A Monetary-Fiscal Theory of Sudden Inflations and Currency Crises

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Abstract

Treating nominal government bonds like other bonds leads to a new theory of sudden inflations and currency crises. Holmstrom (2015) and Gorton (2017) describe bonds as having costly-to-investigate opaque backing that consumers believe is sufficient for repayment. Government bonds' nominal return is their face value, their real return is determined by the government's surplus. In normal times, consumers are confident of repayment but ignorant of the true surpluses that will fund that repayment. When consumers' belief in real repayment wavers, they investigate surpluses. If consumers learn surpluses will be insufficient to repay bonds in real terms, the price level jumps. This explains why we observe inflationary crises, but never deflationary.

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1 Introduction

Holmstrom (2015) and Gorton (2017) explain banks' ability to issue money-like debt as originating from the banks' ability to keep secret the value of the assets that back the debt. Debt is sustainable until consumers worry so much that they are willing to pay the cost to investigate the backing. I translate this explanation to nominal government bonds. A government's ability to issue safe assets comes from its ability to convince consumers that debt will be repaid while the consumers have difficulty in forecasting the government surpluses that will finance repayment. Consumers face the risk that surpluses will be insufficient to fully repay bonds in real terms. High government debt is sustainable until repayment risk drives consumers to worry enough that they investigate the surpluses, potentially setting off a currency crisis or sudden inflation.

Currency crises and sudden inflations occur when consumers shift from ignorance of future surpluses to investigating those surpluses, and find them to be lower than expected. The consequences are driven by concerns over the capability of governments to repay their debts in the future. This explanation matches the analysis of Burnside et al. (2001) of the 1997 Asian currency crisis, as well as the inflationary histories described in Sargent (1982). Countries were able to sustain high levels of debt or cheaply borrow in foreign currencies, until large prospective deficits convinced consumers to investigate future surpluses and realize that governments would use inflation to repay their debts.

The explanation also explains the asymmetry of crises: why there are sudden inflations and devaluations but no corresponding sudden deflations. The asymmetry is a consequence of the payoff structure of bonds, as illustrated in Figure 1. This paper, following and updating the advice of Sargent (1982) that "government debt is valued according to the same economic considerations that give private debt value..." analogizes nominal government bonds to standard corporate bonds. Buying a bond is an investment in a project that has an uncertain outcome. If the project's outcome is higher than the face value of the bond, the bond holder receives the face value of the bond,

no matter how high the outcome is. If the project's outcome is lower than the face value of the bond, the bond holder receives a share of the project's liquidation value.

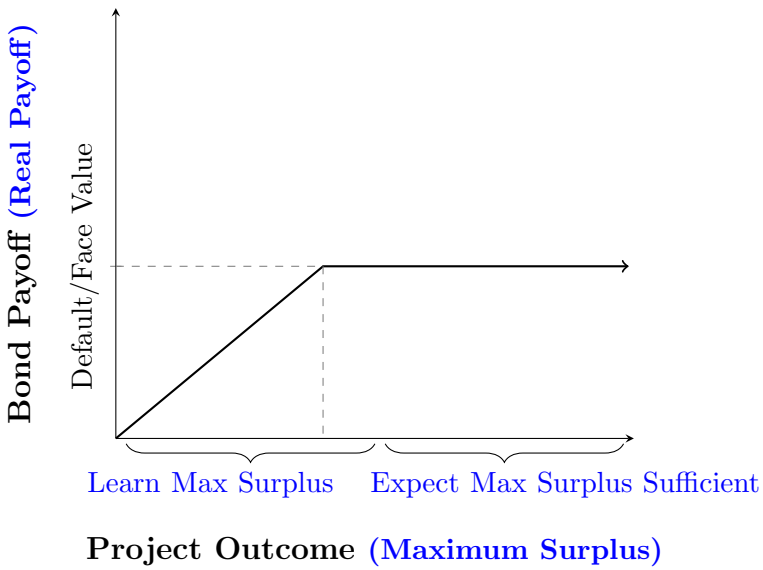


Figure 1: Bond and Government Bond Payoffs With Max Surplus Regions

Buying a nominal government bond is an investment in the government. The bond's nominal payoff will be the face value of the bond; the bond's real payoff is determined by the government's real surplus. The government attempts to ensure that the surplus is large enough to fully repay the bond in real terms. If it is able to raise a sufficient surplus, the price level is unchanged and the bond holder receives the face value of the bond in real terms (the flat part of the bond payoff curve). However, if the maximum size of the surplus is constrained – by a Laffer limit on tax revenue, political constraints on austerity, or the need to bailout the financial sector – the surplus could be lower than the face value of the bond. In this case, the price level rises, decreasing the real payoff of the nominal bond to a share of the government's surplus (the angled part of the bond payoff curve).

The story of currency crises and sudden inflations is a direct consequence

of the shape of the bond payoff curve and its endogenous surplus information structure. Consumers are willing to buy government bonds (with a premium reflecting real repayment risk due to inflation) if they believe the bonds will be repaid in real terms. Due to the cost to generate information about the maximum surplus available to repay the bonds, consumers will choose to generate information only when they believe the max surplus is near the default boundary, where the surplus may not be large enough to ensure a full real payoff.[1]

The lack of observed sudden deflations is due to the lack of an upside to the real payoff of bonds. Governments won't raise the surpluses necessary to provide a windfall for bond holders. For example, as described in Jacobson et al. (2019), in 1933, deflation caused by a rise in the price of gold would have required austere fiscal policy in order to raise the surplus necessary to repay government debt as in Bordo and Kydland (1995). Experiencing deflation and facing the required austerity, Roosevelt chose to leave the gold standard rather than allow further deflation.

As discussed in Bianchi and Melosi (2013), advanced economies have experienced slowly rising inflation, followed by sudden jumps. This paper shows how this pattern is a consequence of the distance between consumers' beliefs and the default boundary. Small changes in beliefs about the possible size of the future surplus – e.g. bad news arrives about the need for future bailouts – or a small change in the interest rate – e.g. raising rates in response to a speculative currency attack – can have large price level consequences, or small consequences that make large consequences more likely in the future. If, after a small change, consumers' beliefs remain sufficiently above the default boundary, only minor effects will be seen. However, beliefs will be closer to the default boundary, making large jumps more likely in response to future changes. If consumers' beliefs are sufficiently close to the default boundary, it

[1] As an example of the cost, and possibility, of generating information about the government's surplus, the Federal Reserve Board has a Fiscal Analysis group of five economists which "forecasts developments in the federal, state, and local government sectors." Presumably, their work improves upon the publicly available forecasts produced by the Congressional Budget Office. Similar groups exist at other central and private banks.

will be worthwhile to generate information, leading consumers to learn that the future surplus will be insufficient for the amount of bonds. Once consumers discover this, the price level snaps to the higher level necessary to guarantee nominal repayment of the bonds consumers already hold.

The paper's model, inspired by Bassetto (2002) and Cochrane (2020), uses a basic reduced form to illustrate the bond-like payoff of nominal government bonds and the decision of the consumer to become informed when deciding how many bonds to buy. The government has, in the second period, a price level target and a maximum surplus it can raise. In the first period, the consumer buys nominal government bonds at an interest rate chosen by the monetary authority. The bonds' real payoff is determined by the government's future surplus. The consumer has uninformed beliefs about the government's max future surplus, and can expend a fixed utility cost to learn the true future surplus.

As long as the surplus necessary to repay the bonds at the price level target is below the maximum surplus, the government sets the surplus – by lowering taxes or increasing spending – to equal the nominal bonds at the target and the bonds return their face value. If the necessary surplus is above the maximum surplus, the government raises the maximum surplus, and the price level rises to equate the max surplus and the face value of the bonds.

I illustrate two stories relevant to currency crises and sudden inflations. First, the story of Burnside et al. (2001), where consumers become uncertain about the size of future government surpluses tomorrow, e.g. the government may have to bailout the financial system or fight a pandemic. If a consumer is confident that future surpluses will be sufficient for repayment, he will buy bonds without investigating the true surplus. As the consumer believes higher future government spending becomes more likely, he becomes less confident in repayment, and the benefit from gathering information rises. Once a consumer is uncertain enough about repayment, he will do research to learn about the future maximum surplus. If a consumer learns the future surplus will be low, he won't buy bonds he knows won't be repaid in real terms, leading to the high price level necessary to balance the government's budget constraint.

The second story illustrates the limit to the power of the monetary authority to control the price level through its control of the interest rate. A monetary authority raises the interest rate, for example due to currency pressures. The higher the interest rate, the more bonds a consumer wants to purchase. However, the more bonds a consumer purchases, the higher the risk that not all of the bonds will be fully repaid in real terms. If the monetary authority offers debt at a low interest rate, a consumer makes bond buying decisions based on just his uninformed beliefs. If the monetary authority offers debt at a high interest rate, a consumer chooses to learn the government's maximum surplus. As before, learning that future surpluses will be low leads to a high price level.

This paper ties together two literatures: Fiscal Theory of the Price Level (FTPL) papers that link the value of nominal government debt to a theory of the price level, and papers creating a theory of safe assets. Leeper (1991), Sims (1994), and relatedly Sargent and Wallace (1985) begin the FTPL literature that claims the price level is linked to the price of nominal government bonds through the government budget constraint. Since nominal government bonds are repaid by the government's future surplus, the surplus will determine the price of government bonds and hence the price level. Woodford (2000) posits that FTPL-type behavior is more likely in times of fiscal stress, a result found endogenously in this paper. Cochrane (2005) shows that the FTPL implies that government debt is priced akin to a share of stock in a corporation. For an overview and criticism of the FTPL, see Bassetto (2002). This paper argues that government debt has a bond-type payoff due to a constraint on the size of government surpluses and the cost to consumers of researching that size. Uniquely, the price level will not respond to changes in the government's max surplus as long as consumers are uninformed. However, uncertainty or excess bond issuance can make it worthwhile for consumers to learn the surplus, and hence restore the connection between the max surplus and the price level.

In this paper, as in the FTPL, the present value of future government surpluses determines the price level as the price level moves to equate the assets and liabilities of the government. In the fiscal theory, the government can specify off-equilibrium surplus values in order to change the price level.

This ability has led to considerable debate over the applicability of the FTPL such as in Bassetto (2002). Here the consumer has beliefs about the size of the surplus, and has the choice to learn more information to update his beliefs, and thereby inform his calculation of the present value.

As an empirical application, some papers have considered the implications of government choices or consumer beliefs switching between FTPL, and non-FTPL regimes. Davig and Leeper (2006) explore how changing regimes can explain the impact of fiscal behavior on the economy. Bianchi and Melosi (2017) consider the lack of then-predicted deflation during the Great Recession, and explain how, and show empirically that, policy uncertainty over the repayment of large government debts could provide support for actual inflation. This paper provides an endogenous explanation that the perceived different regimes come from a single source: the bond-like payoff curve of nominal government debt. Consumer beliefs combined with the behavior of fiscal policy lead to the payoff curve. The payoff curve leads to the two perceived regimes, one that operates when the government is perceived to be able to easily raise tax revenue to repay its debt, and the other when the government is perceived to need tax revenue and inflation to repay its debt.

Pricing safe assets, and defining what safe assets are, has undergone intensive research since the Great Recession. This paper expands that work to pricing nominal government debt. Holmstrom (2015) and Gorton (2017) summarize a research agenda that views safe assets as special, and necessary for their ability to provide savings and insurance. Safe assets are differentiated from other assets by the high cost to research their backing. All consumers will have uninformed beliefs about the repayment of a safe asset. In a crisis, when consumers doubt the backing of the assets, they will pay the price to research it. As shown in Dang et al. (2017), actual knowledge of the safe assets' backing destroys the symmetric ignorance and leads to lower welfare through lack of insurance. In this paper, the concern is simply repayment risk rather than adverse selection and liquidity. The consumer fears he will not be paid back, and chooses to research the government's surplus rather than take that chance.

Some recent extensions of the FTPL in Williamson (2018), Berentsen and Waller (2018), and Bassetto and Cui (2018), have considered the consequences of the liquidity premium of government debt as an attempt to explain why the price level has not responded to recent deficits. Since government debt can be used for exchange, it has value beyond the present value of surpluses. This paper uses the work of Holmstrom (2015) and Gorton (2017) to provide an explanation for when the value of debt will respond to prospective deficits. The information structure of debt is endogenous to the payoff structure of debt, and the value of debt will only respond when consumers have real repayment worries. Also closely related is Andolfatto (2010), which embeds a version of the symmetric ignorance of safe assets in a macro money search model, but without the price level effects seen in this paper.

The next section presents the model, illustrating the consequences of an uninformed bond buying consumer having the option to become informed about future surpluses. In Section 3, I first illustrate how the model implies the bond payoff curve shown in Figure 1. Second, I numerically and analytically solve two illustrative examples, either an increasing likelihood of a small maximum surplus or an increasing interest rate, that lead a consumer to become informed, and the price level to rise suddenly. Finally, Section 4 concludes.

2 Model

The model concentrates on a consumer buying nominal government bonds, and choosing whether or not to become informed about the bonds' backing. The core of the model is a two period FTPL model. In order to make buying nominal government bonds mirror a standard investment decision, missing the price level target because the government is unable to raise enough surplus – analogous to a bad project outcome – is costly to the consumer. The benefit of information about the government's surplus is the ability to avoid this cost.

2.1 Consumer

The representative consumer has per-period utility $u(c)$, overall utility

$$U(c_1, c_2, \delta_\gamma) = u(c_1) - \delta_\gamma \gamma + \beta u(c_2) - c(P_2, P^*)$$

Utility is, in c_1, c_2, strictly increasing, strictly quasiconcave, and continuously differentiable. δ_γ is an indicator of whether or not the consumer chooses in the first period to expend γ utils to learn the government's maximum surplus in the second period. The cost of missing the price level target P^* in the second period, $c(P_2, P^*) \geq 0$, is continuously differentiable and strictly increasing in P_2 on $P_2 \geq P^*$. Including the cost of inflation as a separate function allows me to simplify the rest of the model. The cost function serves, in this purely nominal model, to justify the asymmetry of the government's fiscal and monetary policy goals, where fiscal policy will attempt to use taxation to just achieve the price level target.

The budget constraints are

$$\begin{aligned} B_0 + P_1 e_1 &= P_1 c_1 + P_1 \tau_1 + Q B_1^d, \\ B_1^d + P_2 e_2 &= P_2 c_2 + P_2 \tau_2 \end{aligned} \tag{1}$$

In each period, the consumer sells his real endowment e_t and his nominal bonds B_t^d are repaid at the price level P_t. Using that money, he buys real consumption c_t, pays net taxes minus transfers τ_t. He begins period 1 with endowed nominal bonds B_0 that pay off one nominal unit in period 1. He demands to buy nominal bonds $B_1^d > 0$ that pay off one nominal unit in period 2, at the nominal price $Q = \frac{1}{1+i}$.

In the first period, the consumer knows the probabilities $\pi, 1-\pi$ that the maximum tax revenue minus money transfers the government can raise in the second period τ^{max} (such that $\tau_2 \leq \tau^{max}$) will be low L or high H, respectively. The consumer will learn the true τ^{max} in second period, but he also has the choice in the first period to expend γ utils to learn which τ^{max} will occur rather than waiting.

The consumer's first order condition is

$$\frac{1}{1+i} = E\left[\frac{P_1 u'(c_2)}{P_2 u'(c_1)}\right] \tag{2}$$

where i is the nominal interest rate, set by the monetary authority.

2.2 Government

At the beginning of each period, the government prints money to repay the extant bonds B_{t-1}. The government's constraints clear the market for money,

$$\begin{aligned} B_0 &= P_1\tau_1 + QB_1^s, \\ B_1^s &= P_2\tau_2 \end{aligned} \tag{3}$$

subject to $\tau_2 \leq \tau^{max}$. In the first period, the government repays nominal bonds B_0, supplies new nominal bonds B_1^s at the price $Q = \frac{1}{1+i}$, and collects τ_1 in tax revenue minus money transfers, thus clearing the market for money by extinguishing reserves. In the second period, the government repays the nominal bonds it supplied in the first period B_1^s, and collects τ_2 in tax revenue minus money transfers, subject to remaining below the maximum level τ^{max}. There is a probability π that the maximum tax revenue minus money transfers in the second period is low $\tau^{max} = L$, and a probability $1-\pi$ that it is high $\tau^{max} = H$.

The government combines a fiscal and a monetary authority. The monetary authority chooses the nominal interest rate $i > 0$ and a price level target $P^* > 0$ for the second period. Nominal bonds supplied by the government B_1^s equal bonds demanded by the consumer $B_1^d(Q)$ at the chosen bond price as in Bassetto (2002). Equivalently, the monetary authority controls the number of bonds sold, and the interest rate clears the market. As explained in Cochrane (2020), this basic monetary authority is a simplification of the role that the Federal Reserve together with the Treasury Department plays in the market for U.S. government bonds. The Treasury Department issues debt which is

expected to be repaid using future surpluses while Federal Reserve open market operations control the quantity of debt without creating expectations of repayment.

The fiscal authority chooses τ_1, τ_2 which represent tax revenue minus money transfers, i.e. net taxes which function to drain money from the economy. These taxes are specified in nominal terms because taxes are paid in nominal dollars rather than real goods. There is a maximum level of tax revenue minus money transfers in the second period $\tau^{max} \geq \tau_2$ that the government can collect. This maximum could come from either revenue or spending constraints. Revenue may be constrained by a Laffer or political economy limit to maximum taxation. Spending may be constrained by a political economy limit to austerity policies, or a banking crisis where the government chooses to transfers reserves to bail out banks.

The government always tries to raise enough revenue to repay government bonds in real terms at the price level target P^*. If it can't, it tries its best and maximizes the real return of the bonds by setting $\tau_2 = \tau^{max}$;

$$\tau_2 = \arg\min_{\tau_2} \left[P_2(\tau_2) - P^*\right] \text{ subject to } \tau_2 \leq \tau^{max} \tag{4}$$

where price level determination is described in Section 2.3.

The resource constraints are

$$c_1 = e_1, c_2 = e_2. \tag{5}$$

2.3 Price Level Determination

In both periods, the equilibrium price level is determined as in standard FTPL models. Bonds are repaid in real terms by the government's real surplus. In the first period, this is the standard FTPL pricing equation, derived from the standard bond pricing equation. In the second period, the presence of a maximum level of tax revenue minus money transfers τ^{max} and the price level target P^* lead to a new way to describe the behavior of the price level. If at the price level target P^*, the government's maximum surplus is larger than

the face value of bonds to be repaid, then the price level will be P^* and the government net taxes will be below their max $\tau_2 < \tau^{max}$. If, at the price level target P^*, the government's maximum surplus is smaller than the face value of bonds to be repaid, then net taxes will be at their max $\tau_2 = \tau^{max}$ and the price level $P_2 > P^*$ will equate the surplus and required bond repayment.

2.4 Equilibrium Definition

With initial bonds B_0, cost-to-learn γ, cost of missing the price level target $c(\cdot)$, and $\pi, 1-\pi$ probability of maximum tax revenue minus money transfers τ^{max} of L, H respectively, an equilibrium is a set of consumer choices $\{c_1, c_2, \delta_\gamma, B_2\}$, price levels $\{P_1, P_2\}$, and government choices $\{\tau_1, \tau_2, i, P^*\}$ such that

1. Given price levels, government policy, and initial beliefs, the consumer maximizes his utility subject to the per-period budget constraints, Equations 1 and first order condition, Equation 2.

2. Government constraints, Equations 3 are satisfied. The fiscal authority follows Equation 4.

3. The resource constraints hold, Equations 5

4. Given bond price Q, hence bond demand $B_1^d(Q)$, the government supplies $B_1^s = B_1^d(Q)$ bonds.

The per-period equilibrium conditions, defining the price levels, derived from Equations 1 and the behavior of the government are

$$\begin{aligned} \frac{B_0}{P_1} &= \tau_1 + Q\frac{B_1}{P_1} \\ \frac{B_1}{P_2} &= \min\left[\frac{B_1}{P^*}, \tau^{max}\right] \end{aligned} \tag{6}$$

In equilibrium, the nominal bond price is defined by the consumer's first order condition, Equation 2

$$\frac{1}{1+i} = \beta E\left[\frac{P_1 u'(e_2)}{P_2 u'(e_1)}\right] \tag{7}$$

The consumer chooses to expend γ to learn τ^{max} if the difference in expected utility between knowing τ^{max}, and only knowing the probabilities $\pi, 1-\pi$ of $\tau^{max} = L, H$ is greater than the cost of information γ. Define the value of information

$$V(i, B_0, \tau_1, L, H, \pi) =$$
$$\left[\pi \max_{B_2} U(c_1, c_2, \delta_\gamma = 1 | \tau^{max} = L) + (1-\pi) \max_{B_2} U(c_1, c_2, \delta_\gamma = 1 | \tau^{max} = H)\right]$$
$$- \max_{B_2} E\left[U(c_1, c_2, \delta_\gamma = 0)\right]$$

The consumer will choose in the first period to learn the future surplus if $V(.) > \gamma$.

3 Model Analysis

I use the model to analyze two situations illuminating currency crises and sudden inflations: the effect of lower surplus expectations due, for example, to the need for a bank bailout as in Burnside et al. (2001), and the effect of a rise in the interest rate, due, for example, to the response to a speculative currency attack.

First, I eliminate uncertainty in the model to show how in each situation the existence of the maximum net tax rate τ^{max} leads to a real payoff structure for nominal government debt that resembles standard corporate debt as in Figure 1. I describe the behavior of the fiscal and monetary authorities. The payoff structure causes non-linear first period price level dynamics, and explains why there are sudden inflations, but never sudden deflations.

Second, using the model with uncertainty of τ^{max}, I provide numerical examples of currency crises and sudden inflations, and prove that these situations may arise more generally. In each situation, I concentrate on how the price level in the first period responds discontinuously to changes in the relevant parameter, π the likelihood of a banking crisis, and i the interest rate.

3.1 Model without Uncertainty

I do comparative statics exercises in the simplest possible version of the model to illustrate the bond-like real payoff of nominal government debt. I then analyze the effects of an MIT shock (an unexpected shock in an otherwise deterministic model) to show how currency crises and sudden inflations can occur even in this simple setting.

Assume there is no uncertainty about τ^{max} (let $1-\pi=0$ so $\tau^{max}=L$), that $e_1=e_2$, $\tau_1=0$, and $c(\cdot)=0$. Hence the bond price is constant $\frac{1}{1+i}=\beta\frac{P_1}{P_2}$. Then Equation 6, becomes

$$\begin{aligned} \frac{B_0}{P_1} &= \left(\beta\frac{P_1}{P_2}\right)\frac{B_1}{P_1} = \beta\frac{B_1}{P_2}, \\ \frac{B_1}{P_2} &= \min\left[\frac{B_1}{P^*}, \tau^{max}\right] \end{aligned} \tag{8}$$

I use this model to investigate the two regions, corresponding to the two parts of the bond payoff curve, that arise due to the constraint τ^{max}.

3.1.1 Maximum Surplus Regions

I illustrate the effects of lower surplus expectations by investigating how the relevant variables behave in two different regions. Let $q=\frac{Q}{P_1}$ be the real bond price, and $\Pi=qB_1$ be the real revenue from bond sales. Using Equations 8, there are two regions

$$\begin{aligned} &\text{For } \tau^{max} < \frac{B_1}{P^*}: \qquad \frac{B_0}{P_1}=\beta\tau^{max}, \frac{B_1}{P_2}=\tau^{max}, q=\beta\frac{\tau^{max}}{B_1}, \Pi=\beta\tau^{max}; \\ &\text{For } \tau^{max} \geq \frac{B_1}{P^*}: \qquad \frac{B_0}{P_1}=\beta\frac{B_1}{P^*}, \frac{B_1}{P_2}=\frac{B_1}{P^*}, q=\beta\frac{1}{P^*}, \Pi=\beta\frac{B_1}{P^*} \end{aligned} \tag{9}$$

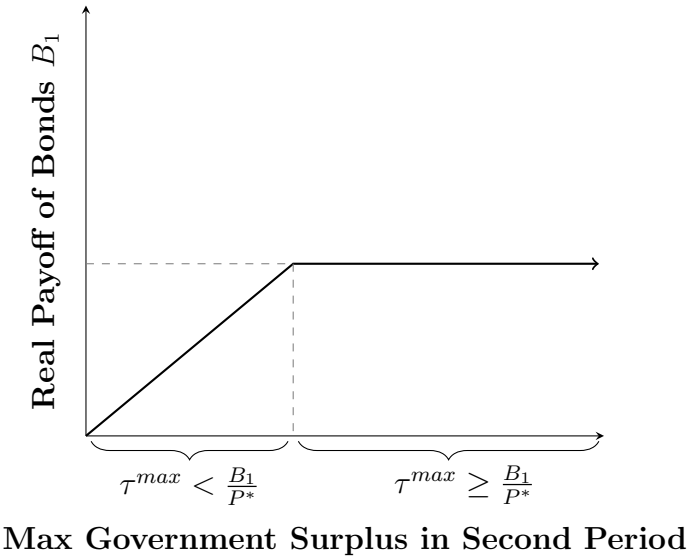


Figure 2: Real Bond Payoff With Maximum Surplus Regions

This simple example, shown in Figure 2, highlights the behavior of the fiscal authority and the bond-like real payoff of government debt. The fiscal authority tries to run surpluses to hit the price level target $\tau_2 = \frac{B_1}{P^*}$. If the amount of revenue necessary to do so is greater than the maximum possible surplus $\frac{B_1}{P^*} > \tau^{max}$, the fiscal authority sets $\tau_2 = \tau^{max}$, resulting in unexpected inflation. Hence there is an asymmetric possibility of state-contingent default through inflation, but no possibility of state-contingent gains through deflation.

Describing the two regions, if $\tau^{max} < \frac{B_1}{P^*}$, the government is unable to raise enough revenue to fully repay the bonds B_1 in real terms. Instead, the fiscal authority sets taxes to the maximum possible τ^{max}, and the price level in the second period P_2 adjusts so the real return equals τ^{max}. In the first period, the government is only able to raise the present value of τ^{max} in revenue through selling bonds B_1. Selling additional bonds doesn't raise additional real revenue as the additional bonds lead to an increase in the price level in the second period P_2, and a corresponding decrease in the nominal bond price Q.

If $\tau^{max} \geq \frac{B_1}{P^*}$, the government is able to raise enough revenue to fully repay the bonds B_1 in real terms. If the government chooses to sell additional bonds B_1, the new bonds will be backed by increased tax revenue in the second period. Hence selling additional bonds will raise revenue. The increased revenue causes the price level in the first period P_1 to decline as the government absorbs more money and bonds B_0 are repaid.

The sudden inflations and currency crises arise from the non-linear response of the price level in the first period P_1 as the economy moves from the region where $\tau^{max} \geq \frac{B_1}{P^*}$ to the region where $\tau^{max} < \frac{B_1}{P^*}$. For example, consider a negative MIT shock – the government has to bail out the banking sector hence the max surplus is unexpectedly small – that occurs after bonds have been sold. Whether the shock has an effect on the price level depends on whether the shock is large enough to shift regions. If τ^{max} is large relative to the real repayment target B_1/P^*, equivalent to being far to the right (in the money) in Figure 2, a small shock won't move τ^{max} to, or across, the kink in the payoff curve that defines the border between regions. If τ^{max} is already near the border between regions, any reasonable shock will push the economy across the border. When the economy shifts from the regime where taxes alone are sufficient to repay debt at the price level target to the one where taxes and inflation are required, consumers face a sudden inflation that devalues the real repayment of their bonds

In section 3.2, I analyze a model where both consumers and government are uncertain about the size of the max surplus τ^{max}, and consumers can learn the true τ^{max} through costly verification. The dynamics are similar to the deterministic model. If there is a possibility that τ^{max} will be in the $\tau^{max} < \frac{B_1}{P^*}$ region, consumers will demand a repayment risk premium on bonds. When the government tries to sell too much debt, consumers uncertain about the future fiscal surplus fear that additional bonds won't be repaid in real terms, that $\frac{B_1}{P^*}$ will surpass their beliefs about τ^{max}, and will pay the cost to learn the true surplus. Once they know the true surplus, the model with uncertainty reduces to the deterministic model: consumers face the same possibility of a sudden inflation if τ^{max} turns out to be low.

3.1.2 Interest Rate Regions

I illustrate the effects of raising the interest rate by investigating how the relevant variables behave in two different interest rate regions. Using Equation 8 and the bond price, in this simple case $B_1 = B_0(1+i)$. Debt in the first period is rolled over to the second period. Control of i gives the monetary authority some control over bond demand and bond revenue, and thus the price level P_1. Translating Equations 9 to the choice of i shows

$$\begin{aligned}
&\text{For } \tau^{max} < \frac{B_0(1+i)}{P^*}: && \frac{B_0}{P_1} = \beta\tau^{max}, \frac{B_0(1+i)}{P_2} = \tau^{max}, \\
& && q = \beta\frac{\tau^{max}}{B_1}, \Pi = \beta\tau^{max}; \\
&\text{For } \tau^{max} > \frac{B_0(1+i)}{P^*}: && \frac{B_0}{P_1} = \beta\frac{B_0(1+i)}{P^*}, \frac{B_0(1+i)}{P_2} = \frac{B_0(1+i)}{P^*}, \\
& && q = \beta\frac{1}{P^*}, \Pi = \beta\frac{B_0(1+i)}{P^*}
\end{aligned} \tag{10}$$

The two regions are defined by the interest rate. Changes in the interest rate lead to changes in the first period price level P_1 only when the additional bonds sold at a higher interest rate are backed by additional revenues in the second period. The government is limited in its ability to roll over debt by the size of the future fiscal surplus.

In the first region, if $1 + i > \frac{\tau^{max}P^*}{B_0}$, raising the interest rate leads to no change in second period surplus, which is already $\tau_2 = \tau^{max}$. Additional bonds won't be repaid in real terms, and hence real revenue is constant. The price level in the first period P_1 isn't affected, while the price level in the second period P_2 increases above the price level target to repay the new bonds with the same surplus τ^{max}. In the second region, $1+i \leq \frac{\tau^{max}P^*}{B_0}$, raising the interest rate leads to higher real revenue as the second period surplus rises to repay the additional bonds sold. $P_2 = P^*$ is constant, and the higher real revenue drives down the price level in the first period P_1.

3.2 Currency Crises and Sudden Inflations

I provide numerical examples to show how currency crises and sudden inflations arise, then prove their existence more generally. I allow uncertainty in $\tau^{max} \in (L, H)$ with probabilities $\pi, 1-\pi$, assume that $u(c) = \ln c, c(P_2, P^*) = P_2 - P^*, P^* = 1, e_1 = e_2 = 1, B_0 = 1, \tau_1 = 0.8, \beta = 1, L = 0.1, H \approx \infty$, and choose remaining parameters such that $L < B_1$ for the domains examined. In the situations below, the chosen L, H parameters will ensure the consumer risks missing the price level target, and its utility cost, when making the bond buying decision. The value of information is exactly the probability of missing, multiplied by its cost. However, in general, it's possible that for a two point distribution both L and H would be sufficient to repay B_1 for reasonable B_1, thus leaving no uncertainty about repayment, no asymmetry in price level response, and hence no currency crises nor sudden inflations. As discussed in Section 3.1.1, a sufficiently large negative MIT shock to the max surplus provokes the same basic shift in the economy to a region where the government uses inflation and taxes to repay debt.

The bond choice variable B_1 is the solution to the consumer's first order condition

$$\begin{aligned}\left(\frac{1}{1+i}\right)\left(\frac{1}{P_1e_1 - P_1\tau_1 + B_0 - QB_1}\right) &= \underbrace{\frac{1-\pi}{P_2(e_2-\tau_2)+B_1}}_{\tau^{max}=H} + \underbrace{\frac{\pi}{P_2(e_2-\tau_2)+B_1}}_{\tau^{max}=L} \\ &= \frac{1-\pi}{e_2} + \frac{\pi L}{B_1 e_2}\end{aligned}$$

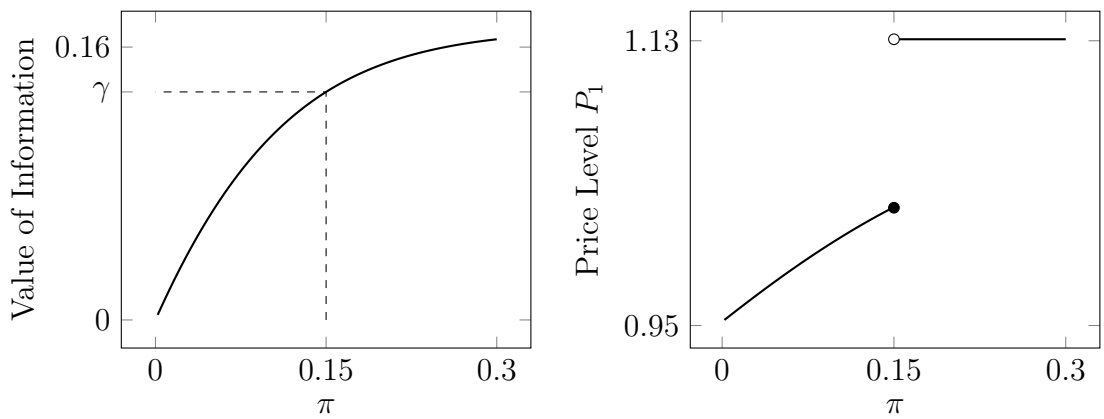
Importantly, I will parameterize the examples to place the expectations of consumers regarding the maximum surplus $\tau^{max} \in (L, H)$ such that a good outcome for the surplus results in full repayment

3.3 Lower Max Surplus Expectations

In the first situation, I illustrate the cause of the Asian currency crisis in Burnside et al. (2001). A future bailout of the financial system by the government becomes more likely, leading consumers to lower their expectations about the

possible size of future maximum surpluses. As expectations fall, eventually it becomes worthwhile for consumers to generate information about the true size of future max surpluses. If they do so, and discover future surpluses will be small, the price level in the first period will shoot up as consumers won't buy bonds that the government will be unable to repay in real terms.[2]

Figure 3: Value of Information, Price Level as Functions of Probability of Low Surplus State



For a numerical example, use the parameters above and $i = 0.05, \gamma = 0.13$. I restrict to looking at $\pi \in (0, 0.3]$ to simplify analysis: V(.) can be hump-shaped as information has no value if beliefs are certain $\lim_{\pi \to 1} V(., \pi) = \lim_{\pi \to 0} V(., \pi) = 0$ while $V \geq 0$ for all $\pi \in (0, 1)$.

As can be seen in Figure 3, as beliefs about the probability of $\tau^{max} = L$ rise, the value of information rises correspondingly. Consumers purchase fewer bonds as the probability rises, leading to a rise in the price level in the first period. When $\pi = 0.15$, the value of information equals the cost of information

[2]Of course, it's also possible that consumers will generate information and learn that $\tau^{max} = H$. In that case, the price level in the first period may fall, and the price level in the second period may approach or equal the P^* bound, as bond demand rises after repayment uncertainty has been eliminated.

γ. For probabilities above 0.15, consumers purchase information and learn that $\tau^{max} = L$. With the knowledge of τ^{max}, they will only purchase bonds that will be repaid, hence $B_1 = \tau^{max}$, and the price level in the first period rises discontinuously as a function of π.

The discontinuity occurs when $V(.) > \gamma$ and consumers purchase information. I'll prove that I can always choose a γ such that the consumer purchases information for beliefs near $\pi = 0$.

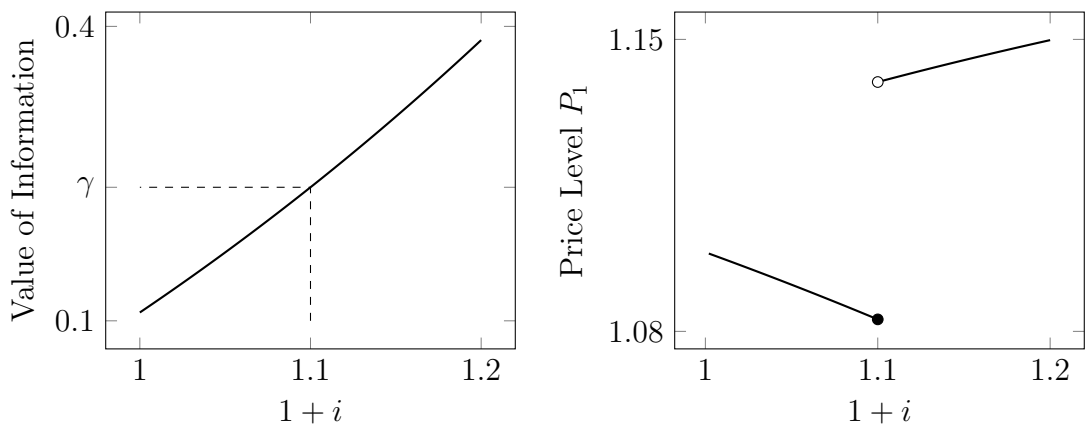
Theorem 1 *Given bond demand $B_1(., \pi), L < B_1$ for all $\pi \in (0, 1)$, there exist $k, \gamma > 0$ such that P_1 is discontinuous on $\pi \in (0, k]$ if $\tau^{max} = L$.*

Proof. It's only necessary to show that the value of information is positive for some $0 < \pi' < k$. By assumption, $B_1 > L$, hence there is the possibility of missing the price level target, and $V(\cdot, \pi') > 0$ at that π'. Because U is strictly increasing, strictly quasiconcave, and continuously differentiable in c_1, c_2, and $c(P_2, P^*)$ is as well on the relevant domain, V is continuous. By Jensen's inequality, $V(\cdot, \pi') > 0$, while $\lim_{\pi \to 0} V(., \pi) = 0$, hence the derivative with respect to π is positive on a neighborhood around π'. Thus there exists γ such that $V > \gamma$, leading to the discontinuity in P_1. ■

3.4 Interest Rate Rise

In the second situation, I illustrate why a country's monetary tightening in response to currency pressures may have limited effectiveness. The monetary authority is limited in its ability to determine the price level in the first period. Keeping all else constant, as the monetary authority raises the interest rate, consumers demand more bonds. Given the cost of information, at some level of bond demand it's worthwhile for consumers to generate information about the true value of future max surpluses. If consumers learn that future surpluses will be small, they'll purchase fewer bonds, and the price level in the first period will jump compared to what it would be without the information.

Figure 4: Value of Information, Price Level as Functions of Interest Rate



To illustrate with a numerical example, I use the parameters from before and $\pi = 0.5, \gamma = 0.24$ on the domain $1 + i \in [1, 1.2]$. As can be seen in Figure 4, as the interest rate rises, the value of information rises along with it. Consumers purchase more bonds at a higher interest rate, leading to a decline in the price level in the first period. At $1 + i = 1.1$, the value of information equals the cost of information γ. For interest rates above 1.1, consumers purchase information and learn that $\tau^{max} = L$. Once they know the future max surplus is small, they only want to purchase bonds that will be repaid, hence $B_2 = \tau^{max}$, and the price level in the first period rises discontinuously as a function of i. As i continues to rise, bond purchases are constant in nominal amounts but bring in less revenue, hence the price level shows an upward slope.

Theorem 2 *Given bond demand $B_1(., i), L < B_1$ for all $1 + i \in [a, b]$, then there exists $\gamma > 0$ such that P_1 is discontinuous on $1 + i \in [a, b]$ if $\tau^{max} = L$.*

Proof. We only need to show that V is increasing on $1 + i \in [a, b]$. Because U is strictly increasing, strictly quasiconcave, and continuously differentiable in c_1, c_2, and $c(P_2, P^*)$ is as well on the relevant domain, bond demand is

increasing in $1+i$ on [a,b]. By Jensen's inequality, $V > 0$, as is the derivative with respect to i. ■

4 Conclusion

This paper analogizes nominal government bonds to Holmstrom (2015) and Gorton (2017)'s description of corporate bonds. The real payoff of government bonds is the face value, if the government is able to raise that much real revenue, or less than the face value, but never more. This payoff curve explains the sharp dynamics of sudden inflations and currency crises, and why there are no sudden deflations. A consumer will buy and hold government bonds without knowing the government's true future maximum surplus because he believes the bonds will be repaid, and it's too costly to learn the truth.

It can become worthwhile for the consumer to learn future max surpluses if he suspects that the future surplus will be too low to repay his bonds, or the monetary authority has raised the interest too high. Once the consumer knows future max surpluses, he won't purchase bonds he knows won't be repaid. Since bond revenue helps determine the price level, the price level shoots up. The theory, and the story, describe sudden inflations and a currency crises.

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