-\alpha)(1-\theta)(1-\zeta)+\alpha\gamma\}}\hat{g}_2\\ & + \frac{(1-\theta)(1-\zeta)\{\alpha+(1-\alpha)\varepsilon\}+\gamma\{(\varepsilon-1)\alpha-\varepsilon(1-\zeta)\}}{\{\alpha+(1-\alpha)\varepsilon\}\{(1-\alpha)(1-\theta)(1-\zeta)+\alpha\gamma\}}\cdot\frac{\omega}{(1+\omega)\psi}\hat{g}_2.\end{aligned} \tag{B.43}$$

B.5. Proof of Lemma 1. Sign of the signaling effects of fiscal policy

This section proves Lemma 1. We discuss the condition under which a signaling effect of government spending (i.e., κ_g^{Signal} in equation B.21) is negative for countercyclical response of fiscal policy ($\psi < 0$). The signaling effect turns to be negative if

$$(1-\theta)(1-\zeta)\{\alpha + (1-\alpha)\varepsilon\} + \gamma\{(\varepsilon - 1)\alpha - \varepsilon(1-\zeta)\} > 0. \tag{B.44}$$

This inequality can be rewritten as

$$(1-\zeta)[(1-\theta)\{\alpha + (1-\alpha)\varepsilon\} - \gamma\varepsilon] > -\alpha\gamma(\varepsilon - 1). \tag{B.45}$$

Since the sign of the left-hand side of the inequality is ambiguous, we will consider each of the two cases.

The first case is $(1-\theta)\{\alpha + (1-\alpha)\varepsilon\} - \gamma\varepsilon > 0$, namely:

$$\gamma < (1-\theta)\frac{\alpha + (1-\alpha)\varepsilon}{\varepsilon}. \tag{B.46}$$

Then, inequality (B.45) can be transformed as

$$1 - \zeta > \frac{-\alpha\gamma(\varepsilon - 1)}{(1-\theta)\{\alpha + (1-\alpha)\varepsilon\} - \gamma\varepsilon}, \tag{B.47}$$

and this inequality is always satisfied for a possible value of $0 < \zeta < 1$ because the right-hand side of the inequality is negative.

In the case of $(1-\theta)\{\alpha + (1-\alpha)\varepsilon\} - \gamma\varepsilon < 0$, inequality (B.45) can be written as

$$1 - \zeta < \frac{-\alpha\gamma(\varepsilon - 1)}{(1-\theta)\{\alpha + (1-\alpha)\varepsilon\} - \gamma\varepsilon}, \tag{B.48}$$

for

$$\gamma > (1-\theta)\frac{\alpha + (1-\alpha)\varepsilon}{\varepsilon}. \tag{B.49}$$

It is noticed that inequality (B.48) is always satisfied again for a possible value of ζ in the case of

$$-\alpha\gamma(\varepsilon - 1) < (1-\theta)\{\alpha + (1-\alpha)\varepsilon\} - \gamma\varepsilon \quad \Leftrightarrow \quad \gamma < 1 - \theta \tag{B.50}$$

because the right-hand side of (B.48) exceed one. On the contrary, the signaling effect turns out to be positive if and only if

$$\gamma > 1-\theta, \quad \text{and} \quad 1-\zeta > \frac{-\alpha\gamma(\varepsilon-1)}{(1-\theta)\{\alpha+(1-\alpha)\varepsilon\}-\gamma\varepsilon}. \tag{B.51}$$

Namely, it is possible that a signaling effect of fiscal announcements become positive for countercyclical response of fiscal policy in the case of low degree of price rigidities and high risk aversion. However, the limit of ζ that satisfies inequality (B.51) as γ approaches infinity is obtained by l'Hôpital's rule as

$$\zeta < \lim_{\gamma\to\infty}\left\{1-\frac{-\alpha\gamma(\varepsilon-1)}{(1-\theta)\{\alpha+(1-\alpha)\varepsilon\}-\gamma\varepsilon}\right\} = 1-\frac{(\varepsilon-1)\alpha}{\varepsilon}. \tag{B.52}$$

For infinite risk aversion, the limit of threshold in ζ is 0.54 in our benchmark of $\alpha = 0.55$ and $\varepsilon = 6$, but this constraint seems not to be binding unless risk aversion is extremely high in the range of price rigidities usually assumed in the macroeconomic literature.

B.6. Data on total factor productivity and government spending in Japan

The annual data of government spending and total factor productivity (TFP) are used to estimate the elasticity of government spending to productivity for the period from 1980 to 2019.

Total Factor Productivity

The source of TFP data is Penn World Table, version 10.0 (`https://www.rug.nl/ggdc/productivity/`). Whereas the several series of TFP are available in this dataset, we use TFP at constant national prices (2017=1), denoted as *rtfpna* in the data source.

Government Spending

The data for government spending is downloaded from Annual Report on National Accounts 2019 (`https://www.esri.cao.go.jp/en/sna/kakuhou/kakuhou_top.html`), which is published from the Cabinet Office, Government of Japan. We can collect the time series of government consumption and public investment from the data source, and then total government spending is constructed as a sum of these two categories of government expenditures. The data with a baseline year of 2015 is only available from 1994 onwards, so we construct the connected series back to 1980 using the provisional estimates, which is also released by the Cabinet Office.

C. Robustness for empirical analyses

This section presents more details and robustness for the empirical analysis. Subsection C.1 reports more precise information on the timing of each fiscal announcement. Subsection C.2 informally evaluates the key theoretical prediction that signaling effects are stronger when uncertainty is higher. Subsection C.3 details the regression specification for the residuals plotted in Figure 3. Subsection C.4 shows other specifications of the local projection. Subsection C.5 explains how the series of government spending forecast revision is constructed, and Subsection C.6 exhibits additional robustness for the VAR analysis.

C.1. Detailed timings of fiscal announcements

Table C.1: Dates of Fiscal Announcements: 1992–2022

Indicator	Dates of Announcements		
	Order	Size	Ratify
(1) $\mathbb{I}\{A_{1,t}\}$	07/31/1992	08/28/1992	10/30/1992
(2) $\mathbb{I}\{A_{2,t}\}$	04/02/1993	04/13/1993	05/14/1993
(3) $\mathbb{I}\{A_{3,t}\}$	09/08/1993	09/16/1993	11/30/1993
(4) $\mathbb{I}\{A_{4,t}\}$	12/27/1993	02/09/1994	02/14/1994
(5) $\mathbb{I}\{A_{5,t}\}$	08/29/1995	09/20/1995	09/29/1995
(6) $\mathbb{I}\{A_{6,t}\}$	02/17/1998	04/24/1998	05/11/1998
(7) $\mathbb{I}\{A_{7,t}\}$	10/06/1998	11/16/1998	11/27/1998
(8) $\mathbb{I}\{A_{8,t}\}$	10/08/1999	11/11/1999	11/25/1999
(9) $\mathbb{I}\{A_{9,t}\}$	09/20/2000	10/19/2000	11/10/2000
(10) $\mathbb{I}\{A_{10,t}\}$	08/04/2008	08/29/2008	09/29/2008
(11) $\mathbb{I}\{A_{11,t}\}$	10/09/2008	10/31/2008	12/22/2008
(12) $\mathbb{I}\{A_{12,t}\}$	12/15/2008	12/19/2008	12/22/2008
(13) $\mathbb{I}\{A_{13,t}\}$	03/13/2009	04/09/2009	04/27/2009
(14) $\mathbb{I}\{A_{14,t}\}$	11/12/2009	12/08/2009	12/15/2009
(15) $\mathbb{I}\{A_{15,t}\}$	08/20/2010	08/31/2010	
(16) $\mathbb{I}\{A_{16,t}\}$	09/28/2010	10/08/2010	10/26/2010
(17) $\mathbb{I}\{A_{17,t}\}$	03/29/2011	04/18/2011	04/22/2011
(18) $\mathbb{I}\{A_{18,t}\}$	06/14/2011	06/30/2011	07/05/2011
(19) $\mathbb{I}\{A_{19,t}\}$	07/12/2011	10/17/2011	10/21/2011
(20) $\mathbb{I}\{A_{20,t}\}$	10/18/2012	10/25/2012	
(21) $\mathbb{I}\{A_{21,t}\}$	11/16/2012	11/27/2012	
(22) $\mathbb{I}\{A_{22,t}\}$	12/27/2012	01/11/2013	01/16/2013
(23) $\mathbb{I}\{A_{23,t}\}$	09/11/2013	12/05/2013	12/13/2013
(24) $\mathbb{I}\{A_{24,t}\}$	11/19/2014	12/29/2014	01/13/2015
(25) $\mathbb{I}\{A_{25,t}\}$	07/13/2016	08/02/2016	08/25/2016
(26) $\mathbb{I}\{A_{26,t}\}$	11/08/2019	12/05/2019	12/16/2019
(27) $\mathbb{I}\{A_{27,t}\}$	02/07/2020	02/14/2020	
(28) $\mathbb{I}\{A_{28,t}\}$	03/02/2020	03/11/2020	
(29) $\mathbb{I}\{A_{29,t}\}$	03/30/2020	04/07/2020	04/08/2020
(30) $\mathbb{I}\{A_{30,t}\}$	05/15/2020	05/27/2020	05/28/2020
(31) $\mathbb{I}\{A_{31,t}\}$	11/10/2020	12/08/2020	12/16/2020
(32) $\mathbb{I}\{A_{32,t}\}$	10/08/2021	11/19/2021	11/29/2021
(33) $\mathbb{I}\{A_{33,t}\}$	03/29/2022	04/27/2022	05/18/2022
(34) $\mathbb{I}\{A_{34,t}\}$	09/30/2020	10/28/2020	11/09/2022

Notes: The table summarizes the dates of fiscal announcements over the period 1992–2022, as reported in the *Nikkei* newspaper. The dates "Order" are the dates in which the Prime Minister orders the fiscal stimulus packages or supplementary budgets. The dates "Size" are those in which the draft of the package is finalized. Lastly, the dates "Ratify" are those in which the budget supporting the fiscal stimulus package is officially ratified by the Cabinet. Some packages using reserve funds do not require additional budget approval and therefore do not have a Ratify date.

C.2. Private Sector's Uncertainty and Signaling Effects

In this section, we aim to informally evaluate a key prediction of the stylized model presented in Section 2: that signaling effects are stronger when the private sector has greater uncertainty about the economic outlook. If that is the case, the negative responses of stock prices to fiscal news, as shown in Figure 3, are more likely to occur when uncertainty is high. We measure uncertainty in two ways. Subsection C.2.1 uses a market measure of uncertainty, while Subsection C.2.2 relies on households' and firms' survey measures of disagreement.

C.2.1. The Nikkei VI

In this subsection, we use the Nikkei 225 Volatility Index (Nikkei VI) – a daily measure of the expected volatility of stock prices – as a proxy for stock markets' uncertainty. This index reflects the stock market's uncertainty regarding the near-term economic outlook. Figure C.1 shows the time profile of daily Nikkei VI with the sign of the stock prices response on the day of each fiscal announcement that we considered in Figure 3. High stock market volatility tends to correlate with a negative response (− marker) of stock prices to the fiscal announcement, while the response of stock prices tends to be positive (+ marker) when stock market volatility is below sample average.

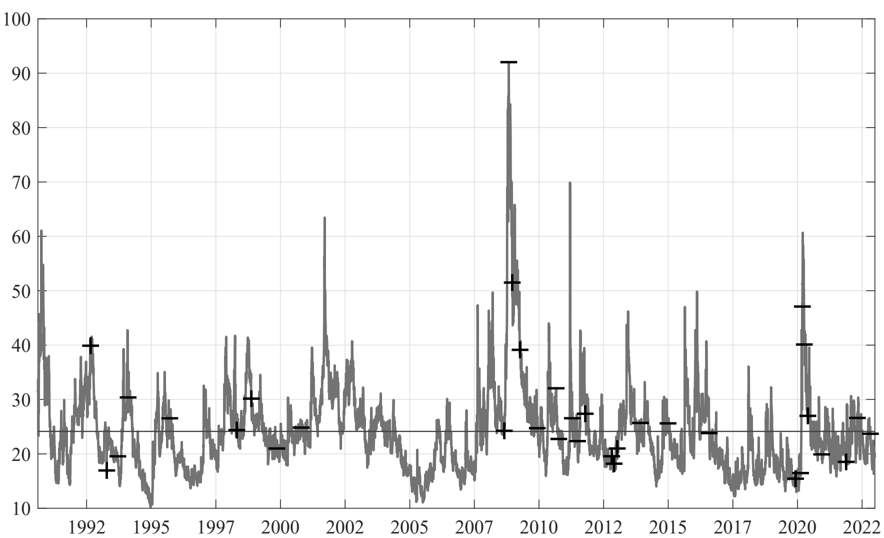

Figure C.1: **Nikkei 225 VI and fiscal announcements.** This figure shows the daily variation in Nikkei 225 VI (solid thick line) and the timing of fiscal announcements (+ or − marks). The horizontal line is the historical average of Nikkei 225 VI. The marks of + and − in the figures are attached to be consistent with the impact responses in Figure 3.

C.2.2. Households and firms' disagreement

We now conduct a similar analysis by looking into survey expectations of households and firms at the time of the fiscal announcements. We acquire household expectations from the *Consumer Confidence Survey* that has been administered monthly by the Cabinet Office since 2004.[15] It covers 8,400 households selected from over 50 million households nationwide by excluding foreigners, students, and households living in institutions and it surveys the consumer perception on a broad range of issues including overall livelihood, asset prices, and economic growth. Respondents answer each question on a one-to-five scale: improve, improve slightly, no change, worsen slightly, and worsen. We focus on the items about the outlook for overall livelihood, asset prices, and income growth over the next six months.

We also use firm expectations from the Short-Term Economic Survey of Enterprises in Japan, known as the *Tankan Survey*, administered by the Bank of Japan on a quarterly frequency since 1974. The survey provides qualitative information about the nationwide private corporate activity in Japan. The target population is the private enterprises with a capital of 20 million yen or more. The Survey encompasses 220,000 firms and 10,000 enterprises. We use the section on the Judgment Survey of Business Conditions that mandatorily requires each surveyed legal enterprise to indicate the business conditions based on the expectations of profits in the next quarter. The survey requires participants to answer questions by choosing one of the following three alternative options: favourable, not so favourable, and unfavourable.

Figure C.2 shows the cross-sectional standard deviation in the responses of household expectations from the *Consumer Confidence Survey*, related to questions about livelihood (Panel a), asset prices (Panel b), and income growth (Panel c). The markers + and − denote the sign of the percentage change of stock prices on the day after each of the thirty-four announcements (described in Figure 3). Figure C.2 shows the standard deviation across firms' expectations from the *Tankan Survey*, together with markers for each of the sixteen announcements. We normalize the standard deviation to be equal to one in the initial period, and the solid horizontal line represents the sample average of standard deviation for each survey.

The four panels in Figure C.2 illustrate a consistent and systematic relationship between stock price responses and expectations about the future. In both surveys, more dispersed expectations are more likely to be associated with a negative response of stock prices to fiscal announcements. Generally, stock prices respond positively when the dispersion of households' or firms' expectations is below the historical average. Conversely, stock prices tend to respond negatively during periods of heightened disagreement, such as the Great East Japan Earthquake in March 2011 and the recent COVID-19 pandemic in March 2020. Both findings are consistent with the theory of signaling effects (Section 2).

To sum up, this first pass to the data provides preliminary evidence indicative of a wide range of responses of stock prices to an expansionary fiscal policy. The response of stock prices is positive when the fiscal intervention is independent of economic conditions. Never-

[15] The predecessor survey began in 1957, and at that time only urban households were surveyed twice a year. The current monthly survey of nationwide households has been conducted since 2004.

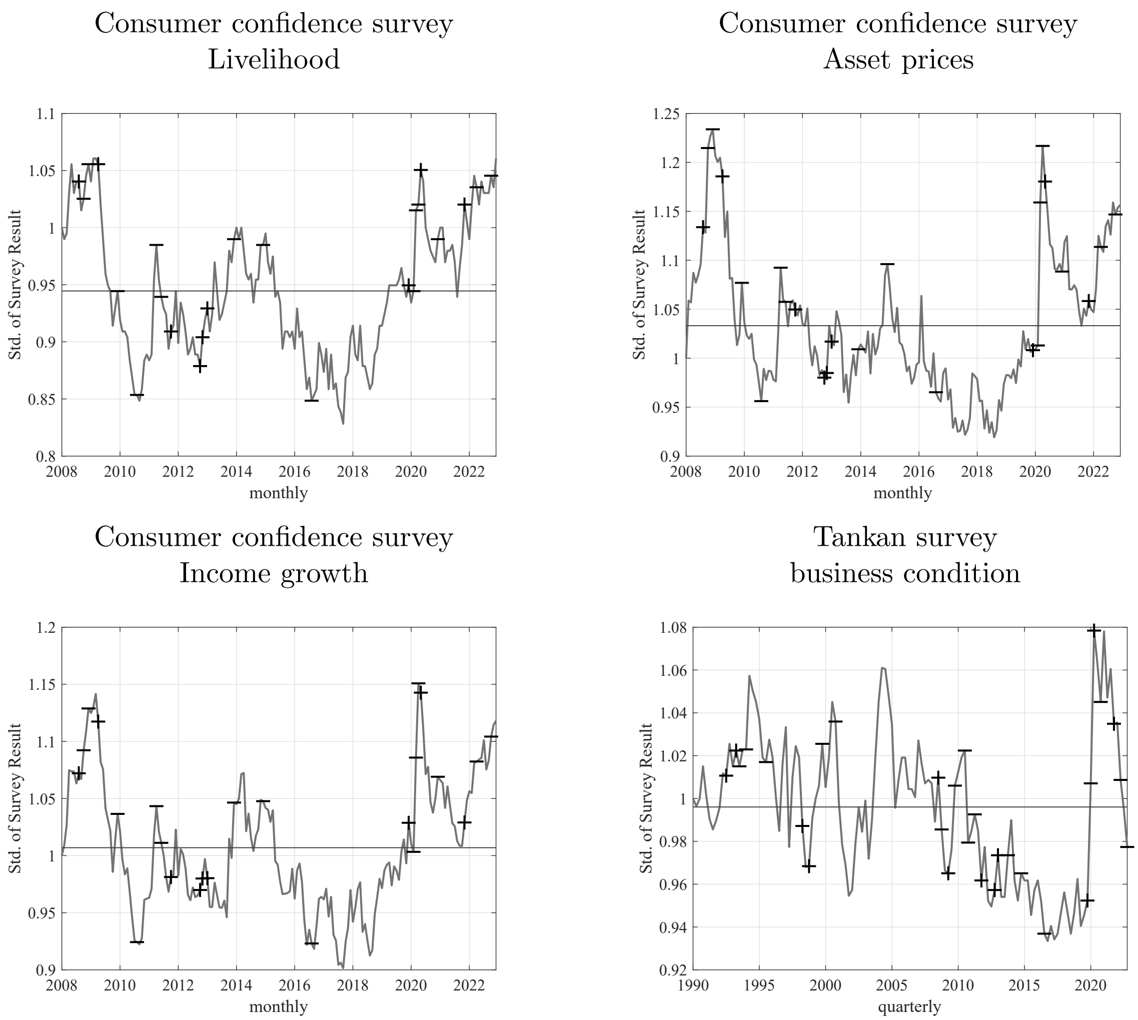

Figure C.2: **Standard deviation of survey results and fiscal announcements.** This figure shows the standard deviation of the answers to the *Consumer Confidence Survey* (Panels a-c) in the period January 2008– December 2022, and the *Tankan Survey* (Panel d) for the period 1990Q1 – 2022Q4. We compute standard deviations as follows. First, we calculate the weighted average of the results by multiplying the evaluation points for each alternative and the component ratio. We set the evaluation points in the *Consumer Confidence Survey* as +1 (improve), +0.75 (slightly improve), +0.5 (no change), +0.25 (worsen slightly), and 0 (worsen), and for the *Tankan* survey +1 (favorable), 0 (not so favorable), and -1 (unfavorable). Then, for each alternative, the square of the deviation between the evaluation point and the weighted average is calculated in each period, and the squared root of its sum, weighted by the component ratio, is used as the standard deviation. For comparison, we normalize the standard deviation at the initial point to be equal to one. The marks of + and − in the figures are attached to be consistent with the impact responses in Figure 3. For the Tankan Survey, two announcements may be included in the same quarter for some events, in which case the sign of the sum of stock-price responses within the same quarter is plotted in the figure.

theless, the response is typically more muted and possibly negative when the fiscal announcement is made to address adverse economic conditions and, particularly, when households' and firms' expectations are more dispersed in line with the theory.

In Section C.2.1, we have used Nikkei 225 VI as a proxy of stock market's uncertainty. A major difference between Nikkei 225 VI and the survey measures is the frequency, the former being available at daily frequency, while the latter at lower frequency. Table C.2 shows the correlation coefficients between the dispersion in the survey expectations (for the survey questions about livelihood, asset prices and income growth) and the Nikkei VI converted into the monthly basis by time average. The p-values (in parentheses) test the hypothesis that the correlation between variables is equal to zero. The entries show that the correlations between the Nikkei VI and the different measures of consumer confidence from the Consumer Confidence Survey (last row) are positive at a 1% significance level, indicating that the Nikkei VI robustly tracks the dispersion in the expectations from survey data.

Table C.2: Correlations among the consumer confidence and the Nikkei VI

	Consumer confidence survey			Nikkei VI
	Overall livelihood	Asset prices	Income growth	
Overall livelihood	1			
Asset prices	0.86 (0.00)	1		
Income growth	0.94 (0.00)	0.91 (0.00)	1	
Nikkei VI	0.39 (0.00)	0.55 (0.00)	0.39 (0.00)	1

Notes: The entries show the correlation coefficients between the standard deviations for the *Consumer Confidence Survey* (Figure C.2) related to the questions about livelihood, asset prices and income growth, and the monthly Nikkei VI for January 2008 – December 2022. The values in parenthesis indicate the p-value for the hypothesis that the correlation between variables is insignificant.

C.3. Regression specification of Figure 3

Figure 3 plots the residuals from the following regression:

$$\sum_{j=0}^{h} \Delta s_{t+j} = \alpha_h \mathbb{I}\{A_t^{\text{size}}\} + \beta_h \mathbb{I}\{A_t^{\text{size}}\} \times VI_{t-1} + Z_{t-1}\gamma' + \delta_h + e_{t+h}$$

where Δs_{t+j} is the response of the change in stock prices to fiscal announcements, $\mathbb{I}\{A_t^{\text{size}}\}$ is an indicator variable taking a value equal to unity when one of the thirty-four supplementary fiscal packages is finalized and announced (the second phase) – see Table 1. VI_t denotes the Nikkei 225 Volatility Index, normalized so as to have zero mean and unit variance. This index reflects the stock market's uncertainty regarding the near-term economic outlook. The coefficient δ_h is a time dummy at horizon h. Finally, Z_{t-1} denotes the vector of control variables, including: the lagged change in the volatility index (ΔVI_{t-1}), the lagged change in stock prices (Δs_{t-1}), the Dow Jones Industrial Average for the US Stock Market at trading closure in the preceding day ($\Delta DJIA_{t-1}$), the change in the yen—dollar exchange rate ($\Delta EXCH_{t-1}$), and the ten-year Japanese Government Bond (JGB) yields ($BOND_{t-1}$).

C.4. Robustness of LP regression

Table C.3: Impact effects of fiscal announcements: Robustness checks

	1990–2022	2008–2022	
VARIABLES	$\Delta s_t = \Delta\text{TOPIX}_t$	Δs_t	$\Delta\text{JGB\_VIX}_t$
	(1)	(2)	(3)
$\mathbb{I}\left\{A_t^{\text{size}}\right\}$	0.188	−0.077	0.711
	(0.228)	(0.242)	(1.163)
$\mathbb{I}\left\{A_t^{\text{size}}\right\} * VI_{t-1}$	−0.373*	−0.722***	0.378
	(0.231)	(0.244)	(0.823)
VI_{t-1}	0.043**	0.062	−0.241**
	(0.026)	(0.051)	(0.135)
Δs_{t-1}	0.002	−0.145***	0.007
	(0.017)	(0.024)	(0.094)
$\Delta DJIA_{t-1}$	0.441***	0.605***	−0.036
	(0.066)	(0.048)	(0.176)
$\Delta EXCH_{t-1}$	0.041**		
	(0.025)		
$\Delta NEER_{t-1}$		−0.437***	−0.123
		(0.062)	(0.274)
ΔJGB_VIX_{t-1}		0.000	−0.026
		(0.003)	(0.033)
$BOND_{t-1}$	−0.019***	−0.094**	0.066
	(0.009)	(0.051)	(0.217)
Constant	0.021	0.061**	−0.041
	(0.020)	(0.037)	(0.183)
Observations	7,949	3,661	3,661
Adj. R-squared	0.171	0.325	0.023

Notes: This table shows local projection estimates –Equation (8)– by changing variables and the sample period. Column (1) presents estimates when using TOPIX, an alternative stock market price index to Nikkei225, for the sample period 1990—2022. Column (2) shows the estimation under the specification in which nominal effective exchange rate is included instead of yen—dollar exchange rate and the JGB_{VIX}, a measure of implied volatility of Japanese government bond, is included. For data availability, the sample period is limited to 2008—2022. Column (3) shows estimates in which JGB_{VIX} is used as dependent variable. The estimated result indicates that the JGB_{VIX} is not affected by fiscal announcements, meaning that fiscal announcement is not likely to induce private agents to perceive default risk of Japanese government.

C.5. The series for the revision of the forecast of government spending

In this Appendix, we describe the construction of our series for the revision of the forecast of government spending. We use forecast data on government spending from *JCER ESP Forecast*, published by *Japan Center for Economic Research*, which collects professional economists' forecasts of various economic variables. Government expenditure forecasts have been included in the survey since June 2009. Each month, forecasters make forecasts on the annual growth rate of government expenditure for one and two fiscal years ahead. The Japanese fiscal year (FY) starts in April and ends the following March, so the forecasted period measured by the monthly basis is different each month. For example, consider the forecasts of government expenditure annual growth rates for FY2009 and FY2010, which are released in June 2009 and July 2009. In this case, the monthly basis forecast periods are 21 months for June 2009 release (there are nine months remaining in FY2009 and 12 months in FY2010), and 20 months for the July 2009 release. Exploiting this forecast data, we construct a monthly series of the quasi one-year (i.e., 12 months) ahead forecasts of government expenditure growth rates by taking a weighted average of the forecasted value for each fiscal year and the number of months included within 12 months from the period of forecasting. To be specific, a quasi one-year ahead forecasts in June 2009, denoted as $E_t\hat{G}_{t,t+12}$, is computed as:

$$E_t\left[\hat{G}_{t,t+12}\right] = \frac{9}{12} \times E_t\left[G_{FY2009}\right] + \frac{3}{12} \times E_t\left[G_{FY2010}\right],\ t = 2009\text{M}06,$$

where E_tG_{FY2009} and E_tG_{FY2010} denote the forecasts of annual growth rates of government expenditure for FY2009 and FY2010 at period t (= June 2009). We first-difference this series to construct the revision of forecast on the one-year ahead government expenditure growth rate:

$$\Delta E_t\left[\hat{G}_{t,t+12}\right] = E_t\left[\hat{G}_{t,t+12}\right] - E_{t-1}\left[\hat{G}_{t-1,(t-1)+12}\right].$$

We use $\Delta E_t\left[\hat{G}_{t,t+12}\right]$ in the month when fiscal announcements are released as our government expenditure forecast revision in f_t. As for the macroeconomic variables included in y_t, they are taken from the *JCER Monthly GDP Estimate*, also published by the *JCER*. Differently from the official statistics that are realeased at quarterly frequency, these estimates are available at monthly frequency.

C.6. Robustness of VAR analysis

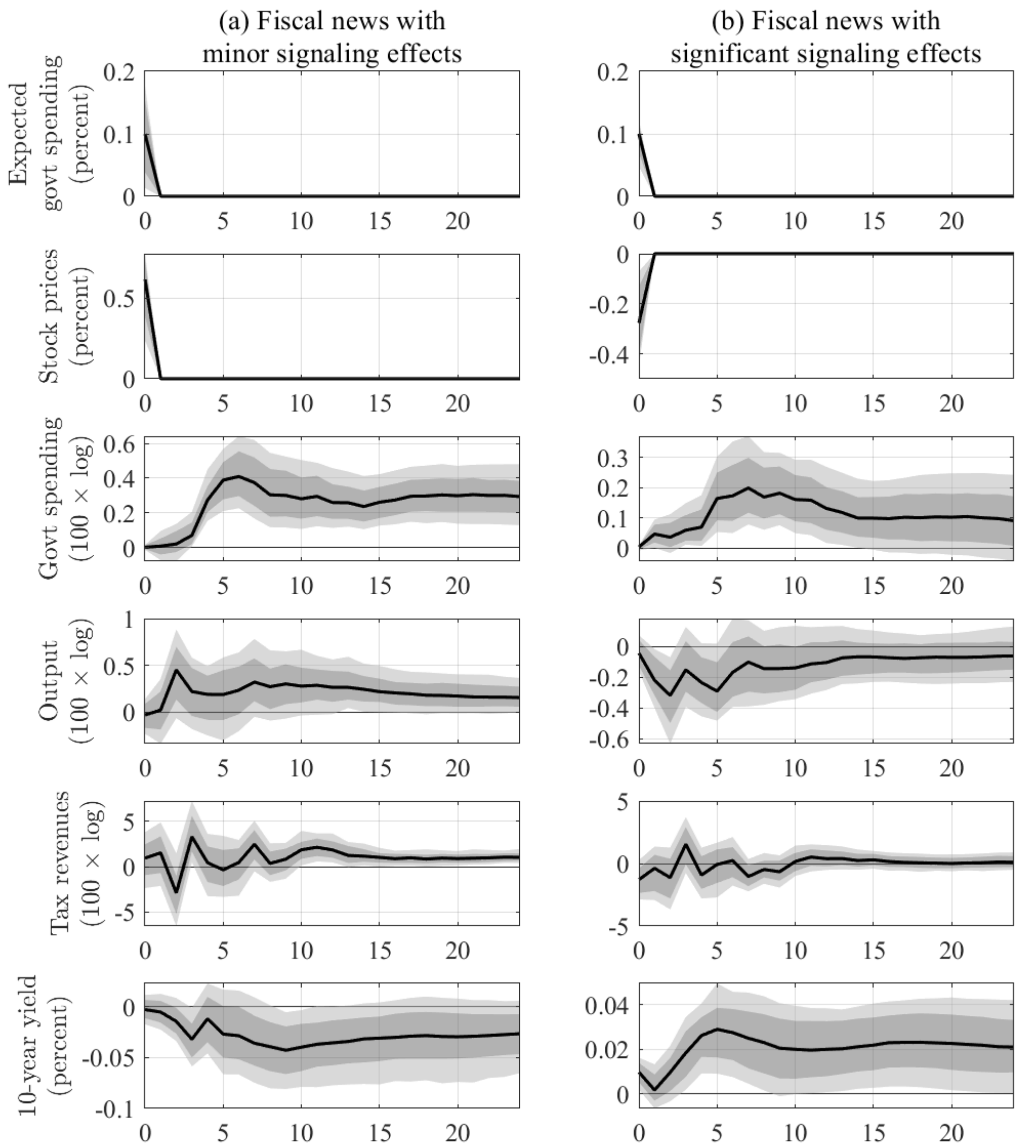

Figure C.3: **Impulse response functions (with interest rate).**
This figure shows the impulse response functions of the VAR model obtained under a specification including the 10-year Japanese government bond yields. The unit of government spending, output, and tax revenue is $100 \times \log$. The 10-year yield is in percent. Expected government expenditure growth and stock market index growth are both in percent. The main results of impulse responses are robust in quantitative and qualitative senses, compared with our main results shown in Figure 4.