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## Gambling to preserve price (and fiscal) stability

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**Abstract**

We study a model in which policy aims at aggregate price stability. A fiscal imbalance materializes that, if uncorrected, must cause inflation, but the imbalance may get corrected in the future with some probability. By maintaining price stability in the near term, monetary policy can buy time for a correction to take place. The policy gamble may succeed, preserving price and fiscal stability, or fail, leading to a delayed, possibly large jump in the price level. The resulting dynamics resemble the models of a currency crisis following Krugman (1979) and Obstfeld (1986). Like in Obstfeld's work, multiple equilibria arise naturally: whether or not price stability is preserved may depend on private agents' expectations. The model can be reinterpreted as a model of partial default on public debt, in which case it is reminiscent of Calvo (1988).

**Keywords:** multiple equilibria, self-fulfilling beliefs, fiscal theory of the price level, inflation expectations, currency crisis, sovereign default (*JEL*: E31, F31, F41).

## NON-TECHNICAL SUMMARY

It is well understood that a budget deficit can cause inflation, but most economic models focus on a scenario in which a deficit increases the price level with little delay. This paper develops a model in which, after a deficit materializes, price stability may be preserved for several quarters followed by a delayed surge in inflation. The analysis may help us understand some historical episodes including the post-COVID inflation.

We consider a model in which initially the economy is in a steady state with price stability. At some point, a bad shock such as a recession, a pandemic, or a war causes a budget deficit. If nothing else happens, the fiscal imbalance will be growing over time, because after new public debt was issued to finance the deficit, the new debt will be rolled over at a strictly positive real interest rate. Therefore, price stability will be unsustainable – at some point, inflation will have to "pay" for the deficit. However, in the model a fiscal correction *may* occur in the future with some probability, in which case *price stability will become sustainable again*. A potential correction may reflect a strong recovery from the recession that caused the initial deficit. Thus, when the deficit materializes, monetary policymakers face the choice between "inflation now" and "inflation in the future *with some probability*." The policy of maintaining price stability in the near term, to buy time for a correction, amounts to a gamble to preserve price stability indefinitely.

We use the model to understand what can happen if policymakers decide to take the gamble. If a correction occurs soon enough, price stability is maintained indefinitely (the gamble succeeds). Otherwise, the economy experiences a delayed surge in inflation (the gamble fails). Importantly, the outcome of the gamble depends on private agents' expectations. *The policy of price stability may continue indefinitely if private agents expect it to continue, and it may fail if private agents expect it to fail*. An adverse shift in inflation expectations can be self-fulfilling because it feeds into the state of the economy in a way that makes a correction harder to achieve, and hence less likely. The gamble to preserve price (and fiscal) stability may well be worth taking, but it makes the economy vulnerable to a self-fulfilling shift in expectations.

The resulting dynamics resemble the models of a currency crisis following Paul Krugman and Maurice Obstfeld. Like in Obstfeld's work, whether or not price stability is preserved depends on private agents' expectations. The model can be reinterpreted as a model of partial default on public debt instead of inflation, in which case it becomes reminiscent of the work by Guillermo Calvo.

# 1 Introduction

Sometimes, a very bad shock such as a pandemic or a war has a sharp economic impact, creating a need for socially costly adjustment. However, there is a chance that the economy will bounce back strongly, which would reduce the required scale of adjustment or at least diminish its cost. In such situations, macroeconomic policymakers face a choice that may be approximated as "adjustment now" versus "deeper adjustment in the future *with some probability*" if the economy fails to improve sufficiently. Delaying adjustment may be the better policy decision, even though it amounts to taking a gamble on the economic recovery. In this paper, we study a model in which the outcome may depend not only on luck but, disturbingly, also on *expectations of private agents.*

We consider an economy with private agents, a central bank, and a fiscal authority which issues nominal long-term debt. Initially, the economy is in a steady state in which the price level is constant. At some point, there is a one-time unanticipated budget deficit – one can think of the deficit as being caused by a recession. If nothing else happens, the fiscal imbalance will be growing over time, because after new debt was issued to finance the deficit, the new debt will be rolled over at a strictly positive real interest rate. Therefore, price stability will be unsustainable – at some point, inflation will have to "pay" for the deficit.[1] However, we assume that a fiscal correction *may* take place in a future period with some probability, *in which case price stability will become sustainable again.* One can think of a potential correction as reflecting a strong recovery from the recession that caused the initial deficit. Thus, when the deficit materializes, monetary policymakers face the choice between "inflation now" and "inflation in the future *with some probability.*" The policy of maintaining price stability in the near term, to buy time for a correction, amounts to a gamble to preserve price stability indefinitely. The gamble may well be worth taking, if the probability of a correction is high enough.

We use the model to understand the dynamics if the central bank decides to take the gamble. Since the fiscal imbalance is growing, the correction or budget surplus necessary to preserve price stability is increasing over time. We suppose that monetary policy will delay inflation as long as the required correction is not too large. We also assume that the

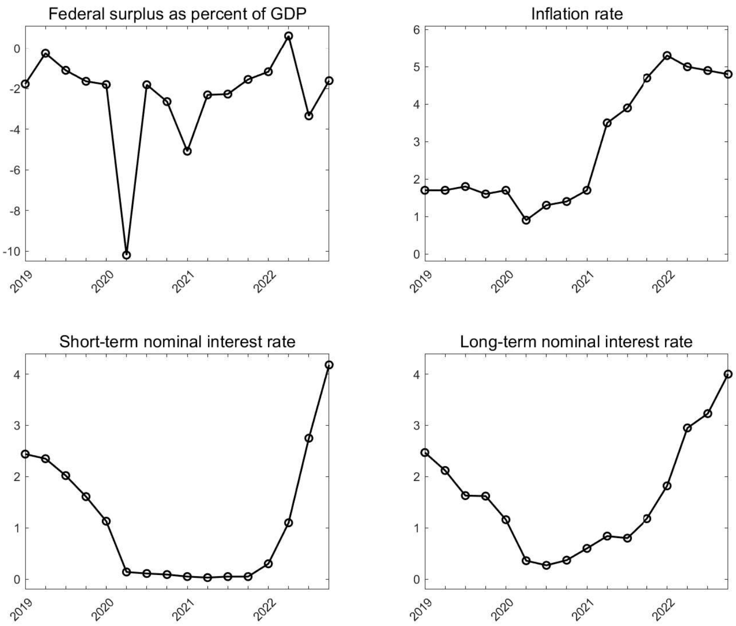
[1] In Section 6, we also study a version of the model with default on public debt instead of inflation.

probability of a correction falls with the necessary size of the correction. In equilibrium, if a correction occurs soon enough, price stability is maintained indefinitely. Otherwise, the economy experiences a delayed jump in the price level that is larger than if price stability had been abandoned right away. Moreover, the outcome of the policy gamble depends also on private agents' expectations – the model has multiple equilibria. For the same sequence of exogenous shocks, *the policy of price stability may continue indefinitely if private agents expect it to continue, and it may fail if private agents expect it to fail.* A shift in inflation expectations can be self-fulfilling because it feeds into the state of the economy (bond prices change, which affects debt issuance for a given deficit and thus the size of the required correction) and from there to policy behavior (the probability of a correction changes). The gamble to preserve price stability may well be worth taking, but it makes the economy vulnerable to a self-fulfilling shift in expectations.

**Remark.** We find it important to clarify from the start that our focus is on a positive analysis of what can happen when a fiscal imbalance is growing over time and everyone is uncertain about how the fiscal imbalance will be resolved. We specify fiscal policy as a stochastic process for the real primary surplus, which the central bank and private agents take as given. This modeling approach aims to capture that: (i) in extreme situations, such as a pandemic, a war, or a deep recession, fiscal policy "moves first" or "dominates," and (ii) everyone is uncertain if the fiscal dominance will be reversed or not (in other words, if the initial deficit will be paid for by future surpluses or not). In reality, realizations of the budget may reflect a mix of events beyond the control of fiscal policy ("a strong recovery") and fiscal policy responses to such events ("a budgetary consolidation"). The precise mix of "exogenous" shocks and "endogenous" fiscal responses is unimportant for the analysis. What is important is that there is uncertainty about future budget outcomes. In the concluding section, we outline desirable future work with optimizing policymakers.

**Motivation.** The paper is motivated by a long history of instability of fixed exchange rate regimes, but also by the surge in inflation during the COVID-19 pandemic. Figure 1 reports the federal budget surplus as fraction of GDP as well as measures of the inflation rate, the short-term nominal interest rate, and the long-term nominal interest rate in the United States in the period 2019Q1-2022Q4. The federal government ran a very large

Figure 1: **Federal budget, inflation, and interest rates in recent U.S. data**




United States, 2019Q1-2022Q4, FRED data. "Inflation rate" is the PCE deflator excluding food and energy, seasonally adjusted, percent change from quarter one year ago, "short-term nominal interest rate" is the 3-month T-bill rate, "long-term nominal interest rate" is the 5-year Treasury note rate, in percent per year.

budget deficit, in excess of 10 percent of GDP, after the outbreak of the pandemic in the second quarter of 2020. The inflation rate and the interest rates did not rise in that quarter; if anything, they fell. The inflation rate jumped only in the second quarter of 2021, with a delay of at least a year. The long-term interest rate began rising some time in advance of the jump in inflation. In the concluding section, we comment on how one can think of the recent history from the perspective of the model.

**Literature.** We wrote this paper for a conference honoring Maurice Obstfeld. Maury's contributions to the theory of currency and price level (in)stability feature preeminently in his overall vast research output. His work on this topic includes technical papers on foundational, closed-economy issues such as "dynamic seigniorage" and "ruling out speculative hyperinflations" (Obstfeld, 1991b, Obstfeld and Rogoff, 1983, 2021) as well as less technical, open-economy papers on "the logic of currency crises" (Obstfeld 1986, 1991a, 1994, 1996, 1997).[2] From the outset, the vulnerability of a fixed exchange rate policy to belief-driven speculative attacks has been a leitmotif in Maury's research. His first paper with this theme, Obstfeld (1986), can be seen as a response to Krugman (1979). Krugman (1979) questioned the idea, popular at the time, that currency crises are caused by the vagaries of irrational speculation, proposing a model in which the timing of a speculative attack is unique because of the rational anticipation by market participants of the policymakers' ability or willingness to defend a fixed exchange rate. Reversing Krugman's conclusion, Obstfeld (1986) showed, in a very similar setting, that the outcome can be indeterminate, depending on beliefs that are both rational and self-fulfilling. In his subsequent papers, Maury further developed the idea that there is feedback from private agents' expectations to the state of the economy and from the state of the economy to policy, which opens the door to multiple equilibria. The general lesson from his work in this area is that currency and price level stability are fragile because they may be vulnerable to a self-fulfilling shift in expectations.

One contribution of the paper may be to help readers appreciate how different strands of literature connect (the "first generation" currency crisis model of Krugman (1979), the "second generation" literature after Obstfeld (1986), the models of sovereign debt default following Calvo (1988),[3] and the fiscal theory of the price level, or the FTPL, initiated by Leeper (1991), Sims (1994), Woodford (1994), and Cochrane (2001)). We make some specific points about the literature at the end of each Section 3-6. Here let us make the following general observations. While in the early models of Krugman (1979) and Obstfeld (1986) inflation is fiscally beneficial to the extent that it produces seigniorage revenues from expansion of the monetary base (or more specifically, of non-interest-bearing currency), the subsequent literature on fiscally-driven currency crises broadens the scope of the analysis (e.g., Burnside, Eichenbaum, and Rebelo, 2001, Daniel, 2001, and Corsetti and Maćkowiak, 2006). Inflation is also, or perhaps mainly, fiscally beneficial because it reduces the real value of two quantities – nominal public debt and government expenditure commitments such as pensions that are imperfectly indexed to the price level – and this effect can be

[2] This series of papers had a profound influence on the policy debate about the Exchange Rate Mechanism of the European Monetary System.

[3] Recently, e.g., Corsetti and Dedola (2016), Ayres et al. (2018), Lorenzoni and Werning (2019), and Corsetti and Maeng (2020).

large in most modern economies. To focus on this effect of inflation, we adopt the modeling approach of the FTPL and we include nominal *long-term* public debt. Bond prices can then drop in response to news that there may be inflation in the future, producing a transfer from private agents to the public sector, even if there is no inflation at present.[4] The FTPL literature recognizes that while monetary policy may be unable to preserve price stability, the central bank may be able to choose the path of inflation for given fiscal policy – Cochrane (2023) makes this point a recurrent theme of his book (e.g., "Monetary policy can (...) shift inflation over time as it pleases," p. 70). However, the literature typically focuses on situations when inflation responds to a shock smoothly with little delay,[5] whereas we stress the possibility that the price level can be constant or approximately so for several quarters after a shock, followed by a delayed large jump in the price level. This may be an appealing way to think about the period after the outbreak of the COVID-19 pandemic. Furthermore, in our model monetary policy *may be* able, depending both on luck and private agents' expectations, to buy enough time for a fiscal correction so that inflation *never* happens.

**Outline of the paper.** The next section sets up the baseline model. We then solve the model under three different assumptions about what can happen after the budget deficit materializes. Section 3 assumes that the fiscal imbalance will not be corrected. Next, we introduce the possibility that the imbalance may be corrected in the future. In Section 4, we analyze the simplest case in which the probability of a correction over time is independent of the state of the economy. In this case, the model has a unique equilibrium in the spirit of Krugman (1979). In Section 5, we study the main case in which the probability of a correction over time is decreasing in the necessary size of the correction. This analysis, summarized above, is in the spirit of Obstfeld (1986). In Section 6, we reinterpret our model of inflation (which may be avoided) as a model of partial default on public debt (which may also be avoided). The parallel to models of currency crises with multiple equilibria à la

[4] An FTPL approach is inessential for modeling delayed inflation (to give an example, Burnside, Eichenbaum, and Rebelo, 2001 do not use this approach) but we think that it is helpful.

[5] For instance, Cochrane (2023) emphasizes "the stepping on a rake" effect from Sims (2011) where inflation initially declines and then rises following a monetary policy tightening; the impulse response of inflation is non-monotonic but it is smooth.

Obstfeld (1986) becomes the parallel to models of sovereign default with multiple equilibria à la Calvo (1988), Section I. Section 7 concludes.

## 2 Model

We study a dynamic model, in discrete time, with a continuum of private agents distributed on the unit interval, a central bank, and a fiscal authority.

The fiscal authority issues nominal long-term bonds. Let $B_t$ denote the stock of bonds at the end of period $t$. Let $Q_t$ be the period $t$ price of a bond. Following Woodford (2001), a bond issued in period $t$ pays a nominal coupon $\rho^k$ $k+1$ periods later, for each $k \geq 0$, where $\rho$ is a parameter satisfying $0 < \rho \leq 1$. With this formulation, the bond's yield-to-maturity simply equals $1/Q_t + \rho$. The flow budget constraint of a representative private agent reads

$$Q_t B_t = (1 + \rho Q_t) B_{t-1} + P_t Y_t - P_t C_t - P_t S_t \tag{1}$$

where $Y_t$ is endowment income in period $t$, $C_t$ is consumption, $P_t$ is the price level, and $S_t$ is a lump-sum tax (or transfer, if negative). The flow budget constraint of the public sector, or the government, reads

$$Q_t B_t = (1 + \rho Q_t) B_{t-1} - P_t S_t. \tag{2}$$

Since the model abstracts from money, one can think of the price level as the rate of exchange between bonds and the consumption good.

Optimizing behavior of private agents implies that the following relations hold in equilibrium:

$$\frac{Q_t}{P_t} = E_t \left[ \beta \frac{(1 + \rho Q_{t+1})}{P_{t+1}} \right] \tag{3}$$

and

$$\lim_{T \to \infty} E_t \left[ \beta^T \frac{Q_T B_T}{P_T} \right] = 0. \tag{4}$$

The first equation is the bond-pricing equation, where for simplicity we assume that private agents discount future payoffs with the discount factor $\beta \in (0, 1)$. The second equation is the transversality condition. Solving forward equation (3), the bond price depends on the entire expected path of the price level:

$$Q_t = \sum_{k=1}^{\infty} \beta^k \rho^{k-1} E_t \left[ \frac{P_t}{P_{t+k}} \right]. \tag{5}$$

In addition, it is convenient to define the period $t$ (short-term) nominal interest rate $R_t$ according to the equation

$$\frac{1}{R_t} = E_t \left[ \beta \frac{P_t}{P_{t+1}} \right]. \tag{6}$$

When we solve forward the government flow budget constraint (2), using equilibrium relations (3) and (4), we arrive at the equation stating that in equilibrium the real value of public debt must equal the expected present value of lump-sum taxes, or real primary budget surpluses:

$$\frac{(1 + \rho Q_t) B_{t-1}}{P_t} = \sum_{k=0}^{\infty} \beta^k E_t [S_{t+k}]. \tag{7}$$

We suppose that initially the economy is in a steady state in which monetary policy and fiscal policy are consistent with price stability. Monetary policy picks a price level target $P > 0$, and fiscal policy sets a path for the primary surplus such that equation (7) holds in every period with, on the left-hand side, the price level equal to $P$ and the bond price equal to $Q = \beta / (1 - \beta\rho)$ (this is the solution of equation (3) in the steady state with a constant price level). For simplicity, we assume that fiscal policy sets a time-invariant primary surplus $S > 0$ with this property.

Relative to this baseline, we will study the consequences of an unexpected fiscal imbalance which may or may not be corrected in the future. We consider three alternative specifications of the model: the imbalance is there to stay (Section 3); the imbalance may be corrected with a constant probability in each future period (Section 4); the probability of a correction is decreasing in the necessary size of the correction (Section 5).

## 3 Delaying inflation

In our first specification, there is perfect foresight and once a fiscal imbalance materializes, it will not be corrected. Thus, the imbalance makes the policy of price stability unsustainable. The remaining monetary policy options are "inflation now" and "inflation in the future." Let us describe the two alternatives.[6]

[6] We consider default on public debt in Section 6.

### 3.1 Analytics

In period $t = -1$, the economy is in the steady-state defined at the end of Section 2 with price stability and a primary surplus $S > 0$. In period $t = 0$, there is a one-time unanticipated shock: the primary surplus falls by $\Delta > 0$, that is, the primary surplus equals $S - \Delta$ (we refer to the period 0 primary balance as a deficit, assuming that $S - \Delta < 0$).[7] One can think of the period 0 deficit as being caused by a pandemic, a war, or a deep recession – an event which makes it clear to the society that fiscal needs dominate.

Just before the arrival of the shock, equation (7) reads

$$\frac{(1+\rho Q)\, B_{-1}}{P} = \frac{S}{1-\beta} \tag{8}$$

for some $B_{-1} > 0$ inherited from the past. Upon the arrival of the shock, equation (7) changes to

$$\frac{(1+\rho Q_0)\, B_{-1}}{P_0} = \frac{S}{1-\beta} - \Delta, \tag{9}$$

which fails to hold with *both* $P_0 = P$ and $Q_0 = Q$. Either the policy of price stability must be abandoned in period 0 (unanticipated inflation, $P_0 > P$) or it must be abandoned in a future period $t \geq 1$ (an unanticipated drop in the bond price, $Q_0 < Q$, and delayed inflation). Note that inflation could not be postponed if all debt was short-term ($\rho = 0$), since anticipated future price level movements are priced in when the government issues new debt.[8]

Let $T \geq 0$ denote the period in which the policy of price stability is abandoned. We suppose that from time $T$ onwards monetary policy targets the bond price $Q_t$, or equivalently the interest rate $R_t$. For simplicity, we also assume that, whether $T = 0$ or $T \geq 1$, after price stability is abandoned there will be a one-time jump in the price level as opposed to persistent inflation, that is $P_t = P_T$, $t \geq T$. Thus, monetary policy sets $Q_t = Q$, or equivalently $R_t = 1/\beta$, for $t \geq T$. One could modify the specification of monetary policy to obtain a persistent increase in the nominal interest rate and persistent inflation starting in

[7] We also assume that $\Delta < S/(1-\beta)$.

[8] Even in an economy where all public debt is short-term, there may be government expenditure commitments such as pensions that are imperfectly indexed to the price level. Their real value can be reduced via inflation even when inflation is anticipated.

period $T$.[9]

If the policy of price stability is abandoned in period $T = 0$, equations (8)-(9) imply a simple solution for the equilibrium inflation rate:

$$\frac{P_0}{P} = \frac{\frac{S}{1-\beta}}{\frac{S}{1-\beta} - \Delta}.$$

In this case of "inflation now," equation (9) holds with $Q_0 = Q$. Alternatively, if the policy of price stability is abandoned in a future period $T \geq 1$, equations (8)-(9) imply that the period 0 bond price must satisfy

$$Q_0 = \frac{1}{\rho}\left[(1+\rho Q)\left(\frac{\frac{S}{1-\beta} - \Delta}{\frac{S}{1-\beta}}\right) - 1\right]. \tag{10}$$

In this case of "inflation in the future," equation (9) holds with $P_0 = P$.

Let us solve for the time $T$ price level in the delayed inflation case. If the policy of price stability is abandoned in period $T \geq 1$, then equation (5) implies that the period 0 bond price must satisfy

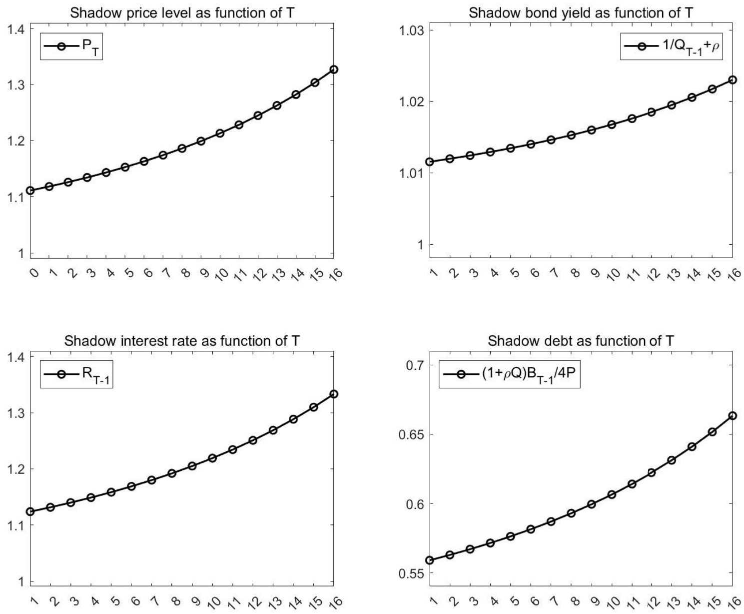
$$Q_0 = \beta\frac{1-(\beta\rho)^{T-1}}{1-\beta\rho} + \frac{\beta^T \rho^{T-1}(P/P_T)}{1-\beta\rho}. \tag{11}$$

Equating expressions (10) and (11) yields a solution for the time $T$ price level, $P_T$, or the inflation rate, $P_T/P$. Two properties of $P_T$ deserve emphasis. First, $P_T$ is increasing in $T$ so that delaying inflation implies *higher* inflation in the future. The reason is that the period 0 bond price $Q_0$ is pinned down by the deficit $\Delta$, independent of $T$ (equation (10)) and in the bond-pricing equation future inflation is discounted (equation (5)). Second, for given $T \geq 1$ and $\Delta$, $P_T$ is decreasing in $\rho$ which implies that longer debt maturity allows lower future inflation. The reason is that with longer debt maturity a given future jump in the price level imposes a larger period 0 capital loss on bondholders.

To solve the rest of the model in the delayed inflation case ($T \geq 1$), from equation (5) we compute the path of the bond price between periods 1 and $T-1$, $Q_t$, $t = 1, \ldots, T-1$ (we already solved for $Q_0$ in the case of $T \geq 1$, and we also know that $Q_t = Q$, $t \geq T$). Given the paths of the bond price and the price level, we use the government flow budget

[9] See Corsetti and Maćkowiak (2006) for the case in which starting in period $T$ monetary policy makes the nominal interest rate react less than one-for-one to the inflation rate, which in equilibrium produces both a price level jump at $T$ and some subsequent growth in the price level.

Figure 2: **Delaying inflation**




Variables from the model in Section 3 as function of $T \geq 0$, the period in which price stability is abandoned.

constraint (2) to compute the path of government debt, $B_t$, $t \geq 0$. In the case of $T \geq 1$, the interest rate in period $T-1$ follows from equation (6), $R_{T-1} = P_T/\beta P$ ($t = T-1$ is the only period in which the interest rate $R_t$ does not equal $1/\beta$).

## 3.2 A numerical example

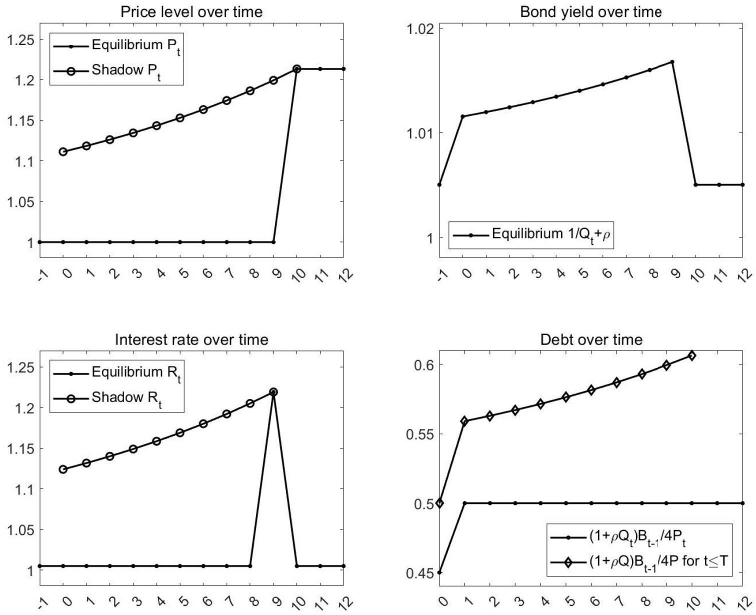
To gain insight, consider a numerical example. One period in the model equals one quarter. We set $\beta = 0.995$, $\rho = 0.95$, and $S = 0.01$, which implies an annual real interest rate of 2 percent, a debt duration of about 20 quarters, and a ratio of debt to annualized GDP of 50 percent in period $-1$ (we think of aggregate income as time-invariant and normalize it to 1 per quarter). We pick $P = 1$ and compute the initial condition $B_{-1} > 0$ from equation (8). We assume $\Delta = 0.2$, which corresponds to a primary deficit equal to 5 percent of annualized GDP.

Figure 2 plots $P_T$, $1/Q_{T-1} + \rho$, $R_{T-1}$, and normalized $B_{T-1}$ *as a function of* $T \geq 0$, *the period in which the policy of price stability is abandoned.* By "normalized $B_{T-1}$" we mean $B_{T-1}$ multiplied by $(1+\rho Q)/4P$; the value of $(1+\rho Q)\,B_{T-1}/4P$ can be compared directly with the debt-to-GDP ratio in the initial steady-state, which equals 0.5 in this parameterization. In analogy to Flood and Garber (1984), one can refer to $P_T$ as the "shadow" price level – this is the price level that would be observed in equilibrium in period $T$, if the policy of price stability were abandoned at $T$. Figure 2 illustrates the property that $P_T$ is increasing in $T$ – the longer the delay, the more inflation there will be. One can show that the shadow price level $P_T$ goes to infinity at a finite $T$.[10] Similarly, $1/Q_{T-1}+\rho$, $R_{T-1}$, and $B_{T-1}$ can be referred to as the shadow bond yield, the shadow interest rate, and the shadow debt. $Q_{T-1}$ and $R_{T-1}$ are simple functions of $P_T$, $Q_{T-1}=Q\,(P/P_T)$ and $R_{T-1}=P_T/\beta P$. The debt ratio $(1+\rho Q)\,B_{T-1}/4P$ keeps growing as the abandonment of price stability is postponed (the lower right-hand panel in Figure 2). This is the case even though there was a *one-time* budget deficit. The reason is that after new debt is issued to finance the deficit, the new debt is being rolled over at a strictly positive net real interest rate. Thus, the fiscal imbalance is growing – as is the size of a hypothetical fiscal correction, or budget surplus, that would be necessary to preserve price stability.

Figure 3 plots the path of the economy assuming, as an example, that the policy of price stability is abandoned at $T=10$. The equilibrium price level equals $P$ through $T-1=9$ and jumps at $T=10$ ($P_t=P$, $t\leq T-1$, $P_t=P_T$, $t\geq T$). The *shadow* price level jumps at $t=0$ and rises gradually through $T=10$. The equilibrium price level and the shadow price level *coincide* at $T=10$. Analogously, the equilibrium interest rate and the shadow interest rate coincide at $T-1=9$ (in equilibrium $R_t=1/\beta$ in every period, except that $R_{T-1}=P_T/\beta P$). The equilibrium bond yield, $1/Q_t+\rho$, rises discretely at $t=0$ and then increases gradually through period 9; it jumps down to $1/Q+\rho$ at $T=10$. The equilibrium real value of debt, $(1+\rho Q_t)\,B_{t-1}/4P_t$, decreases in period 0 (it equals the present value of surpluses, which falls at $t=0$), and returns to 0.5 at $t=1$ as the deficit vanishes. The difference between the equilibrium real value of debt and the debt ratio $(1+\rho Q)\,B_{t-1}/4P$ provides a measure of the fiscal imbalance. Once again, note that the imbalance is growing while inflation is being postponed.

[10] See Corsetti and Maćkowiak (2006), Section 3.3.

Figure 3: **Delaying inflation to $T = 10$**




The economy from Section 3 with $T = 10$ ($T$ is the period in which price stability is abandoned).

## 3.3 Discussion

The delayed inflation scenario, just analyzed, closely resembles the currency crisis model of Krugman (1979). In principle, monetary policy wants to maintain price stability, or a fixed exchange rate, but a fiscal imbalance makes this policy unsustainable. The shadow price level (exchange rate) rises over time. The only question is *when* the policy of price stability, or the exchange rate peg, will be abandoned – in other words, when will the shadow price level coincide with the equilibrium price level?

Krugman famously showed that the timing of devaluation, $T$, was uniquely determined in his model. He assumed that there was no (privately-held) government debt, the central bank started out with a finite stock of international reserves, and it would abandon the exchange rate peg when the reserves fell to zero. There are several equivalent ways to to reproduce Krugman's uniqueness-of-$T$ result in our framework. Specifically, we could assume that there is an upper bound on net debt of the public sector $(1 + \rho Q)\, B_{t-1}/4P$ (a generalization of Krugman's lower bound on reserves, when these can be borrowed) and that price stability is abandoned in the period directly after debt reaches the threshold. Alternatively, as in Corsetti and Maćkowiak (2006), we could assume that there is an upper bound on the interest rate $R_t$ (raising the interest rate "in defense" of price stability is socially costly, because it amounts to raising the real rate of interest in a world with sticky prices) and that price stability is abandoned in the period directly after the interest rate reaches the threshold. Either assumption implies a unique timing of inflation $T$, with $T-1$ as the period of a "speculative attack" in which the interest rate rises in anticipation of the jump in the price level at $T$.[11]

It is also instructive to discuss the relation to the FTPL literature. In the initial steady state, using the language of Leeper (1991), monetary policy is active and fiscal policy is passive. This policy mix is consistent with price stability. In period 0, fiscal policy switches to active and produces a budget deficit. The assumptions of no default on public debt and a constant post-$T$ bond price amount to passive monetary policy.[12] The FTPL literature (see, e.g., Leeper and Leith (2016), Section 2, for a review) recognizes that, with long-term debt and active fiscal policy, passive monetary policy can choose the path of the price level for given fiscal policy. Cochrane (2023) stresses the role of monetary policy in shaping the path of inflation when fiscal policy is active. As noted in the introduction, the literature focuses on models in which inflation responds to a shock smoothly with little delay, whereas here a period of price stability is followed by a delayed jump in the price level.

So far, there is no rationale in the model for delay once the budget deficit materializes, just like in Krugman's model it is unclear why the central bank is losing reserves instead of

[11] See also Corsetti and Maćkowiak (2006), in particular Sections 3.3-3.4, for a more thorough comparison with the Krugman model. Like Krugman, Sargent and Wallace (1981) assume that inflation is fiscally beneficial because growth in the non-interest-paying monetary base produces seigniorage revenue. Fixing a path for the budget deficit and a $T$, they famously show that tighter monetary policy before $T$, and thus lower inflation before $T$, implies higher inflation after $T$. Uribe (2020) points out that if smoothing inflation over time is socially beneficial, then the optimal inflation path in the Sargent-Wallace economy involves a constant, strictly positive inflation rate. In the Sargent-Wallace model, like in the Krugman model, inflation is unavoidable and there is a unique equilibrium.

[12] Another interpretation is that the policy configuration is always "active fiscal policy" and "passive monetary policy," but in the initial steady state the active fiscal policy happens to be consistent with price stability, whereas from period 0 the active fiscal policy is no longer consistent with price stability.

abandoning the exchange rate peg sooner. The next section adds to the model a rationale for delay.

# 4 Gambling to preserve price stability: Krugman (1979) equilibrium

We now introduce the possibility that the fiscal imbalance *may be* corrected in the future, in which case price stability will be preserved. One can think of a potential correction as reflecting a strong recovery from the recession that caused the initial deficit (a strong recovery is *possible*, not a given). In this setting, there may be a reason to wait as the monetary policy choice becomes "inflation now" versus "higher inflation in the future *with some probability*." The policy of delaying inflation amounts to a gamble to avoid inflation altogether – a gamble that may well be worth taking, if the probability of a correction is high enough.

In the rest of the paper, we want to understand the dynamics if monetary policymakers decide to take the gamble. In particular, once we think of delay as potentially justified in terms of buying time for a fiscal correction, it is interesting to ask if expectations of inflation, or expectations of price stability, can become self-fulfilling. In this section, we give an example of an environment where the answer is no, in the spirit of Krugman (1979). In Section 5 we provide another example, which we think is more appealing, where the answer is yes, in the spirit of Obstfeld (1986).

## 4.1 Analytics

Compared with Section 3, we modify the model by assuming that the policy of price stability will be abandoned in period $T \geq 1$ *unless* a fiscal correction has occurred. We model a possible correction as follows. In every period $t = 1, \ldots, T$, nature draws a realization of the primary surplus: with some probability the surplus equals $S + \omega_t > S$, where the value $\omega_t > 0$ is such that the economy returns immediately to the steady state with the price level equal to $P$; and with the complementary probability, the surplus equals $S$. Once the economy is back in the initial steady state or the price level jumps in period $T$, all uncertainty has been resolved. As emphasized in the introduction, future realizations of the surplus are uncertain – there is a chance that the fiscal dominance will be reversed, but there is also a chance that it will not be. It is unimportant whether the high surplus realization, if it occurs, reflects a random shock beyond the control of fiscal policy ("a strong recovery"), or a budgetary consolidation which was uncertain *ex ante* but occurs *as a response* to some non-policy event (e.g., a delayed consolidation in response to the period 0 shock), or a mix of both.

How long will monetary policy wait for a fiscal correction? Recall from the previous section that as inflation is being delayed, the fiscal imbalance is growing. Therefore, the correction or budget surplus necessary to preserve price stability, $S + \omega_t$, is increasing over time. It seems natural to suppose that monetary policy will wait as long as the required correction is not too large – there is a maximum correction that can be achieved, for economic or political-economy reasons, and the policy of price stability will be abandoned when this threshold is reached (and a correction has not occurred thus far). Specifically, we assume that monetary policy follows the rule "$T$ is the first period $t \geq 1$ in which $\omega_t \geq \bar{\omega}$ and a fiscal correction has not occurred," where $\bar{\omega} > 0$ is a constant. In this section, we also suppose that the probability of a correction is independent of the state of the economy and equals a constant, $\psi \in (0, 1)$, in every period $t = 1, \ldots, T$.

We can solve the model for a given time when price stability is abandoned absent a correction, $T \geq 1$, and verify that a unique $T$ is consistent with the policy rule stated in the previous paragraph. To solve the model for a given $T \geq 1$, we proceed backwards from time $T$ to 0. In period $T$, with probability $\psi$ the price level equals $P = 1$ and equation (7) reads $(1 + \rho Q) B_{T-1} = S/(1 - \beta) + \omega_T$. We guess $B_{T-1}$ (we will verify this guess) and we solve this equation for $\omega_T$, which is the fiscal correction necessary for the policy of price stability to become sustainable in period $T$. With probability $1 - \psi$ the price level jumps to $P_T$ pinned down by equation (7), $(1 + \rho Q) B_{T-1}/P_T = S/(1 - \beta)$. We move to period $T - 1$, when from equation (3) the bond price satisfies $Q_{T-1} = \beta (1 + \rho Q) [\psi + (1 - \psi)/P_T]$; thus, the bond price at $T - 1$ depends on the probability of a correction at $T$ and on the magnitude of inflation, if inflation occurs. We compute $B_{T-2}$ from $Q_{T-1} B_{T-1} = (1 + \rho Q_{T-1}) B_{T-2} - S$ (equation (2)). We calculate $\omega_{T-1}$ from $(1 + \rho Q) B_{T-2} = S/(1 - \beta) + \omega_{T-1}$. At this point, we have solved for $P_T$, $Q_{T-1}$, $\omega_T$, $\omega_{T-1}$, and $B_{T-2}$ given a guess about $B_{T-1}$. Period $T-2$ is very similar to $T-1$, except that when solving for $Q_{T-2}$ from equation (3) we use $Q_{T-2} = \beta\left[\psi\left(1+\rho Q\right) + \left(1-\psi\right)\left(1+\rho Q_{T-1}\right)\right]$ which links the bond price at $T-2$ with the bond price at $T-1$. Every period before is exactly analogous, until we arrive at time 0 when we compute $B_{-1}$ from a slightly modified equation (2): $Q_0 B_0 = \left(1+\rho Q_0\right) B_{-1} - S + \Delta$. We have solved for $P_T$, $Q_{T-1}$, …, $Q_0$, $\omega_T$, …, $\omega_1$, $B_{T-2}$, …, $B_{-1}$ given a guess about $B_{T-1}$. If the solution for $B_{-1}$ differs from the actual initial condition $B_{-1}$, we adjust the guess for $B_{T-1}$. We can simulate the path of the economy *either* assuming that a correction never takes place and the price level jumps at $T$ ($S_t = S$, $t = 1, \ldots, T$), *or* assuming that a correction takes place in some period $\tau = 1, \ldots, T$ and the price level never jumps ($S_\tau = S + \omega_\tau$ and $S_t = S$ for $t \neq \tau$).

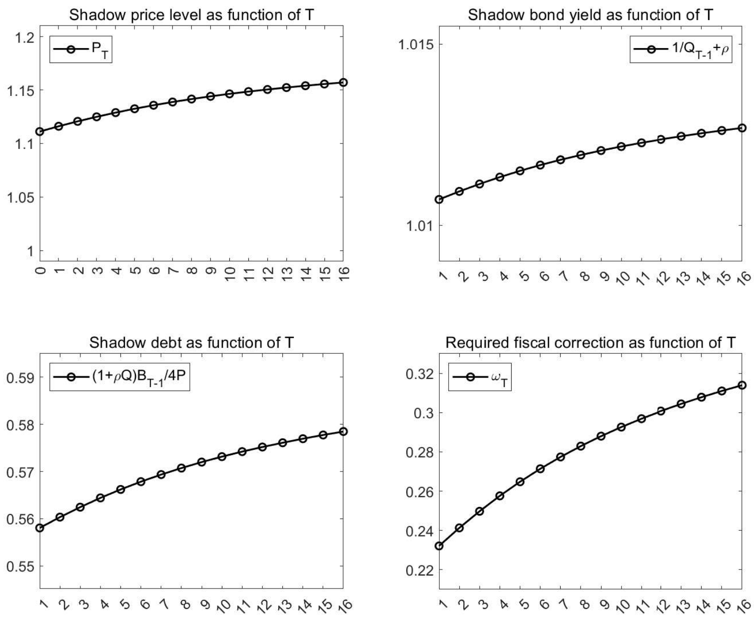
## 4.2 A numerical example

We use the same numerical example as in Section 3, except that now we allow for a random correction with probability $\psi = 0.1$, subject to the constraint on the size of the correction with $\bar{\omega} = 0.3$. Figure 4 plots $P_T$, $1/Q_{T-1} - \rho$, normalized $B_{T-1}$, and $\omega_T$ as a function of $T \geq 0$, the period in which the policy of price stability is abandoned. In this new figure, $P_T$, $1/Q_{T-1} + \rho$, and $\left(1+\rho Q\right) B_{T-1}/4P$ are similar to Figure 2. The difference to Figure 2 is that now the possibility of a correction keeps $P_T$, $1/Q_{T-1}$ and $B_{T-1}$ lower at any given $T$.[13] As already emphasized, the new variable in Figure 4, $\omega_T$, is increasing in $T$ – the budgetary improvement required to eliminate the imbalance is increasing over time. Note that $\omega_T$ starts out slightly greater than 0.2 (the value of $\Delta$), and becomes greater than or equal to 0.3 (the value of $\bar{\omega}$) in period 12, indicating the time when price stability will be abandoned absent a correction.

Figure 5 plots the equilibrium path of the economy in two cases: in case 1, the policy of price stability is abandoned at $T = 12$, which is the equilibrium value of $T$ in this economy; in case 2, the fiscal correction happens to occur in period 12 (in period 12, the surplus drawn by nature equals $S + \omega_{12}$ instead of $S$) and price stability is preserved. Case 2 is just an

[13] With a time-invariant $\psi > 0$ the probability that a correction takes place in period $T \geq 2$ *or sooner* equals $1 - (1-\psi)^T$, which approaches 1 as $T$ goes to infinity.

Figure 4: **Delaying inflation when fiscal correction is possible**

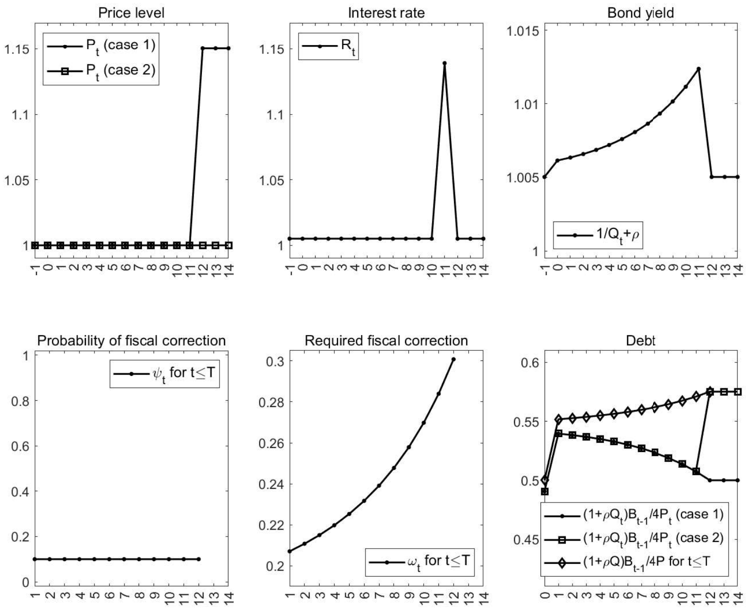



Variables from the model in Section 4 as function of $T \geq 0$, the period in which price stability is abandoned.

example of equilibrium path with a correction (a correction can take place with probability $\psi = 0.1$, shown in Figure 5, in any period $t = 1, \ldots, T$). In case 1, the price level $P_t$ jumps in period 12, while in case 2 the price level remains constant. The interest rate $R_t$ and the bond yield $1/Q_t + \rho$ each follows the same path in case 1 and in case 2. From the figure, note that the equilibrium real value of debt, $(1 + \rho Q_t)\, B_{t-1}/4P_t$, is identical in both cases *until* period $T = 12$. In this period, in case 2 the correction raises the real value of debt relative to case 1 *and* relative to the initial steady state (in case 2, the period 0 deficit is being paid for by the period $T$ surplus, and the period $T$ surplus is greater than the period 0 deficit because the debt issued to finance the deficit has accumulated interest). As in the previous section, the difference between the equilibrium real value of debt and the debt ratio $(1 + \rho Q)\, B_{t-1}/4P$ in the figure provides a measure of the fiscal imbalance. In case 2, the difference falls to zero in period $T$ when the correction eliminates the imbalance.

Let us summarize the insights from this specification of the model. There is a reason to maintain price stability in the near term in the face of a fiscal imbalance – to buy time

Figure 5: **Gambling to preserve price stability: Krugman (1979) equilibrium**




The economy from Section 4: in case 1, price stability is abandoned in period 12; in case 2, the fiscal correction happens to occur in period 12 and price stability is preserved.

for a possible fiscal correction that, if it materializes, will make price stability sustainable indefinitely. Whether or not price stability is preserved depends on luck. If a correction occurs soon enough, the gamble for price stability succeeds. Otherwise, the gamble fails and the economy experiences delayed inflation. For a given sequence of exogenous shocks (nature's draws of the budget surplus), the model predicts a unique outcome. In particular, if inflation does occur in equilibrium, its timing is determinate. Furthermore, by the logic of the previous section, if the gamble fails, the economy experiences *more* inflation than if the policy of price stability had been abandoned in period 0.

### 4.3 Discussion: Krugman (1979) redux

This version of the model, with a possible future fiscal correction, remains in the spirit of Krugman (1979). Yet, going beyond his model, it provides a rationale for why delaying inflation may be an attractive policy or, in the context of a fixed exchange rate, why policymakers may want to postpone abandoning an exchange rate peg for some time in the face of a budget deficit. In further contrast to the Krugman model, price stability may end up being preserved in equilibrium. A key feature of Krugman (1979) remains intact, however – the timing of inflation, absent a fiscal correction, is unique.

Several papers in the FTPL literature (e.g., Davig and Leeper, 2007, Bianchi and Ilut, 2017) study models in which the fiscal-monetary configuration is subject to random changes over time. In this model, fiscal policy becomes active in period 0 but may revert to passive in the future with some probability. And if fiscal policy reverts to passive, the fiscal correction implemented at that time will be sufficient to pay for the period 0 deficit with accumulated interest. By maintaining price stability in the short run, monetary policy buys time for fiscal policy to return to passivity – if that happens, price stability can be preserved indefinitely.[14]

In closing this section, it is worth observing that the model predicts an impact hike in the bond yield (the long-term interest rate) in period 0, as soon as the fiscal imbalance appears; thereafter, the long rate keeps rising as time $T$ approaches. In contrast, the short-term interest rate increases only if and when the economy arrives in period $T-1$. See Figure 5. The prediction that long-term interest rates rise, or the yield curve steepens, soon after a fiscal imbalance materializes may be counterfactual. In the next section, we propose a specification of the model in which this prediction changes.

# 5 Gambling to preserve price stability: Obstfeld (1986) equilibria

We now show that the policy gamble to preserve price stability may expose the economy to multiple equilibria. To highlight the mechanism, we make one change in the model from the previous section. Instead of assuming that the probability of a fiscal correction is independent of the state of the economy, we suppose that the probability of a correction *falls* with the required size of the correction. It seems natural that, as the necessary correction increases over time, achieving it becomes more difficult, and hence less likely.

[14] A subset of the literature (e.g., Davig, Leeper, and Walker, 2010) analyzes the consequences of "a fiscal limit," an assumption similar to the upper bound on the fiscal correction here.

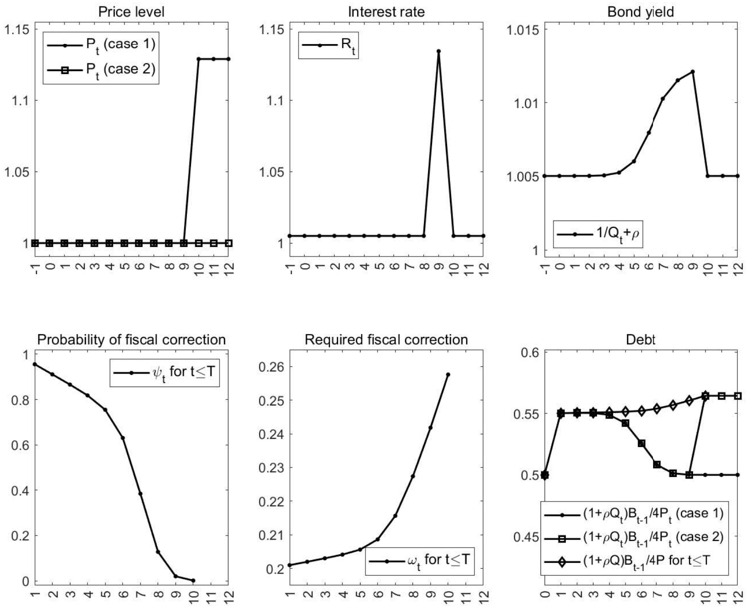
### 5.1 Analytics

Specifically, the model is as in Section 4 except that the probability of a correction is time-varying, $\psi_t \geq 0$, $t = 1, \ldots, T$, and it is a decreasing function of the necessary correction, $\psi_t(\omega_t)$ with $\psi_t'(\cdot) \leq 0$. The solution method is analogous to Section 4: we solve the model for a given time when price stability is abandoned absent a correction, $T \geq 1$, and we find values of $T$ that are consistent with the policy rule "$T$ is the first period $t \geq 1$ in which $\omega_t \geq \bar{\omega}$ and a fiscal correction has not occurred." It turns out that, in general, there are multiple such values in this specification of the model.

The key feature of this economy is that, in contrast to Section 4, *private agents' beliefs affect the probability of a fiscal correction.* This feedback from expectations to the probability of a correction opens the door to multiple equilibria where expectations of inflation, or expectations of price stability, can be self-fulfilling. Consider the economy in period 0 when the fiscal imbalance appears. If private agents are "optimistic," they hold the belief that price stability will be maintained for a long time absent a correction – they think that $T$ is far from 0 ("even if the economy is out of luck for many quarters, price stability will be maintained"). A correction is likely to occur during that long period. Optimism enters the model via equation (3), or equivalently equation (5), which connect the probability of a future correction to the current bond price. If private agents are optimistic, then the bond price is high, and debt issuance is low for a given deficit. As the stock of debt grows slowly, the necessary correction is moderate, and *the probability of a correction is high.* In equilibrium, the optimism is validated and $T$ is much greater tan 0 – delaying inflation buys a lot of time for correcting the fiscal imbalance. However, if private agents are "pessimistic," they hold the belief that price stability will be maintained for a short time absent a correction – they think that $T$ is close to 0. Then the bond price is low, debt issuance is high for a given deficit, the necessary correction is large, and *the probability of a correction is low.* In equilibrium, the pessimism is also validated and $T$ is close to 0 – delaying inflation buys little time for correcting the imbalance.[15]

[15]While in this section we generically find multiple equilibria, in Section 4 we always find a unique equilibrium. In Section 4, a hypothetical shift in private agents' expectations could be expected to change bond prices and thus debt issuance, but the probability of a correction would remain unaffected – a feature which

Figure 6: **Gambling to preserve price stability: An equilibrium with $T = 10$**




The economy from Section 5: in case 1, price stability is abandoned in period 10; in case 2, the fiscal correction happens to occur in period 10 and price stability is preserved.

## 5.2 A numerical example

Let us return to the numerical example from the previous section, except that now we set $\bar{\omega} = 0.25$ (this number is slightly lower compared with $\bar{\omega} = 0.3$ in Section 4). We also suppose that $\psi_t$ is determined by the function $\psi_t(\omega_t) = 1 - erf\left[(\omega_t - \Delta) / \left(\sigma\sqrt{2}\right)\right]$, where $\sigma > 0$ is a parameter, and we set $\sigma = 0.018$.[16] We find three equilibrium values of $T$, $T = 10, 4$, and 2. We simulate the model for each of these equilibrium values of $T$.[17]

Figure 6 plots the equilibrium path of the economy when in period 0 private agents form the belief that $T = 10$. In analogy to Figure 5, we consider two cases: in case 1, price

turns out to be critical for equilibrium determinacy in this model, according to our numerical results.

[16]The error function appearing in the formula is the same as the cumulative distribution function of a truncated normal random variable, so that $\psi_t(\omega_t) = 1$ for $\omega_t = \Delta$ and $\psi_t(\omega_t)$ decreases smoothly to 0 as $\omega_t$ rises away from $\Delta$.

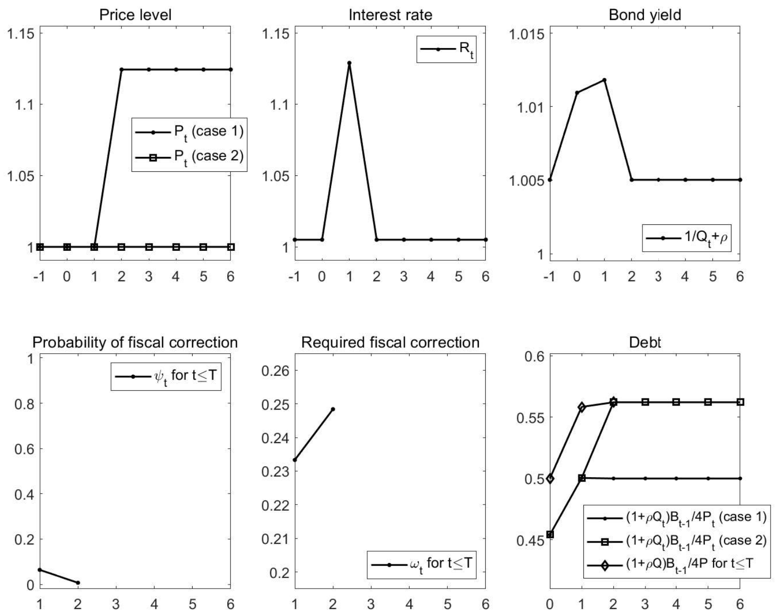
[17]We solve for equilibrium assuming that in period 0 private agents form a belief about $T$ and thereafter stick to that belief. We conjecture that we would find additional equilibria if after period 0 we allowed private agents to change their belief about $T$.

stability is abandoned in period 10; in case 2, the fiscal correction happens to occur in period 10 (in period 10, the surplus drawn by nature equals $S+\omega_{10}$ instead of $S$) and price stability is preserved. As above, case 2 is only one example of equilibrium path with a correction given the belief that $T = 10$ (a correction can take place with probability $\psi_t$, shown in Figure 6, in any period $t = 1, \ldots, T$). To understand Figure 6, note that private agents hold the optimistic belief that price stability will be maintained for 10 quarters absent a correction. The optimism produces a low bond yield $1/Q_t + \rho$, a moderate required correction $\omega_t$, and a probability of a correction $\psi_t$ close to 1 *for several quarters* – remarkably, the bond yield remains essentially unchanged at its initial steady-state level for as long as five quarters after the deficit appears ($t = 0, \ldots, 4$). Thereafter, as the required correction keeps rising steadily, the probability of a correction drops and the bond yield increases. In case 1 (no correction), the price level jumps in period 10. In case 2 (the correction in period 10), the gamble to preserve price stability succeeds at the last possible moment, with the correction eliminating the gap between the equilibrium value of debt and $(1 + \rho Q)\, B_{t-1}/4P$ (the lower right-hand panel in Figure 6).

Figure 7 plots the path of the same economy when in period 0 private agents form the belief that $T = 2$, instead of $T = 10$, in two cases analogous to Figure 6: in case 1, price stability is abandoned in period 2; in case 2, the correction happens to occur in period 2 and price stability is preserved. Now private agents hold the pessimistic belief that price stability will be maintained only for 2 quarters absent a correction. The bond yield jumps sharply *already in period zero*, which quickly raises debt issuance and the required correction by large amounts. As a consequence, the probability of a correction $\psi_t$ falls below 0.1 *already in period one.* In case 1, the policy of price stability does not survive past period 2. In case 2, the economy gets lucky and the correction takes place in period 2.

Figure 8 illustrates the third equilibrium in which in period 0 private agents form the belief that $T = 4$, in the two familiar cases: in case 1, price stability is abandoned in period 4; in case 2, the correction happens to occur in period 4 and price stability is preserved. This is an intermediate situation between Figures 6 and 7, with the probability of a correction $\psi_t$ starting out in period 1 at about 0.5, instead of close to 1 (Figure 6) or close to 0 (Figure

Figure 7: **Gambling to preserve price stability: An equilibrium with $T = 2$**




The economy from Section 5: in case 1, price stability is abandoned in period 2; in case 2, the fiscal correction happens to occur in period 2 and price stability is preserved.

7).[18]

In this specification of the model, whether or not price stability is preserved may depend on private agents' expectations. For the *same* sequence of exogenous shocks (nature's draws of the primary surplus), the gamble to preserve price stability may succeed if private agents expect it to succeed, and it may fail if they expect it to fail. Consider the economy from our numerical example, and suppose that the correction will occur in period $t = 6$ if the policy of price stability is still in place. If private agents are optimistic ($T = 10$), then the policy of price stability is still in place in period 6, the correction occurs, and price stability is preserved. If private agents are pessimistic ($T = 2$) or in the intermediate case ($T = 4$), price stability will be abandoned before the correction can take place.

[18]One can ask if an equilibrium is "stable" in the following sense: if initial debt $B_{-1}$ is lowered, do debt $B_t$ and the bond yield $1/Q_t + \rho$ fall in every subsequent period $t = 0, \ldots, T-1$? It turns out that the answer is "yes" for the "optimistic" equilibrium with $T = 10$ and for the "pessimistic" equilibrium with $T = 2$, and "no" for the intermediate equilibrium with $T = 4$.

The timing of inflation, in the absence of a correction, also depends on expectations: inflation occurs with a delay of 2 quarters in the equilibrium with $T = 2$ and with a delay of 4 quarters in the equilibrium with $T = 4$, for the same realization of the random state of the economy over time.

Finally, this version of the model predicts that, if private agents are optimistic, long-term interest rates may not change perceptively for several quarters, even though everyone knows that there may be inflation in the future. The reason is that, for some time, the probability of inflation is very small if private agents are optimistic. Both this empirical prediction about long rates and the assumption that the probability of a correction depends on the state of the economy seem more realistic compared with Section 4.

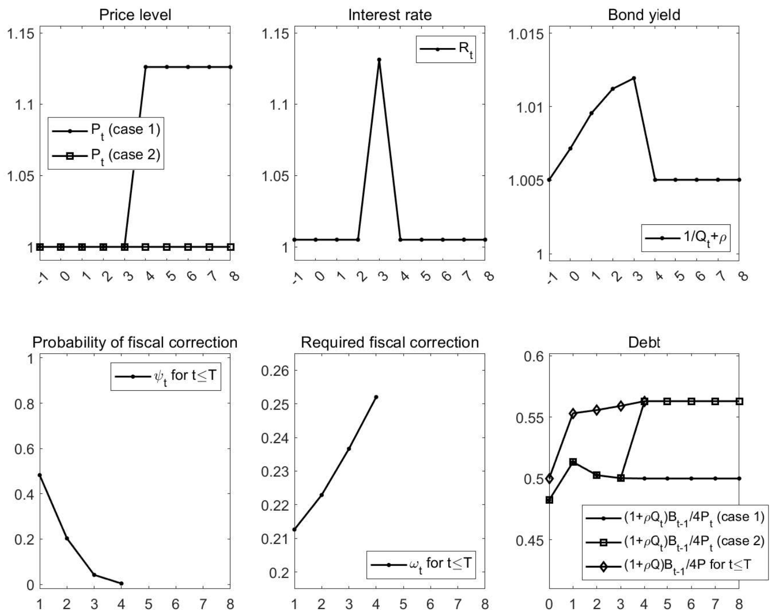
While expectations of price stability help win the policy gamble, luck continues to matter in this economy. Even if initially inflation expectations are anchored and long-term interest rates remain low for a considerable time, the economy may experience an unfavorable sequence of shocks, and it may end up with higher inflation than if the policy of price stability had been abandoned without delay.

### 5.3 Discussion: Obstfeld (1986) redux

In the previous sections, we drew a parallel between our model and the currency crisis model of Krugman (1979). In this section, we examined our preferred specification in which private agents' beliefs affect the probability of a fiscal correction. This version closely resembles Obstfeld (1986) and his subsequent work on rational and self-fulfilling currency crises. In the words of Obstfeld (1996), p. 1039, "speculation against a currency creates objective economic conditions that make liability devaluation more likely" – in terms of this model, unanchored inflation expectations raise the required size of a fiscal correction, and thereby increase the chance that price stability will be abandoned. Furthermore, "even sustainable currency pegs may be attacked and even broken" (Obstfeld, 1996, p. 1038) – here, the policy of price stability may fail if private agents expect it to fail, and it may continue if they expect it to continue. The gamble to preserve price stability is vulnerable to a shift in expectations.

In Obstfeld (1986), a speculative attack directly triggers a shift in policy from price

Figure 8: **Gambling to preserve price stability: An equilibrium with $T = 4$**




The economy from Section 5: in case 1, price stability is abandoned in period 4; in case 2, the fiscal correction happens to occur in period 4 and price stability is preserved.

(exchange rate) stability to an inflationary regime, whereas in the absence of an attack the fixed exchange rate policy continues. In later work, Obstfeld modeled explicitly the feedback from beliefs to the state of the economy and from the state of the economy to policy. For example, in Obstfeld (1996) he showed that multiple equilibria can be ranked by the degree of market skepticism in the policy of currency stability, and by the resulting worsening of the state of the economy conditional on that policy remaining in place. Furthermore, he demonstrated that different equilibria entail different probabilities of the policy's collapse. The model in this section shares both features with Obstfeld (1996), as we just described.

From the perspective of the FTPL literature, the model provides an example in which a policy regime switch (here, from active back to passive fiscal policy) reflects the state of the economy and it may or may not occur in equilibrium depending on private agents' expectations. Maćkowiak (2007) solves a dynamic stochastic model in which a similarly endogenous switch from passive to active fiscal policy causes a currency crisis, noting the possibility of multiple equilibria, although his model includes only short-term debt. Bassetto and Miller (2022) study a three-period model in which private agents are imperfectly informed about future fiscal policy and can pay to acquire information. Bassetto and Miller analyze an equilibrium in which, in the second period, agents do not acquire information and the price level remains stable, and another equilibrium in which agents acquire information and inflation results – thus, inflation can be delayed until the third period if agents remain uninformed in the second period.

# 6 Gambling to avoid default

The model can be reinterpreted as a model of default on public debt instead of inflation. The gamble to preserve price stability with multiple equilibria à la Obstfeld (1986) then becomes the gamble to avoid default with multiple equilibria à la Calvo (1988), Section I.

## 6.1 A reinterpretation of the model

Suppose that the price level is exogenously fixed at $P = 1$. Then the analysis of the model goes through unchanged provided that we introduce a new variable, the "recovery rate" for each private agent on a bond in period $t \geq 0$, $0 < \theta_t \leq 1$, and assume that the recovery rate satisfies $\theta_t = 1/P_t$, where $P_t$ is the period $t$ price level from the model in Sections 2-5. It may be helpful to note that private agents' optimality condition (3) then becomes

$$Q_t = E_t \left[ \beta \left( 1 + \rho Q_{t+1} \right) \theta_{t+1} \right]$$

while the intertemporal government budget constraint, equation (7), reads

$$\left( 1 + \rho Q_t \right) \theta_t B_{t-1} = \sum_{k=0}^{\infty} \beta^k E_t \left[ S_{t+k} \right].$$

Delayed inflation becomes delayed partial default in this version of the model, with the timing and size of the haircut the same as in the case of the price level jumps in Sections 3-5. By the logic of Sections 4-5, conditional on a fiscal imbalance in period 0, it may be worthwhile to delay default in order to buy time for a possible fiscal correction that would make default avoidable. The gamble to avoid default may succeed or fail depending on private agents' expectations, exactly like in Section 5.[19]

[19] One could think of the sovereign borrower as deciding how long to wait for a correction, or one could think of the central bank which can "backstop" the sovereign borrower as deciding how long to provide the

## 6.2 Discussion: Calvo (1988) redux

Under the interpretation as a model of default, Section 5 closely resembles the model of sovereign default with multiple equilibria in Calvo (1988), Section I. Default may occur or may be avoided for the same sequence of exogenous shocks, depending on private agents' expectations – a conclusion very much in Calvo's spirit. His insight that multiple equilibria arise naturally in the market for defaultable sovereign debt has recently been refined by Corsetti and Dedola (2016), Ayres et al. (2018), Lorenzoni and Werning (2019), and Corsetti and Maeng (2020), among others.[20] Our dynamic model with long-term debt is close to Lorenzoni and Werning (2019). Default can be "a slow moving crisis" here similar to their work (think of the equilibrium with $T = 10$ in the numerical example in Section 5 in the case when a fiscal correction fails to materialize and default occurs with a delay of 10 quarters).

Uribe (2006) studies a "fiscal theory of sovereign risk" related to the FTPL. He analyzes a scenario similar to the delayed adjustment case in Section 3 in which partial default is postponed, noting the relation between the time of default and the haircut. In his model, default is unavoidable (like in Section 3) and there are no multiple equilibria.

The version of the model with default instead of inflation may be especially relevant for countries with significant foreign-currency-denominated public debt. One can also envision a version of the model in which *both* inflation and default can occur in parallel, absent a fiscal correction – the self-fulfilling feedback between private agents' beliefs and policy would remain. This specification would be particularly appropriate to discuss the role of the central bank in providing a monetary backstop to government bonds – see Corsetti and Dedola (2016) for a model with optimizing fiscal and monetary authorities. The recent euro area sovereign debt crisis has spurred theoretical and applied work on this issue.

backstop.

[20] Calvo (1988), Section II, studies a model of inflation with multiple equilibria, and therefore one may argue that Section 5 of our model with inflation is in the spirit of Obstfeld (1986) *and* Calvo (1988), Section II. See Corsetti and Dedola (2016) on the role of the cost of inflation in that section of Calvo's paper.

# 7 Conclusions

We studied a model of adjustment to a fiscal imbalance. The imbalance may be corrected in the future, which gives policymakers a reason to gamble that no adjustment will ever be necessary. The policy gamble may well be worth taking, but it exposes the economy to a self-fulfilling shift in expectations that precipitates inflation or default.

We think that this basic insight is likely to hold up in models with optimizing policymakers. An optimizing fiscal authority may want to postpone adjustment to a budget deficit in a recession if the probability of a strong bounce-back is high enough, because the costs of a budgetary consolidation are lower when the economy is growing than in a recession. An optimizing monetary authority may accept the option of "no inflation today, and inflation in the future *with some probability*" if there is a fixed cost of inflation (implied by the risk of unanchoring of long-term inflation expectations) and if the probability of a budgetary consolidation is high enough. An outstanding challenge to the literature is how to model such trade-offs explicitly, both in a social planner's problem and in a game between policy authorities.

We are writing at the time when inflation has surged. How can one interpret this outcome from the perspective of the model? The model focuses on the possible consequences of budget deficits for inflation, abstracting from the effects of supply chain problems and energy price hikes – such factors could explain, and justify, a departure from price stability for some time even in the absence of budget deficits. Keeping this in mind, one interpretation of the recent experience based on the model is that during the COVID-19 pandemic in 2020-21 policymakers took the gamble to preserve price stability, and the gamble has been lost due to bad luck – we are past time $T$ (and supply chain problems and energy price hikes may be seen as part of "the bad luck" in the gamble taken primarily to buy time for fiscal policy). The policy challenge now is to ensure that the adjustment will involve mostly a one-time jump in the price level, without very persistent inflation. Another interpretation is that a part of the gamble may still be ongoing. The economy experienced multiple very bad shocks, and we can think of each shock as triggering a revision of the required adjustment and the terminal date $T$. So far long-term inflation expectations have remained fairly well anchored, but in the future they may yet become unanchored. The bond market's reaction to the announcement of the "mini-budget" by Liz Truss's government in the United Kingdom in 2022 reminds us that an unanchoring can occur suddenly – and the model cautions that an unanchoring may be self-fulfilling.

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