A Fiscal Theory of Sovereign Risk: Expanded Version*

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First draft October 12, 2001
This draft November 9, 2003

Abstract

Under certain monetary-fiscal regimes the risk of default and thus the emergence of sovereign risk premiums are inevitable. This paper argues that in this context even small differences in the specification of monetary policy can have enormous effects on the equilibrium behavior of default rates and risk premiums. Under some monetary policy rules studied, the conditional expectation of default rates and sovereign risk premiums are constant, so movements in these variables always arrive as a surprise. Under other monetary regimes considered, the equilibrium default rate and the sovereign risk premium are serially correlated and therefore forecastable. The paper also studies the consequences of delaying default. It characterizes environments under which procrastinating on default is counterproductive. ***JEL* classification:** E6, F4.

Keywords: Default, Country Risk, Public Debt.

*I would like to thank for comments Stephanie Schmitt-Grohé, an anonymous referee, and seminar participants at Cornell University, New York University, Rutgers University, Duke University, Indiana University, Georgetown University, Columbia University, the London School of Economics, the University of Illinois, the University of North Carolina, the European Central Bank, the International Monetary Fund, the conference "Sovereign Debt in the 21st Century," held at the Federal Reserve Bank of Dallas on November 6-9, 2003, the 2002 meeting of the Society for Economic Dynamics (New York, NY), and the International Monetary Fund. Newer versions of this paper are maintained at http://www.econ.duke.edu/∼uribe.

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1 Introduction

Certain monetary-fiscal arrangements are incompatible with price stability and government solvency. Consider, for example, the case of a country with a chronic fiscal deficit and an independent central bank. Suppose that the central bank's policy is to peg the price level (or the exchange rate). Under such a monetary regime, the government cannot use the price level as an absorber of negative fiscal shocks. By sticking to a price level target, the government gives up its ability to inflate away part of the real value of public debt via surprise inflation in response to sudden deteriorations of the fiscal budget. Under these circumstances, default on the public debt is inevitable.[1]

Policy regimes of this type under which debt repudiation is under certain states of the world the only possible outcome are not unheard of. A point in case is the recent debt crisis in Argentina. Between 1991 and early 2002, Argentina pegged the domestic price of tradables to the US counterpart by fixing the peso/dollar exchange rate. Abandoning the exchange-rate peg was never an easy option for the Argentine government. For the peg was instituted by a law of Congress—the 1991 Convertibility Law—which required the enactment of another law to be deactivated. In 2001, in the midst of a prolonged recession, many began to doubt the government's ability to curb fiscal imbalances. These fears placed the country risk premium, measured by the interest-rate differential between Argentine and U.S. dollar-denominated bonds of similar maturities, over 1,800 basis points, among the world's highest at the time. Eventually, the Argentine government defaulted. First on interest obligations, in December of 2001, and shortly thereafter on the principal.

Price level targeting is not the only monetary arrangement under which pressures for default can arise under certain fiscal scenarios. Consider the case of a central bank that aggressively pursues an inflation target by setting the nominal interest rate as an increasing function of inflation with a reaction coefficient larger than unity. This type of policy rule is often referred to as a Taylor rule after John Taylor's (1993) seminal paper. Suppose that, at the same time, the fiscal authority follows an active stance whereby it does not adjust the primary deficit to ensure intertemporal solvency. Under this policy mix, if the government refrains from defaulting, then price stability is in general unattainable. In particular, the equilibrium rate of inflation converges to either plus or minus infinity. Loyo (1999) refers to the latter equilibrium as a 'fiscalist hyperinflation.' Given this monetary-fiscal regime, default is a necessary consequence if price stability is to be preserved. An example of the policy regime described here is given by Brazil. Since mid 1999, the Brazilian central bank

[1] Krugman's (1979) celebrated model of balance of payments crises is an example in which the aforementioned incompatibility is resolved by abandoning the price stability goal.

has been actively using the interest rate as an instrument to target inflation. Although in recent years fiscal discipline has been enhanced, the Brazilian Treasury is facing serious difficulties implementing additional fiscal reforms necessary to slowdown the rapid growth in public debt. Interestingly, a growing number of observers are beginning to consider a 'unilateral restructuring' of Brazil's public debt as a likely way out of hyperinflation.[2]

The fact that given a particular fiscal policy many different monetary regimes can inevitably be associated with default should not be surprising—for the same reasons why high-fiscal-deficit countries that do not default should be expected to suffer from habitual inflation. A less obvious question is how precisely the equilibrium distributions of default rates and country risk premiums are affected by the particular monetary policy in place. This paper argues that even small differences in the specification of monetary policy can have enormous effects on the equilibrium behavior of default rates and risk premiums.

The analysis is centered around two canonical policy arrangements. Under both environments fiscal policy is assumed to be 'active' in the sense of Leeper (1991). Specifically, real primary surpluses are assumed to be exogenous and random. In one of the policy regimes considered, the central bank pegs the price level. In the other, the monetary authority follows a Taylor-type interest-rate feedback rule.

Our characterization of equilibrium under default reveals that the properties of the equilibrium stochastic process followed by the default rate and the sovereign risk premium depend heavily upon the underlying monetary policy regime. For example, in the Taylor-rule economy, although the government defaults regularly, the expected default rate and the country risk premium are zero. This means that the default rate is unforecastable. By contrast, in the price-targeting economy the equilibrium default rate is serially correlated. Moreover, in this case current and past fiscal deficits predict future default rates.

But even within each of the classes of regimes described above variations in the precise description of the monetary policy can induce dramatic changes in the equilibrium behavior of default rates. For example, if the Taylor rule is assumed to respond to a measure of expected future inflation rather than current inflation, then the inflation target can be attained—i.e., inflationary expectations can be successfully anchored at the target level—without having to default. It is in this sense that we conclude that, the details of monetary policy appear to matter a great deal for default outcomes.

The paper also studies the consequences of delaying default. Understandably, having to default is a situation no policymaker wishes to be involved in. So procrastination is com-

[2]See, for example, the articles by Ted Truman (former assistant secretary of the Treasury for international affairs) published in the *Financial Times* on June 25, 2002, and by Joaquín Cottani (chief economist of Lehman Brothers) published in the Argentine newspaper *La Nación* on June 23, 2002. See also the June 29, 2002 issue of *The Economist*.

monplace. Sometimes governments choose to let go of their price stability goal temporarily in the hopes of inflating their way out of default. A natural question, therefore, is what standard general equilibrium models tell us about the consequences of delaying default. We find that substituting a temporary increase in inflation for default is not always possible. Specifically, we identify environments in which postponing the decision to default leads to a hyperinflationary situation that in order to be stopped requires an eventual default of larger dimension than the one that would have taken place had the government not chosen to procrastinate.

The analysis in this paper departs from a large existing literature on sovereign debt in that here the government is assumed to be able to commit to its promises and, given the monetary and fiscal regimes, it always chooses to honor its financial obligations if it can.[3]

Throughout the paper, it is assumed that public debt is nonindexed. In practice this is typically not the case. A large fraction of emerging market debt in the form of bonds is denominated in foreign currency or stipulates returns tied to some domestic price index. However, in many developing countries a large amount of non-bond government liabilities are not index. Examples of such obligations include social security debt and transfers related to entitlement programs, such as health and unemployment insurance. Moreover, in many of these countries public employment plays the role of a covered source of unemployment insurance. In conjunction these non-dollarized, often implicit, public liabilities represent a quantitatively important part of the fiscal revenue associated with inflationary finance. In effect, Burnside, Eichenbaum, and Rebelo (2003), study government finance in the wake of currency crises. They analyze data from three recent episodes: Mexico, 1994; Korea, 1997; and Turkey, 2001. They find that for all three countries debt deflation is a more important source of government income than seignorage. Also, they report that declines in the dollar value of transfers were the single most significant source of government revenue in Mexico and Korea. In any event, introducing indexation does not affect the qualitative results of the paper. But it does introduce quantitative differences. This is because the more pervasive indexation is, the larger are the price level changes necessary to obtain a given decline in government's total liabilities.[4]

The remainder of the paper is organized in six sections. Section 2 presents the model. Section 3 characterizes the equilibrium behavior of default and sovereign risk when monetary policy takes the form of a Taylor rule. Section 4 analyzes the consequences of delaying default. Section 5 studies default and country risk under a price-level peg. Section 6 closes the paper.

[3] See Eaton and Fernández (1995) for a survey of the literature on sovereign debt with strategic default.

[4] Even if the totality of public debt was indexed, changes in the price level would still introduce fiscal effects in the presence of fiat money. In this paper we do away with money for analytical simplicity.

2 The Model

Consider an economy populated by a large number of identical households, each of which has preferences described by the utility function

$$E_t \sum_{t=0}^{\infty} \beta^t U(c_t), \tag{1}$$

where c_t denotes consumption of a perishable good, U denotes the single-period utility function, $\beta \in (0,1)$ denotes the subjective discount factor, and E_t denotes the mathematical expectation operator conditional on information available in period t. The function U is assumed to be increasing, strictly concave, and continuously differentiable.

Each period households are endowed with an exogenous and constant amount of perishable goods y and pay real lump-sum taxes in the amount τ_t. Households have access to a complete set of nominal state-contingent claims. Specifically, let r_{t+1} denote the stochastic nominal discount factor such that the price in period t of a random payment D_{t+1} in period $t+1$ is $E_t r_{t+1} D_{t+1}$. The flow budget constraint of the household in period t is then given by:

$$P_t c_t + E_t r_{t+1} D_{t+1} + P_t \tau_t \quad \leq \quad D_t + P_t y, \tag{2}$$

where P_t denotes the price level. The left-hand side of the budget constraint represents the uses of wealth: consumption spending, purchases of contingent claims, and tax payments. The right-hand side displays the sources of wealth: the payoff of contingent claims acquired in the previous period and the endowment. In addition, the household is subject to the following borrowing constraint that prevents it from engaging in Ponzi schemes:

$$\lim_{j \to \infty} E_t q_{t+j} D_{t+j} \geq 0, \tag{3}$$

where q_t is given by

$$q_t = r_1 r_2 \dots r_t,$$

with $q_0 \equiv 1$.

The household chooses the set of processes $\{c_t, D_{t+1}\}_{t=0}^{\infty}$, so as to maximize (1) subject to (2) and (3), taking as given the set of processes $\{P_t, r_{t+1}, \tau_t\}_{t=0}^{\infty}$ and the initial condition D_0. Let the Lagrange multiplier on the flow budget constraint of period t be $\beta^t \lambda_t / P_t$. Then the first-order conditions associated with the household's maximization problem are (2) and

(3) holding with equality and

$$U_c(c_t) = \lambda_t \tag{4}$$

$$\frac{\lambda_t}{P_t} r_{t+1} = \beta \frac{\lambda_{t+1}}{P_{t+1}}. \tag{5}$$

The interpretation of these optimality conditions is straightforward. Condition (4) states that the marginal utility of consumption must equal the marginal utility of wealth, λ_t, at all times. Equation (5) represents a standard pricing equation for one-step-ahead nominal contingent claims. Note that $E_t r_{t+1}$ is the period-t price of an asset that pays one unit of currency in every state of period $t+1$. Thus $E_t r_{t+1}$ represents the inverse of the gross risk-free nominal interest rate. Formally, letting R_t^f denote the gross risk-free nominal interest rate between periods t and $t+1$, we have

$$R_t^f = \frac{1}{E_t r_{t+1}}. \tag{6}$$

2.1 The Fiscal Authority

The government levies lump-sum taxes, τ_t, which are assumed to follow an exogenous, stationary, stochastic process. At some points for simplicity we will further specialize the law of motion of τ_t to an AR(1) process of the form:

$$\tau_t - \bar{\tau} = \rho(\tau_{t-1} - \bar{\tau}) + \epsilon_t, \tag{7}$$

where $\bar{\tau}$ denotes the unconditional expectation of τ_t, the parameter $\rho \in [0, 1)$ denotes the serial correlation of τ_t, and $\epsilon_t \sim N(0, \sigma_\epsilon^2)$ is an i.i.d. random innovation. In period t, the government issues nominal bonds, denoted B_t, that pay a gross nominal interest rate R_t in period $t+1$. The interest rate R_t is known in period t. Government bonds are risky assets. For each period the fiscal authority may default on a fraction δ_t of its total liabilities. The government's sequential budget constraint is then given by

$$B_t = R_{t-1} B_{t-1}(1 - \delta_t) - \tau_t P_t; \quad t \geq 0,$$

with $R_{-1}B_{-1}$ given. A focal point of our analysis is the characterization of the equilibrium distribution of the default rate δ_t.

2.2 Equilibrium

In equilibrium the goods market must clear. That is,

$$c_t = y.$$

The fact that in equilibrium consumption is constant over time implies, by equation (4), that the marginal utility of wealth λ_t is also constant. In turn, the constancy of λ_t implies, by equation (5), that r_{t+1} collapses to

$$r_{t+1} = \beta \frac{P_t}{P_{t+1}}.$$

This expression and equation (6) then imply that in equilibrium the nominally risk free interest rate R_t^f is given by

$$R_t^f = \beta^{-1} \left[E_t \frac{P_t}{P_{t+1}} \right]^{-1}. \tag{8}$$

Because all households are assumed to be identical, in equilibrium there is no borrowing or lending among them. Thus, all asset holdings by private agents are in the form of government securities. That is,

$$D_t = R_{t-1} B_{t-1} (1 - \delta_t),$$

at all dates $t \geq 0$.

Optimizing households must be indifferent between holding government bonds and state contingent bonds. This means that the following Euler equation must hold:

$$\lambda_t = \beta R_t E_t (1 - \delta_{t+1}) \frac{P_t}{P_{t+1}} \lambda_{t+1}.$$

We are now ready to define an equilibrium.

Definition 1 *A rational expectations competitive equilibrium is a set of processes* $\{P_t,\ B_t,\ R_t,\ R_t^f, \delta_t\}_{t=0}^{\infty}$ *satisfying*

$$1 = \beta R_t^f E_t \frac{P_t}{P_{t+1}}; \qquad R_t^f \geq 1 \tag{9}$$

$$1 = \beta R_t E_t (1 - \delta_{t+1}) \frac{P_t}{P_{t+1}} \tag{10}$$

$$B_t = R_{t-1} B_{t-1} (1 - \delta_t) - P_t \tau_t \tag{11}$$

$$\lim_{j \to \infty} \beta^{t+j+1} E_t R_{t+j} (1 - \delta_{t+j+1}) \frac{B_{t+j}}{P_{t+j+1}} = 0, \tag{12}$$

and monetary and fiscal policies, given $R_{-1} B_{-1}$ *and the exogenous process for lump-sum* *taxes* $\{\tau_t\}_{t=0}^{\infty}$.

Multiplying the left- and right-hand sides of equilibrium condition (11) by $R_t(1-\delta_{t+1})$ and iterating forward j times one can write

$$\begin{aligned} R_{t+j}B_{t+j}(1-\delta_{t+j+1}) &= \left(\prod_{h=0}^{j} R_{t+h}(1-\delta_{t+h+1})\right) R_{t-1}B_{t-1}(1-\delta_t) \\ &\quad - \sum_{h=0}^{j}\left(\prod_{k=h}^{j} R_{t+k}(1-\delta_{t+k+1})\right) P_{t+h}\tau_{t+h} \end{aligned}$$

Divide both sides by P_{t+j} to get

$$\begin{aligned} R_{t+j}\frac{B_{t+j}}{P_{t+j+1}}(1-\delta_{t+j+1}) &= \left(\prod_{h=0}^{j} R_{t+h}(1-\delta_{t+h+1})\frac{P_{t+j}}{P_{t+j+1}}\right) R_{t-1}\frac{B_{t-1}}{P_t}(1-\delta_t) \\ &\quad - \sum_{h=0}^{j}\left(\prod_{k=h}^{j} R_{t+k}(1-\delta_{t+k+1})\frac{P_{t+k}}{P_{t+k+1}}\right) \tau_{t+h} \end{aligned}$$

Apply the conditional expectations operator E_t on both sides of this expression, use the equilibrium condition (10), and apply the law of iterated expectations to get

$$E_t R_{t+j}\frac{B_{t+j}}{P_{t+j+1}}(1-\delta_{t+j+1}) = \beta^{-j-1}R_{t-1}\frac{B_{t-1}}{P_t}(1-\delta_t) - \sum_{h=0}^{j}\beta^{h-j-1}E_t\tau_{t+h}.$$

Now multiply both sides of this equation by β^j, take the limit for $j\to\infty$, and use equilibrium condition (12) to obtain

$$\delta_t = 1 - \frac{\sum_{h=0}^{\infty}\beta^h E_t\tau_{t+h}}{R_{t-1}B_{t-1}/P_t}; \quad t \geq 0. \tag{13}$$

This expression, describing the law of motion of the equilibrium default rate, is quite intuitive. It states that the default rate is zero—that is, the government honors its outstanding obligations in the full extent—when the present discounted value of primary surpluses is expected to be equal to the real value of total initial government liabilities. In this case, the government does not need to repudiate its commitments because it is able to raise enough surpluses in the future to pay the interest on its existing real obligations. The government defaults on its debt whenever the present discounted value of primary fiscal surpluses falls short of total real initial liabilities. The extent of the default—i.e., how close δ_t is to one—depends on the gap between real government liabilities and the present value of future expected tax receipts. Note that in computing the present discounted value of fiscal surpluses the real risk-free interest rate is applied, which in equilibrium coincides with the inverse of the subjective rate of discount, $1/\beta$.

If one sets the default rate to zero, this expression collapses to the central equation of the fiscal theory of price level determination (Cochrane, 1998; Sims, 1994; Woodford, 1994). In that literature, the above expression determines the equilibrium price level.

Inspection of equation (13) might lead one to believe that the task of characterizing the equilibrium behavior of the default rate δ_t should be a trivial matter if one knows—from the fiscal theory of the price level, say—the equilibrium path of the price level when the default rate is set to zero at all times. That is, letting P_t^{FTPL} denote the equilibrium price level when δ_t is restricted to be zero for all t, one might conclude that equation (13) implies that any path for P_t and δ_t satisfying $P_t/(1-\delta_t) = P_t^{FTPL}$ could be supported as an equilibrium outcome. But this is not the case. The reason is that equation (13) is not the only equilibrium restriction that P_t and δ_t must satisfy. The model features other equilibrium conditions where P_t and δ_t do not enter in the precise way in which they appear in equation (13).

Using the AR(1) process assumed for τ_t (equation (7)), the above expression becomes

$$\delta_t = 1 - \frac{(1-\beta)(\tau_t - \bar{\tau}) + (1-\beta\rho)\bar{\tau}}{R_{t-1}B_{t-1}/P_t(1-\beta)(1-\beta\rho)}; \quad t \geq 0. \tag{14}$$

Intuitively, this expression shows that given the level of initial real government liabilities, $R_{t-1}B_{t-1}/P_t$, the more persistent is the tax process—i.e., the larger is ρ—the larger is the default on public debt triggered by a given decline in current tax revenues.

But neither equation (13) nor equation (14) represent a full characterization of the equilibrium default rate. For those equations also include the endogenous variable P_t, whose equilibrium behavior has not yet been worked out. Further analysis is therefore in order. We carry out this task in the following sections.

3 Taylor Rules and Default

In the past two decades, monetary policy in industrialized countries has taken the form of an interest-rate feedback rule whereby the short term nominal interest rate is set as a function of inflation and the output gap (Taylor, 1993; and Clarida et al., 1998). Moreover, estimates of this feedback rule feature a slope with respect to inflation that is significantly above unity, typically around 1.5. More recently, a number of developing countries, notably Brazil, have adopted similar active interest-rate rules with the objective of targeting inflation. We therefore wish to consider a monetary regime characterized by a linear feedback rule of the form:[5]

$$R_t = R^* + \alpha \left(\frac{P_t}{P_{t-1}} - \pi^* \right). \tag{15}$$

We assume that monetary policy is active in the sense of Leeper (1991), that is, that $\alpha\beta > 1$. Given available estimates for α and β, this restriction is clearly empirically plausible.

3.1 Impossibility of Achieving the Inflation Target Without Defaulting

Can the government ensure an inflation path equal or close to the target π^* without ever resorting to default? The answer to this question is no. To see why, suppose that the government sets

$$\delta_t = 0; \quad t \geq 0. \tag{16}$$

In this case, the complete set of equilibrium conditions is given by (15), (16), and the equations contained in definition 1. Equations (13) and (16) imply that P_0 is given by

$$P_0 = \frac{R_{-1} B_{-1}}{\sum_{h=0}^{\infty} \beta^h E_0 \tau_h}.$$

The numerator on the right-hand side of this expression is predetermined in period 0. The denominator is determined in period 0, but is exogenously given. This means that in general P_0/P_{-1} will be different from π^*; that is, the equilibrium inflation rate in period zero will in general be off target. Furthermore, as time goes by, the deviation of inflation from target will in general increase without bounds. Specifically, the equilibrium features either hyperinflation or hyperdeflation. To establish this result, assume for simplicity that taxes are non-stochastic. Let $\pi_t \equiv P_t/P_{t-1}$ denote the gross inflation rate in period t. Then combining equations (10) and (15) we obtain the following difference equation in π_t:

$$\pi_{t+1} = \alpha\beta\pi_t + (1 - \alpha\beta)\pi^*.$$

In deriving this expression we set $R^* = \pi^*/\beta$, to ensure that the inflation target π^* is a steady-state solution to the above difference equation. It follows by the fact that $\alpha\beta > 1$, that if $\pi_0 > \pi^*$ then $\pi_t \to \infty$. In this case, the economy embarks on a hyperinflation. Loyo (1999) refers to this equilibrium as a 'fiscalist hyperinflation,' and argues that the monetary/fiscal regime that gives rise to these dynamics was in place in Brazil during the high inflation episode of the early 1980s.

[5]Note that we do not include a term depending on the output gap because in the endowment economy considered here the output gap is nil at all times.

On the other hand, if $\pi_0 < \pi^*$, then $\pi_t \to -\infty$, and the economy falls into a hyperdeflation. Of course, the inflation rate cannot converge to minus infinity because in that case, according to the linear monetary policy rule (15), the nominal interest rate would reach a negative value in finite time, which is impossible. It can be shown that the zero bound on the nominal interest rate implies that when $\pi_0 < \pi^*$, the economy converges to a 'liquidity trap,' characterized by low and possibly negative inflation and low and possibly zero nominal interest rates (Schmitt-Grohé and Uribe, 2000; and Benhabib, Schmitt-Grohé, and Uribe, 2001 and 2002).

3.2 Unforecastability of the Default Rate

It follows from the preceeding analysis that if the government is to preserve price stability (i.e., if it is to succeed in attaining the inflation target π^*), then it must default sometimes. It turns out that if δ_t is allowed to be different from zero, then the government can indeed ensure a constant rate of inflation equal to π^*. That is, the monetary authority can set

$$\frac{P_t}{P_{t-1}} = \pi^*; \quad t \geq 0. \tag{17}$$

This expression along with the Taylor rule (15) and the equations listed in definition 1 represent the complete set of equilibrium conditions. Equations (15) and (17) imply that $R_t = R^* = \pi^*/\beta$ for all $t \geq 0$. (We are again assuming that $R^* = \pi^*/\beta$.) The Euler equation (9) then implies that

$$E_t \delta_{t+1} = 0; \quad t \geq 0.$$

This means that the equilibrium default rate in effect in period $t+1$ is unforecastable in period t. The exact equilibrium process followed by δ_t can be obtained with the help of equation (13). Evaluating that expression at $t = 0$, yields

$$\delta_0 = 1 - \frac{\pi^* \sum_{h=0}^{\infty} \beta^h E_0 \tau_h}{R_{-1} B_{-1}/P_{-1}}. \tag{18}$$

The numerator on the right-hand side of this expression is exogenously given. At the same time, the denominator is predetermined in period 0. So the above equation fully characterizes the equilibrium default rate in period 0. The default rate is increasing in the initial level of real government liabilities and decreasing in the expected present discounted value of future primary surpluses.

In periods $t > 0$, equation (13) and the fact that $R_{t-1} = \pi^*/\beta$ imply that the default rate is given by

$$\delta_t = 1 - \frac{\beta \sum_{h=0}^{\infty} \beta^h E_t \tau_{t+h}}{B_{t-1}/P_{t-1}}; \quad t \geq 1. \tag{19}$$

In this expression, B_{t-1}/P_{t-1} is an endogenous variable, which we want to express in terms of exogenous variables. To this end, note that equation (11) implies that

$$\frac{B_{t-1}}{P_{t-1}} = \frac{R_{t-2}B_{t-2}}{P_{t-1}}(1-\delta_{t-1}) - \tau_{t-1}; \quad t \geq 1.$$

Using equations (18) and (19) to eliminate $\frac{R_{t-2}B_{t-2}}{P_{t-1}}(1-\delta_{t-1})$ from this expression yields

$$\frac{B_{t-1}}{P_{t-1}} = \beta \sum_{h=0}^{\infty} \beta^h E_{t-1}\tau_{t+h}; \quad t \geq 1.$$

In turn, using this formula to eliminate B_{t-1}/P_{t-1} from (19) we obtain the following expression for the equilibrium default rate:

$$\delta_t = 1 - \frac{\sum_{h=0}^{\infty} \beta^h E_t \tau_{t+h}}{\sum_{h=0}^{\infty} \beta^h E_{t-1} \tau_{t+h}}; \quad t \geq 1.$$

This equation states that in any period $t > 0$, the government defaults when the present discounted value of primary fiscal surpluses is below the value expected for this variable in period $t-1$. That is, the government defaults in response to unanticipated deteriorations in expected future tax receipts. Note that the fact that δ_t has mean zero implies that sometimes—when $\delta_t < 0$—the government subsidizes bond holders. It is straightforward to show that if one departs from the assumption that $R^* = \pi^*/\beta$ and assumes instead that $R^* > \pi^*/\beta$, then an equilibrium in which the inflation rate is always equal to the target ($\pi_t = \pi^*$) still exists and $E_t\delta_{t+1} = 1 - \pi^*/(\beta R^*) > 0$.[6] The assumption $R^* > \pi^*/\beta$ could capture a situation in which the government overestimates the real interest rate $1/\beta$. Of course, if one assumes that $R^* < \pi^*/\beta$, then the conditional expectation of the default rate is negative. A more direct and perhaps also more realistic approach is to impose a nonnegativity constraint on the default rate δ_t. The appendix analyzes ways to implement

[6] In this case, the Taylor rule (15) implies that the equilibrium interest rate is constant and equal to R^*. In turn, the Euler equation (10) implies that the conditional expectation of the default rate in period $t+1 > 0$ given information available in t is given by $E_t\delta_{t+1} = 1 - \pi^*/(\beta R^*) > 0$. It is easy to show that the equilibrium default rate in period 0 is still given by equation (18), while the default rate in periods $t > 0$ is given by $\delta_t = 1 - \frac{\pi^*}{\beta R^*} \frac{\sum_{h=0}^{\infty} \beta^h E_t \tau_{t+h}}{\sum_{h=0}^{\infty} \beta^h E_{t-1} \tau_{t+h}}$. Note that, ceteris paribus, the default rate is decreasing in the inflation target π^* and increasing in the interest rate target R^*. The intuition behind this result is straightforward. The ratio R^*/π^* denotes the real interest rate promised by the government. The higher is this interest rate, the higher is the cost of serving the debt without defaulting.

this restriction.

Because in this economy the inflation rate is constant over time, the Euler equation (9) implies that the risk-free nominal interest rate is constant and given by $R_t^f = \pi^*/\beta$. But this is precisely the equilibrium value taken by the rate of return on (risky) government bonds. Therefore, the gross sovereign risk premium, given by the ratio of the rate of return on public debt to the risk-free rate, R_t/R_t^f, is constant and equal to unity.

3.3 A Forward-Looking Taylor Rule

To illustrate the extent to which the equilibrium behavior of default rates depends upon the specifics of monetary policy, we now consider a variation of the Taylor-type interest-rate feedback rule in which the central bank's objective is to anchor inflation expectations as opposed to current inflation. Specifically, we consider the following forward-looking Taylor rule

$$R_t = R^* + \alpha \left(\frac{1}{E_t \frac{P_t}{P_{t+1}}} - \pi^* \right), \tag{20}$$

where, as before, $R^* \equiv \pi^*/\beta$ and $\alpha\beta > 1$. This latter parameter restriction implies that the central bank maintains an active stance. Note that the argument of the Taylor rule is taken to be $1/E_t[P_t/P_{t+1}]$ rather than simply $E_t[P_{t+1}/P_t]$. The assumed specification allows us to derive a closed form solution of the model. But both specifications deliver identical equilibrium dynamics up to first order.

Suppose now that the fiscal authority refrains from defaulting at all times, or

$$\delta_t = 0; \quad t \geq 0.$$

We wish to establish that in equilibrium the central bank achieves its inflation target at all dates. This equilibrium is in sharp contrast to that obtained under the current-looking Taylor rule, which, in general features either a hyperinflation or a hyperdeflation. In effect, when $\delta_t = 0$ for all t, equation (10) and the Taylor rule (20) yield

$$R_t = \frac{\pi^*}{\beta}$$

and

$$\frac{1}{E_t[P_t/P_{t+1}]} = \pi^*.$$

So, the monetary authority attains its target at all times and the nominal interest rate is constant. These two expressions and equations (11) and (13) imply that

$$P_0 = \frac{R_{-1}B_{-1}}{\sum_{h=0}^{\infty} \beta^h E_0 \tau_h}$$

$$\frac{P_t}{P_{t-1}} = \pi^* \frac{\sum_{h=0}^{\infty} \beta^h E_{t-1} \tau_{t+h}}{\sum_{h=0}^{\infty} \beta^h E_t \tau_{t+h}}; \quad t \geq 1.$$

According to this formula, deviations of inflation from the target π^* are unforcastable and equal to the innovation in the present discounted value of primary surpluses.

4 The Perils of Delaying Default: Unpleasant Default Arithmetics

Thus far, we have considered only two alternative default policies. One is characterized by no default at any point in time and leads to (fiscalist) hyperinflation or hyperdeflation depending on initial conditions. The second default policy ensures a path for prices consistent with the government's inflation target and features a stochastic, unforecastable default rate.

But there are indeed infinitely many other possible default arrangements. Here we focus on one that captures certain aspects of observed pre-default dynamics in emerging markets. Namely, in practice, governments that follow unsustainable policies tend to procrastinate. Only when the economy is clearly embarked on an explosive path, such as a hyperinflation, do governments dare to make hard decisions, such as defaulting or introducing drastic spending cuts. An example is the pre-default dynamics in Argentina in the second half of 2001. A number of observers believed at the time that under the policy arrangement prevailing at the end of the De la Rua-Cavallo administration, which can be described as a rigid peg to the dollar coupled with a precarious fiscal stance, default was simply a matter of time.[7] At the end, this sentiment materialized and the Argentine government repudiated its outstanding financial obligations. The default was implemented in two steps. First, in December of 2001 the government defaulted partially via a debt swap featuring a unlateral reduction in interest payments. Shortly thereafter the government completely suspended debt service. After the default, Argentina fell into an unprecedented depression and prices began to accelerate rapidly. The ensuing economic collapse led many observers to wonder whether the Argentine government had waited too long to default. The focus of this section is to show that when a policy mix is incompatible with long-run price stability, unpleasant

[7]See, for example, the commentaries on Argentina published in *The Economist* on October 20-26, 2001, and The Washington Post, on October 22, 2001.

default arithmetics might arise. Specifically, delaying default may prove counterproductive for two reasons. First, the longer a government waits to default, the higher is the inflation rate the economy is exposed to. Second, the longer is the delay, the higher is the default rate required to stabilize prices. To illustrate this point, consider a perfect-foresight environment and suppose that the government decides to delay default for $T > 0$ periods. That is, the fiscal authority sets

$$\delta_t = 0; \quad 0 \leq t < T. \tag{21}$$

In period T, the government finally decides to default in a magnitude sufficient to ensure price stability. Formally, in periods $t \geq T$ the default rate is set in such a way that

$$\pi_t = \pi^*; \quad t \geq T. \tag{22}$$

In this case, a rational expectations equilibrium is given by definition 1 and equations (15), (21), and (22). Because the default rate is zero before period T, the Euler equation (10) implies that

$$R_t = \beta^{-1}\pi_{t+1}; \quad t \leq T-2. \tag{23}$$

Combining this expression with the Taylor rule (15) we get $\pi_{t+1} = \pi^* + \alpha\beta(\pi_t - \pi^*)$ for $0 \leq t \leq T-2$, where we are assuming that $R^* \equiv \pi^*/\beta$. This expression implies the following pre-default time path for inflation

$$\pi_t = \pi^* + (\alpha\beta)^t(\pi_0 - \pi^*); \quad 0 \leq t \leq T-1. \tag{24}$$

In turn, assuming that $\tau_t = \bar{\tau}$ for all t, equations (13) and (21) imply that the initial inflation rate is exogenously given by $\pi_0 = R_{-1}B_{-1}(1-\beta)/(P_{-1}\bar{\tau})$. We are interested in the case

$$\pi_0 > \pi^*.$$

This assumption and equation (24) show that the longer the government waits to default—i.e., the larger is T—the higher is the inflation rate the public must endure.

In period $T-1$, the Taylor rule (15) states that $\beta R_{T-1} = \pi^* + \alpha\beta(\pi_{T-1} - \pi^*)$. Combining this expression with equation (24) yields

$$\beta R_{T-1} = \pi^* + (\alpha\beta)^T(\pi_0 - \pi^*). \tag{25}$$

Finally, in period T the stabilization policy kicks in, so $\pi_T = \pi^*$. The Euler equation (10) evaluated at $t = T-1$ then implies that $\delta_T = 1 - \pi^*/(\beta R_{T-1})$. Combining this expression with equation (25) yields the following solution for the default rate in period T:

$$\delta_T = 1 - \frac{\pi^*}{\pi^* + (\alpha\beta)^T(\pi_0 - \pi^*)}.$$

This expression shows that the longer the government procrastinates, the larger is the rate of default necessary to bring about price stability. In the limit, as $T \to \infty$, the government is forced to default on the entire stock of public debt. Note that the government defaults only once, in period T. In periods $t \geq T$, the Taylor rule (15) implies that $R_t = \pi^*/\beta$, so that, by the Euler equation (10), $\delta_t = 0$. Summarizing, we have that if the government delays default for T periods, then

$$\lim_{T\to\infty} \pi_{T-1} = \infty,$$

and

$$\lim_{T\to\infty} \delta_T = 1.$$

The intuition why a government that procrastinates for too long ends up defaulting on its entire obligations is simple. If the government puts off default for a sufficiently long period of time, the inflation rate in period $T-1$ climbs to a level far above its intended target π^*. As a result, the Taylor rule prescribes a very high nominal interest rate in that period. In period T, the inflation rate drops sharply to its target π^*. This means that the 'promised' (i.e., before default) real interest rate on government assets held between periods $T-1$ and T, given by R_{T-1}/π^*, experiences a drastic hike, generating a severe solvency problem, which the government resolves by defaulting.

Surprisingly, in this economy the stock of real public debt provides no indication of worsening fundamentals as the economy approaches the default crisis. In effect, the stock of public real debt, $b_t \equiv B_t/P_t$, remains constant along the entire transition. To see this, note that the government's budget constraint implies that $b_0 = R_{-1}b_{-1}/\pi_0 - \bar{\tau}$. Using the fact that $\pi_0 = R_{-1}B_{-1}(1-\beta)/(P_{-1}\bar{\tau})$, we obtain

$$b_0 = \beta\bar{\tau}/(1-\beta).$$

At the same time, in periods $0 < t \leq T-1$ we have that $b_t = R_{t-1}b_{t-1}/\pi_t - \bar{\tau} = b_{t-1}/\beta - \bar{\tau}$. (In the second equality we are using the fact that $\delta_t = 0$ for $t < T$, so that by the Euler equation (10) $R_t = \pi_{t+1}/\beta$.) Then, assuming that $b_{t-1} = \beta\bar{\tau}/(1-\beta)$, we have that $b_t = \frac{\beta\bar{\tau}}{1-\beta}$. It follows, by induction, that

$$b_t = \frac{\beta\bar{\tau}}{1-\beta}; \quad 0 \leq t \leq T-1.$$

Note that the fact that the default rate is zero between periods 0 and $T-1$ implies that the interest-rate premium on public debt is zero between periods 0 and $T-2$. In period $T-1$ the premium jumps up to $(1-\delta_T)^{-1}-1$. Finally, in period T the premium returns to zero and remains at that level thereafter. However, in a model were the date T at which the government decides to 'pull the plug' is random, the interest rare premium will in general be positive for all $0 < t < T$.

5 Price Level Targeting

We now turn our attention to another example of a monetary regime that, if not coupled with some sort of (intertemporal) balanced budget rule, can make default inevitable. Namely, price level pegs.[8] By pegging the price level, the government gives up its ability to inflate away part of the real value of its liabilities in response to negative fiscal shocks. It is therefore clear that short of endogenous regular fiscal instruments able to offset such exogenous fiscal innovations, default emerges as a necessary outcome. As in the previous section, we are interested in characterizing the equilibrium process of the default rate under these circumstances. It turns out that given the fiscal regime, the equilibrium default rate behaves quite differently under a price level peg than under a Taylor rule.

Formally, the monetary regime we wish to study in this section is given by:

$$P_t = 1; \quad t \geq 0. \tag{26}$$

Note that the constancy of the price level implies, by equation (9), that the risk-free interest rate is constant and equal to the inverse of the subjective rate of discount. That is,

$$R_t^f = \beta^{-1}. \tag{27}$$

We can then formally define an equilibrium as folows:

Definition 2 (Rational Expectations Equilibrium Under Price Level Targeting) *A rational expectations competitive equilibrium is a set of processes* $\{B_t, R_t, \delta_t\}_{t=0}^{\infty}$ *satisfying*

$$1 = \beta R_t E_t(1-\delta_{t+1}) \tag{28}$$

$$B_t = R_{t-1}B_{t-1}(1-\delta_t) - \tau_t \tag{29}$$

[8] In open economies, governments interested in pegging the price level typically resort to pegging the exchange rate between the domestic currency and that of a low-inflation country. Recent examples include Argentina, Austria, and Hong-Kong.

$$\lim_{j\to\infty} E_t \beta^{t+j+1} R_{t+j} B_{t+j}(1-\delta_{t+j+1}) = 0.$$

and a fiscal-policy constraint further restricting the behavior of the default rate, given $R_{-1}B_{-1}$ and the exogenous process for lump-sum taxes $\{\tau_t\}_{t=0}^{\infty}$.

5.1 The Equilibrium Stock of Public Debt

Setting $P_t = 1$ in equation (13), we obtain the following expression for the equilibrium default rate:

$$\delta_t = 1 - \frac{\sum_{h=0}^{\infty} \beta^h E_t \tau_{t+h}}{R_{t-1}B_{t-1}} \tag{30}$$

Note that because the price level is constant and normalized at one, the denominator on the right-hand side, $R_{t-1}B_{t-1}$, represents both nominal and real total government liabilities. It will prove convenient to write the above expression using the specific AR(1) process assumed for taxes. This yields

$$\delta_t = 1 - \frac{(1-\beta)(\tau_t - \bar{\tau}) + (1-\beta\rho)\bar{\tau}}{R_{t-1}B_{t-1}(1-\beta)(1-\beta\rho)}. \tag{31}$$

To obtain the equilibrium level of public debt, evaluate equation (30) at time $t+1$ and take expectations conditional on information available at time t. Then use equation (28) to eliminate $E_t\delta_{t+1}$ to get

$$B_t = \sum_{h=1}^{\infty} \beta^h E_t \tau_{t+h}. \tag{32}$$

According to this expression, the government's ability to absorb debt is dictated by the expected value of future tax receipts. Note that the level of debt is independent of the magnitude of liabilities assumed by the government in the past, $R_{t-1}B_{t-1}$. Under the assumed first-order autorregressive structure of taxes, the above expression becomes

$$B_t = \frac{\beta\rho(1-\beta)(\tau_t - \bar{\tau}) + \beta(1-\beta\rho)\bar{\tau}}{(1-\beta)(1-\beta\rho)}. \tag{33}$$

By this formula, a given decline in current tax revenues obliges the government to engineer a larger cut in public debt the more persistent is the tax process.

5.2 Impossibility of Pegging the Price Level Without Defaulting

Evaluating equation (30), which describes the law of motion of the equilibrium default rate, at $t = 0$, we obtain

$$\delta_0 = 1 - \frac{\sum_{h=0}^{\infty} \beta^h E_0 \tau_h}{R_{-1}B_{-1}}.$$

In period 0, the government cannot affect any of the variables entering the right-hand side of this expression. In effect, taxes are assumed to be exogenous, and initial total public liabilities are pre-determined. Consequently, the government has no control over the initial rate of default δ_0. A negative initial tax shock leads inevitably to default. It follows that it is impossible to fix δ_0 equal to zero.

A natural question is whether the government has the ability to arbitrarily fix the level of the default rate (at zero, say) in all periods following period 0. The answer to this question is no. To see why, assume, contrary to our contention, that the government is capable of setting δ_t at a constant level $\bar{\delta}$ for all $t > 0$. Then, evaluating (31) at $t+1$ we have that R_t is implicitly given by

$$\bar{\delta} = 1 - \frac{(1-\beta)(\tau_{t+1} - \bar{\tau}) + (1-\beta\rho)\bar{\tau}}{R_t B_t (1-\beta)(1-\beta\rho)}$$

On the right-hand side, τ_{t+1} is measurable with respect to the information set available in period $t+1$ and B_t is measurable with respect to information available in t. It follows that according to the above expression, R_t is measurable with respect to information available in $t+1$, which is a contradiction, because, by assumption, the government announces R_t in period t. It follows that the government cannot fix the rate of default for all $t > 0$.

Although the government is unable to perfectly control the dynamics of the default rate, it can affect it on a limited basis. This is the focus of what follows.

5.3 Default Rule 1

Consider, for example, a policy rule whereby in each period $t > 0$ the government does not default unless the tax-to-debt ratio falls below a certain threshold. Specifically, suppose that the government restricts δ_t in the following way:

$$\textbf{Default Rule 1:} \qquad \delta_t \begin{cases} > 0 & \text{if } \tau_t/B_{t-1} < \alpha \\ = 0 & \text{if } \tau_t/B_{t-1} = \alpha \\ < 0 & \text{if } \tau_t/B_{t-1} > \alpha \end{cases} \qquad t = 1, 2, \ldots, \tag{34}$$

where the threshold α is chosen arbitrarily by the fiscal authority. In this case, a rational expectations equilibrium is given by this expression and definition 2. According to the above rule, the government defaults on part of the public debt when the tax-to-debt ratio τ_t/B_{t-1} is below the announced threshold α. This situation takes place in periods of relatively low tax realizations. On the other hand, when the tax-to-debt ratio exceeds the threshold α, the government chooses to reward bond holders by implementing a subsidy proportional to the size of their portfolios.

The default rule (34) can be implemented by an appropriate choice of the interest rate promised on public debt, R_t. To see this, consider any period $t > 0$ in which $\tau_t = \alpha B_{t-1}$. In such periods, the equilibrium condition (29) becomes

$$B_t = R_{t-1}B_{t-1} - \alpha B_{t-1}.$$

Using equation (33) to eliminate B_t we obtain

$$\frac{\beta\rho(1-\beta)(\alpha B_{t-1} - \bar{\tau}) + \beta(1-\beta\rho)\bar{\tau}}{(1-\beta)(1-\beta\rho)} = R_{t-1}B_{t-1} - \alpha B_{t-1}.$$

Solving this expression for the interest rate, yields

$$R_t = \alpha + \frac{\beta\rho(1-\beta)(\alpha B_t - \bar{\tau}) + \beta(1-\beta\rho)\bar{\tau}}{B_t(1-\beta)(1-\beta\rho)}; \quad t = 0, 1, \ldots$$

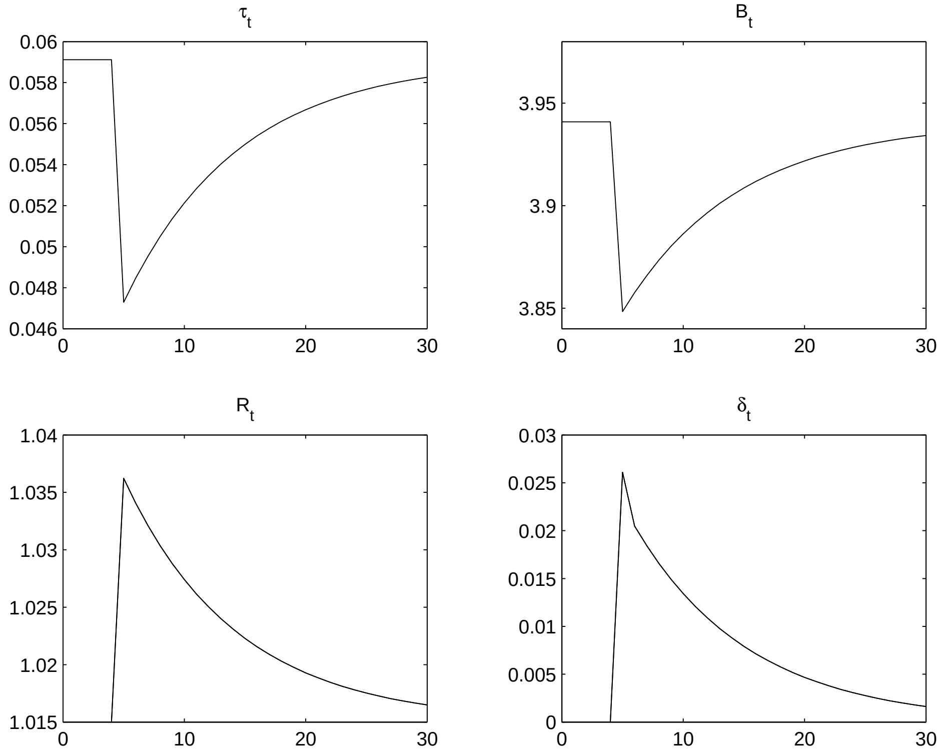
This expression and equation (33), which expresses B_t as a function of τ_t only, jointly describe the equilibrium law of motion of the interest rate as a function of current taxes. Combining the above expression with equation (31) to eliminate R_t, we find that the equilibrium default rate in periods $t > 0$ is given by

$$\delta_t = 1 - \frac{(1-\beta)(\tau_t - \bar{\tau}) + (1-\beta\rho)\bar{\tau}}{\alpha(1-\beta)(1-\beta\rho)B_{t-1} + \beta\rho(1-\beta)(\alpha B_{t-1} - \bar{\tau}) + \beta(1-\beta\rho)\bar{\tau}}.$$

Figure 1 illustrates how the model economy operates under default rule 1. It depicts the equilibrium dynamics of taxes, public debt, the interest rate, and the default rate in response to a negative tax innovation. The model is parameterized as follows. The time period is meant to be one quarter. The subjective discount factor β is set equal to $1/(1 + .06/4)$, which implies an annual real (and nominal) interest rate of 6 percent. Quarterly output, y, is normalized at unity. The initial level of government liabilities, $R_{-1}B_{-1}$, is set at 4, implying a debt-to-annual-GDP ratio of one. The average tax rate, $\bar{\tau}$ is set at $(1-\beta)R_{-1}B_{-1}$, so that if the tax rate in period zero equals its unconditional expectation $\bar{\tau}$, then the equilibrium default rate in that period is zero. The serial correlation of taxes, ρ, is assumed to be 0.9. Finally, we set the threshold α equal to $(1-\beta)/\beta$. This value implies that the government chooses to default whenever the tax-to-debt ratio is below its long-run level $(1-\beta)/\beta$.

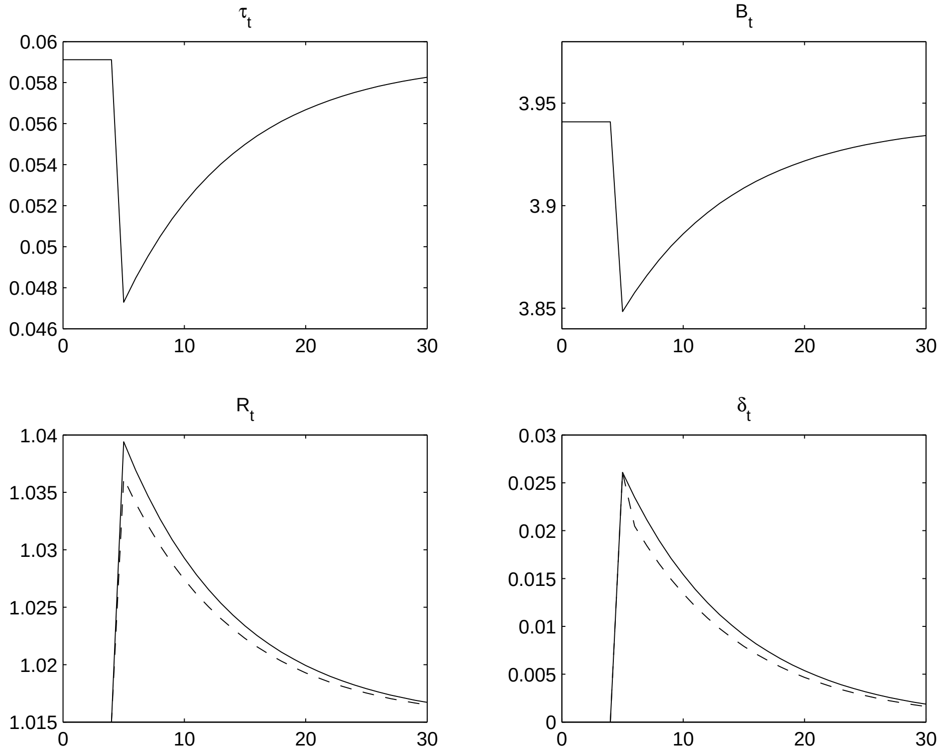
The initial situation depicted in the figure is one in which taxes are equal to their long-run level $\bar{\tau}$. In period 5, the economy experiences a negative tax surprise. Specifically, in that period taxes fall 20 percent below average; that is, $\epsilon_5 = -0.2\bar{\tau}$, or $\tau_5 = 0.8\bar{\tau}$. Tax innovations after period 5 are nil (i.e., $\epsilon_t = 0$ for $t > 5$). Note that the fact that the realizations of the

Figure 1: Equilibrium Dynamics Under Default Rule 1



tax innovation are zero in periods other than period five (($\epsilon_t = 0$ for $t \neq 5$) does not mean that the economy operates under certainty for $t \neq 5$. This is because in any period $t \geq 0$ agents are uncertain about future realizations of ϵ. Between periods 0 and 4, the tax-to-debt ratio is at its long-run level. As a result, the government honors its obligations in full ($\delta_t = 0$ for $t \leq 4$). In period 5, in response to the 20 percent decline in tax revenue, the government defaults on about 2.5 percent of the public debt. Because the tax-to-debt ratio remains below its long-run level along the entire transition, the government continues to default after period 5. The cumulative default, given by $\sum_{t=5}^{\infty} \delta_t$, is about 23 percent. Before period 5, the interest rate on public debt equals the risk-free rate of 1.5 percent reflecting no default expectations ($E_t \delta_{t+1} = 0$). In period 5, the interest rate on government bonds jumps to 3.6 percent and then returns monotonically to its steady-state level of 1.5 percent. The fact that the risk-free interest rate is constant (Eq. (27)) implies that the sovereign risk premium, R_t/R_t^f, is proportional to R_t. Thus, a deterioration in fiscal conditions triggers a persistent increase in sovereign risk.

Figure 2: Equilibrium Dynamics Under Default Rule 2



——- Default Rule 2 - - - - Default Rule 1

5.4 Default Rule 2

As a second example, consider a default rule whereby the government defaults only if the tax rate is below a certain fraction of output. Formally,

$$\textbf{Default Rule 2:} \qquad \delta_t \begin{cases} > 0 & \text{if } \tau_t < \alpha y \\ = 0 & \text{if } \tau_t = \alpha y \\ < 0 & \text{if } \tau_t > \alpha y \end{cases} \qquad t = 1, 2, \ldots, \tag{35}$$

where α is a parameter chosen by the government, and y is the constant endowment. The full set of equilibrium conditions is then given by the above rule and the equations listed in definition 2. It is easy to show that under this rule the interest rate on public debt is given by,

$$R_t = \frac{\alpha}{B_t} + \frac{\beta\rho(1-\beta)(\alpha y - \bar{\tau}) + \beta(1-\beta\rho)\bar{\tau}}{B_t(1-\beta)(1-\beta\rho)}; \quad t = 0, 1, \ldots$$

Figure 2 displays the model's dynamics under default rule 2. The parameterization of the model is identical to that used under rule 1, except for α, which is now set equal to $\bar{\tau}/y$ so as to induce pre-shock dynamics identical to those depicted in figure 1. The experiment shown in figure 2 is the same as the one implemented under rule 1. Namely, the tax innovation ϵ_t is 0 for all $t \neq 5$ and is equal to $-0.20\bar{\tau}$ in period 5, so that in that period tax revenues fall by 20 percent. For comparison, figure 1 reproduces with broken lines the dynamics under rule 1. The dynamics under both rules are qualitatively identical. The interest rate and the default rate rise in period 5 and then converge monotonically to their respective steady states. However, the convergence is somewhat faster under default rule 1. To see why this is the case, note that in periods $t > 5$ the tax-to-output ratio τ_t/y is relatively further below its steady state level than the tax-to-debt ratio, τ_t/B_{t-1}. This is because the stock of public debt adjusts down in response to the tax cut, whereas output remains constant.

5.5 Default Rule 3: An Interest Rate Peg

As a final example, consider the case of a peg of the rate of return on public debt. Specifically, assume that the government sets the interest rate on public debt equal to the risk-free interest rate. That is,

$$R_t = R_t^f = \beta^{-1}. \tag{36}$$

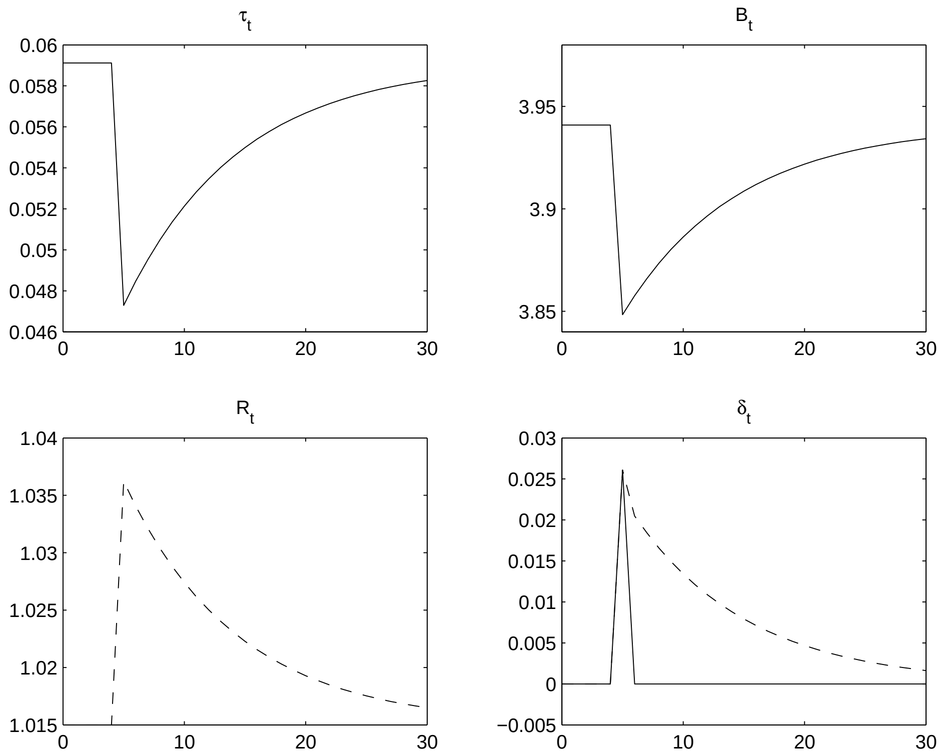
According to this policy, the government completely eliminates the sovereign risk premium. In this case the equilibrium is given by definition 2 and the above rule.

Contrary to what happens under rules 1 and 2, under the interest rate peg considered here the equilibrium default rate is an iid random variable with mean zero. That is, the default rate is completely unforecastable. To see this, combine the interest-rate rule (36) with the Euler equation (28) to get

$$E_t \delta_{t+1} = 0.$$

Figure 3 depicts the model's dynamics under the assumed interest rate peg. For comparison, the figure also reproduces the dynamics implied by default rule 1. Under the interest rate peg, the default rate jumps up in period 5, when the tax shock takes place, but immediately returns to zero. Note that because the magnitude of the jump in the default rate in period 5 is about the same under both rules and because the default rate is serially uncorrelated under rule 3 but persistent under rule 1, the cumulative default is much higher under rule 1. How can this be possible if the initial level of public debt as well as the path of taxes are the same in both economies? The reason is that under rule 3 the interest rate is lower than under rule 1, which makes the post-shock debt burden including interest also smaller under rule 3.

Figure 3: Equilibrium Dynamics Under Default Rule 3



—— Interest Rate Peg - - - Default Rule 1

6 Conclusion

A number of emerging economies have or are facing the need to default. These countries display heterogeneous policy arrangements. A central aim of this paper is to characterize the precise way in which monetary policy affects the equilibrium behavior of default and sovereign risk premiums. We find that monetary policy indeed plays a significant role in shaping the equilibrium distribution of default and risk premiums. For example, in the economy analyzed in section 3, where the government follows a Taylor-type interest rate feedback rule, price stability requires that the government defaults only by surprise. As a result, the country risk premium is nil at all times even though the fiscal authority reneges of its obligations from time to time. On the other hand, in an economy where the central bank pegs the price level, like the one studied in section 5, both default and the country risk premium can be highly persistent. But the precise fiscal and monetary regime in place are not the only characteristics of policy behavior that contribute to giving form to the dynamics of default. An equally important role is played by the government's attitude toward making tough decisions. Some governments have a natural tendency to put off as much as possible unavoidable painful measures. This paper shows that in the case of default, procrastination can have unintended consequences. For instance, in the economy where the monetary authority follows a Taylor rule, postponing default leads not only to an explosive inflation path, but also to an eventual default that is larger than the one that would have taken place if the government had not tried to gain time. It is in this sense that we speak of an unpleasant arithmetics in attempting to substitute inflation for default.

The present study can be extended in a number of ways. For the sake of simplicity, the basic analytical framework leaves out a number of important aspects of actual emerging economies that would be worthwhile incorporating. First, it is assumed that the totality of public debt is nonindexed. In reality a significant fraction of government liabilities in developing countries is denominated in foreign currency, which is a form of indexation to a price index of traded goods. Clearly, the more widespread is indexation, the more limited is the ability of unexpected changes in the price level to act as a capital levy. Second, the model abstracts from a demand for money. Relaxing this assumption would introduce fiscal effects stemming from changes in the price level even if public debt was fully indexed. Finally, the simple model economy we consider is closed to international trade in goods and financial assets. Allowing for international transactions would enrich the analysis in a number of relevant dimensions. Of particular interest is the characterization of default and sovereign risk under alternative exchange rate arrangements and of the role played by foreign investors' holdings of public debt.

Appendix

Taylor Rules and Non-Negative Default Rates

Consider an economy whose equilibrium conditions are given by the equations listed in definition 1 and equations (15) and (17). Suppose in addition, that the default rate is constrained to be nonnegative, that is

$$\delta_t \geq 0; \quad \forall t.$$

. Clearly, equations (18) and (19) that in periods when the expected present discounted value of (regular) taxes exceeds the real value of government liabilities, the government must transfer resources to the public. Since the government cannot implement this transfers via negative values of δ, it must materialize them through regular transfers. We refer to this type of transfers as extraordinary. Specifically, suppose that the government has the ability to transfer in a lump-sum fashion the difference between the expected present discounted value of primary surpluses and current real liabilities. Let total taxes, τ_t, be given by the sum of ordinary taxes, τ_t^o, and extraordinary (negative) taxes, τ_t^e,

$$\tau_t = \tau_t^o + \tau_t^e$$

Ordinary taxes follow an exogenous AR(1) process of the form

$$\tau_t^o - \bar{\tau}^o = \rho(\tau_{t-1}^o - \bar{\tau}^o) + \epsilon_t,$$

We conjecture that the government can implement the equilibrium defined above with non-negative default rates by following the following rule for extraordinary taxes:

$$\tau_0^e = \min\left(0, g_0(\tau_0^o, R_{-1}B_{-1}/P_{-1})\right),$$

and

$$\tau_t^e = \min\left(0, g(\tau_{t-1}^o, \epsilon_t)\right), \quad t > 0,$$

where the functions g_0 and g are to be determined. Under our conjecture, the Taylor rule (15) implies that the interest rate is constant and given by

$$R_t = R^*,$$

where $R^* > 0$ is the exogenously determined interest rate target. It follows from the above expression for τ_t^e that

$$\begin{aligned} E_t \tau_{t+1}^e &= \int_{\{\epsilon\,:\,g(\tau_t^o,\epsilon)\le 0\}} g(\tau_t^o,\epsilon) f(\epsilon)\, d\epsilon \\ &\equiv H_1(\tau_t^o, g), \end{aligned}$$

where f is the density function of the standard normal distribution. Also,

$$\begin{aligned} E_t \tau_{t+2}^e &= E_t E_{t+1} \tau_{t+2}^e \\ &= E_t H_1(\tau_{t+1}^o, g) \\ &= \int_{-\infty}^{\infty} H_1(\bar{\tau}^o + \rho(\tau_t^o - \bar{\tau}^o) + \epsilon, g) f(\epsilon)\, d\epsilon \\ &\equiv H_2(\tau_t^o, g). \end{aligned}$$

In general, we can write

$$E_t \tau_{t+j}^e = H_j(\tau_t^o, g); \quad j \ge 1.$$

We include the second argument in the functions H_j, $j \ge 1$, to emphasize their dependence upon the unknown function g. Clearly, equations (18) and

$$\delta_t = 1 - \frac{\pi^*}{\beta R^*} \frac{\sum_{h=0}^{\infty} \beta^h E_t \tau_{t+h}}{\sum_{h=0}^{\infty} \beta^h E_{t-1} \tau_{t+h}}; \quad t \ge 1. \tag{37}$$

(this last expression introduced in footnote 6) continue to be valid here because their derivation does not depend upon the assumed tax structure. Given the AR(1) process specified for ordinary taxes, we can write $E_t \sum_{h=0}^{\infty} \beta^h \tau_{t+h}^o = \gamma_1 \tau_{t-1}^o + \gamma_2 \epsilon_t + \gamma_3$ and $E_{t-1} \sum_{h=0}^{\infty} \beta^h \tau_{t+h}^o = \gamma_4 \tau_{t-1}^o + \gamma_5$, where γ_i, $i = 1,2,3,4,5$ are known parameters. Then, using this expressions and equation (37), we have that for $t > 0$ the default rate is given by:

$$\delta_t = 1 - \frac{\pi^*}{\beta R^*} \frac{\tau_t^e + \sum_{h=1}^{\infty} \beta^h H_h(\tau_t^o, g) + \gamma_1 \tau_{t-1}^o + \gamma_2 \epsilon_t + \gamma_3}{\sum_{h=0}^{\infty} \beta^h H_{h+1}(\tau_{t-1}^o, g) + \gamma_4 \tau_{t-1}^o + \gamma_5}; \quad t \ge 1.$$

Setting $\delta_t = 0$ and $\tau_t^e = g(\tau_{t-1}^o, \epsilon)$ we obtain the following implicit functional equation in g

$$0 = 1 - \frac{\pi^*}{\beta R^*} \frac{g(\tau_{t-1}^o, \epsilon_t) + \sum_{h=1}^{\infty} \beta^h H_h(\tau_t^o, g) + \gamma_1 \tau_{t-1}^o + \gamma_2 \epsilon_t + \gamma_3}{\sum_{h=0}^{\infty} \beta^h H_{h+1}(\tau_{t-1}^o, g) + \gamma_4 \tau_{t-1}^o + \gamma_5}; \quad t \ge 1.$$

Similarly, using (18) and having found the function g, the function g^0 solves

$$0 = 1 - \pi^* \frac{g^0(\tau_0^o, R_{-1}B_{-1}/p_{-1}) + \sum_{h=1}^{\infty} \beta^h H_h(\tau_0^o, g) + \gamma_6 \tau_0^o + \gamma_7}{R_{-1}B_{-1}/P_{-1}},$$

where $\gamma_6 \tau_0^o + \gamma_7 = E_0 \sum_{h=0}^{\infty} \beta^h \tau_h^o$ and γ_6 and γ_7 are known parameters.

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