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Francesco Bianchi
Duke University
Centre for Economic and Policy Research
National Bureau of Economic Research

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Ernesto Pastén
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Francesco Bianchi
Duke University
Centre for Economic and Policy Research
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For a small open economy, maintaining a stable exchange rate and moderate levels of inflation is often a goal of primary importance. At the same time, the profession has recognized the tight link between fiscal and monetary policies in determining inflation dynamics. Thus, the goal of a stable exchange rate requires a certain level of coordination between the monetary and fiscal authorities. This paper builds on recent advancements in the literature on monetary-fiscal policy interaction to formalize this idea. We study the origins of fiscal inflation, the possibility of stagflation as a result of policy uncertainty, and the role of default on sovereign debt crises that stem from lack of fiscal discipline. We then use the model to interpret the different periods of the Chilean economic history starting from the 1960s.

We model the interaction between the monetary and fiscal authorities in a small open economy, allowing for default and changes in the level of spending. When policymakers follow an exchange-rate-targeting policy mix, in which the central bank is focused on maintaining a stable exchange rate and the fiscal authority makes sure that debt remains on a stable path, fiscal imbalances are irrelevant for the macroeconomy. Thus, if agents are confident that such policy mix will be maintained in the future, the central bank is able to reach the goal of a stable exchange rate and moderate inflation. However, this result disappears as soon as we introduce uncertainty about policymakers' behavior. The possibility of deviations from fiscal discipline generates inflationary pressure that leads to output losses.

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If the fiscal authority moves away from a policy of debt stabilization, a sovereign debt crisis arises, with mounting inflationary pressure that implies a nominal devaluation. If the central bank remains committed to stabilizing the exchange rate, a vicious circle of large debt accumulation, inflation, and contractions in real activity arises.

In this scenario, we introduce the notion of cosmetic default as a default that does not resolve the underlying fiscal problem that led to the crisis. A cosmetic default is unable to remove the contractionary effects arising from the conflicting goals of a stable exchange rate and freedom in the conduct of fiscal policy. On the contrary, the possibility of a cosmetic default exacerbates the vicious circle because it determines an increase in sovereign spreads and, as a result, faster debt accumulation. In this scenario, the lack of coordination between the monetary and fiscal authorities becomes two-dimensional. First, policymakers are not able to implement policies that are consistent with a stable exchange rate and low inflation. Second, policymakers do not provide a clear path to resolve the latent conflict between the two authorities.

To illustrate these and other ideas, we build a model of a small open economy similar to the one used by Kriwoluzky and others (2015), who, in turn, combine ingredients from Galí and Monacelli (2008), Uribe (2006), and Bianchi and Ilut (2017). With respect to these papers, we introduce recurrent changes in the level of fiscal spending and link such changes to the monetary-fiscal policy mix and the occurrence of default. When spending is low, the fiscal authority follows a policy of debt stabilization and the central bank targets the exchange rate. We label this policy mix exchange-rate targeting. When spending is high, deviations from the exchange-rate-targeting regime become possible. Specifically, the fiscal authority might stop responding to the level of debt, perhaps because of political considerations not modeled in this paper. This situation determines a sovereign debt crisis with debt on an unstable path. This crisis cannot persist forever because the ability of the monetary authority to target a stable exchange rate requires the fiscal authority to keep debt on a stable path.

Three scenarios can follow the sovereign debt crisis. First, the fiscal authority can simply revert to a policy of debt stabilization. The economy in this case returns to the exchange-rate-targeting regime. Second, policymakers can decide to default on the existing stock of debt. Third, policymakers might switch to a fiscally-led regime in which the central bank abandons exchange-rate targeting, and inflation is then free to move and stabilize the fiscal burden. This last scenario

has pervasive consequences for the model dynamics. If policymakers were to move to the fiscally-led regime, the sovereign debt crisis would be resolved by a large increase in inflation and a consequent large devaluation. The central bank accommodates these events, with a resulting drop in the real interest rate and an expansion. The cost of such policy is represented by the loss of exchange-rate stability and by an overall increase in macroeconomic volatility.

The expectation that such scenario might follow the sovereign debt crisis creates a vicious circle of large debt accumulation, inflation, and contraction in real activity. The possibility of a switch to the fiscally-led regime creates inflationary pressure and, as a consequence, devaluationary pressure on the exchange rate. Given that the central bank is still trying to keep a stable exchange rate, this leads to an increase in interest rates to prevent depreciation, which in turn results in recession and real appreciation. The recession and the high real interest rate determine further debt accumulation and a consequent increase in inflationary pressure.

The possibility that the crisis might be resolved with a default instead of a switch to the fiscally-led regime exacerbates the vicious circle instead of mitigating it. In this context, a default is only cosmetic because it implies repudiating a certain amount of the existing debt but not a change in the policy mix or in the expected policy mix. Thus, a default only has a limited effect on the expected fiscal burden because it does not address the original sin at the root of the sovereign crisis. When agents expect that policymakers might default on the existing debt, they demand to be compensated for such a possibility and sovereign spreads go up. This makes the cost of financing debt larger, thus increasing the overall amount of debt that policymakers need to stabilize. The spiral of debt accumulation and increasing output losses persists until the economy enters default. Default determines a temporary recovery in the economy because it curbs the current amount of debt that needs to be inflated away. However, given that it does not resolve the underlying fiscal issue, the recovery does not last, the debt-to-GDP starts increasing again, and so does inflation. In other words, the economy experiences a cosmetic default: A drop in the fiscal burden that does not resolve the underlying problem represented by the lack of coordination between the monetary and fiscal authorities.

Even when the economy is not currently experiencing a crisis, the possibility that this might arise in the future determines output losses. When the economy enters a period of high spending, agents understand that there is an increase in the probability of policymakers'

deviating from the exchange-rate-targeting regime. This causes inflationary pressure and a nominal depreciation. The central bank increases the policy rate to counteract the depreciation, thus causing a real appreciation and a recession. Stagflation is now driven by the expectation that a crisis might occur in the future, even if policymakers are currently following the exchange-rate-targeting policy mix. Finally, the losses arising during the high-spending period spill over into the low-spending regime. Thus, fiscal inflation is always present, even if its magnitude varies depending on the current behavior of the monetary and fiscal authorities.

This result also suggests that a sovereign debt crisis with stagflation can arise even if policymakers keep following the exchange-rate-targeting policy mix. To trigger the crisis, it is enough that agents experience a loss of confidence about future policymakers' actions. The loss of confidence implies an increase in the probabilities assigned to default and a switch to the fiscally-led regime. The key mechanism is identical to what has been illustrated for the benchmark case. The possibility of moving away from fiscal discipline causes inflationary pressure that the central bank tries to contain, thus pushing the economy in a recession. Of course, the severity of the crisis is in this case reduced because the actions of the fiscal authority limit the speed with which debt is accumulated. However, this case illustrates how stagflation can arise simply as a result of changes in agents' beliefs, which highlights the importance of clear policy communication about the way spending programs will be financed in the future.

It is then interesting to study when a default is more likely to put a stop to a sovereign crisis. We argue that a default is more likely to mark the end of a sovereign debt crisis if it is paired with a policy reform. In other words, a default can put a stop to the crisis if it is not purely cosmetic, but it also implies a change in the policy mix going forward. We argue that this seems a realistic scenario only if the large debt accumulation is the result of an exceptional event that is not likely to occur again soon, like an unusually large recession or a disaster (like a war). Instead, if the large debt accumulation is the result of high spending, it might be harder to convince agents that the same problem will not occur again in the future.

When the large stock of debt is the result of an exceptional event and not a systematic fiscal problem, a shift to the fiscally-led regime might be perceived as too costly because it requires accepting high exchange-rate volatility for many periods to come. Instead, a default that reduces the existing stock of debt without changing expectations

about future fiscal discipline might seem a better option. The model presented in this paper cannot be used to quantify the advantages and disadvantages of a default with respect to a switch to the fiscally-led regime because default is not costly in the model. Nevertheless, the model can be used to understand the existing tradeoffs from a qualitative point of view. On the one hand, a cosmetic default cannot be the solution to a fiscal issue. On the contrary, a cosmetic default exacerbates the cost associated with policy uncertainty. Introducing a cost of default would not change this result. On the other hand, moving to a fiscally-led regime implies abandoning exchange-rate stability. Thus, the only effective solution for a small open economy is to implement reforms that can create confidence in the fiscal sustainability of the existing levels of spending.

We use the model to study key steps in the Chilean quest for low and stable inflation. In this respect, Chilean economic history starting from 1960 can be divided into four distinct periods. During the 1960s Chile struggled to contain inflation. Interestingly, the government was able to recognize early on that a low inflation rate requires keeping fiscal deficits under control. High fiscal inflation turned into fiscal hyperinflation in the early 1970s as a result of a large increase in primary deficits. The second period, from 1974 to 1981, was characterized by a shift toward conservative fiscal policy and a progressive change in the conduct of monetary policy toward exchange-rate targeting. These two changes led to a significant reduction in inflation, consistently with the model. However, a drastic shift in the conduct of U.S. monetary policy in the early 1980s combined with the exchange-rate-targeting regime determined a banking crisis. The rescue plan implemented by the Chilean government resulted in a large increase in fiscal obligations. Thus, over the period from 1982 to 1988, the Chilean government acted forcefully to avoid a cosmetic default and instead implemented policies meant to build a reputation for fiscal discipline. Inflation remained high but relatively moderate. Finally, the last period, starting in 1989, was characterized by a return to democracy and two major institutional changes. First, the Central Bank of Chile was granted independence. Second, a fiscal rule meant to guarantee long-run fiscal sustainability was introduced. As implied by the model, once the central bank obtained the necessary fiscal backing, it was able to gain control of inflation and guarantee a stable exchange rate.

This paper builds on the work of Bianchi and Ilut (2017), who study the role of fiscal policy in explaining the rise in inflation in the

1970s in the United States; Bianchi and Melosi (2017b), who study the problem of the lack of coordination between the monetary and fiscal authorities for a closed economy; and Kriwoluzky and others (2015), who extend the analysis to a currency union to study the experience of Greece during the recent financial crisis. In this respect, the paper is also related to Woodford (2001) and Loyo (1999), who use a perfect foresight endowment economy to show that, if the central bank follows the Taylor principle while the fiscal authority does not stabilize debt, an explosive path for the price level arises. In our model, the possibility of recurrent changes in the policy mix guarantees that a stationary equilibrium still exists, while allowing for temporarily explosive dynamics. Furthermore, the New-Keynesian framework makes the lack of coordination more costly than in an endowment economy.

Our notion of cosmetic default builds on the idea of Marcet and Nicolini (2003) of a monetary reform that introduces an exchange-rate-targeting policy to counteract hyperinflation. Sargent and others (2009) label such monetary reform cosmetic because it does not address the real reason behind the high inflation: a high level of seigniorage used to finance large fiscal deficits. Cosmetic reforms are more likely to be followed by new episodes of hyperinflation, unless they are able to signal future changes in fundamentals. In a similar fashion, our cosmetic defaults are conducive to new sovereign debt crises. Sargent and others (2009) conduct an empirical study of hyperinflation episodes in several South American countries and show that hyperinflation can arise as the result of government deficits that are monetized but also from destabilizing expectations dynamics that can occasionally divorce inflation from fundamentals. The model presented in this paper can deliver similar results for inflation dynamics and also generate contractions in real activity.

The mechanisms outlined here do not explicitly involve seigniorage, even if we could derive an implied path for money supply. Fiscal inflation instead arises as a result of real or perceived fiscal imbalances. The fact that no explicit link between inflation and seigniorage is required is consistent with the observation made by Marcet and Nicolini (2003) that episodes of hyperinflation can arise with no apparent changes in the level of seigniorage. The authors explain this stylized fact in the light of bounded rationality. In the current paper, the disconnect between seigniorage and inflation is explained by taking a different perspective on the ultimate source of fiscal pressure. In particular, we build on the literature that studies the interaction between fiscal and monetary policies in determining

inflation dynamics: Sargent and Wallace (1981), who consider the problem in a deterministic environment; Leeper (1991), Sims (1994), Cochrane (1998, 2001), and Woodford (1994, 1995, 2001), who focus on the problem of price determinacy; and Bassetto (2002), who studies the game-theoretical aspect of the fiscal theory of price level.

Finally, our results are also related to the important work by Dornbusch (1982). He argues that the prediction of the Mundell-Fleming model that an increase in government spending leads to an appreciation seems at odds with the empirical evidence. He then introduces the possibility that an increase in government spending creates an expectation of future debt monetization. Like in Dornbush's model, our model generates a depreciation of the exchange rate stemming from the lack of fiscal discipline, even if the mechanisms at play are quite different.

The content of this paper can be summarized as follows: Section 1 describes the model. Section 2 discusses the results. Section 3 uses the model to interpret the key steps in Chilean economic history. Section 4 concludes.

1. The Model

We make use of a New-Keynesian model similar to the one employed by Kriwoluzky and others (2015). Specifically, the model builds on the work of Galí and Monacelli (2008) and Corsetti and others (2013), with respect to the modeling of a small open economy. As in Uribe (2006), the government can default on its liabilities. Finally, we follow Bianchi and Ilut (2017) and Bianchi and Melosi (2017b) in modeling periods of lack of coordination between the monetary and fiscal authorities. An important innovation with respect to these contributions is that deviations from fiscal discipline depend on the level of spending: Policymakers default or move to a fiscally-led policy mix only when spending is high. This dependence between policymakers' behavior and spending level is at the center of the results of the paper and the notion of cosmetic default.

We keep the model parsimonious and we only consider changes in nondistortionary spending as a source of fiscal imbalance. This allows us to zoom in on the role of fiscal discipline and agents' expectations. The main results would still hold if the increase in the fiscal burden were driven by contractionary shocks. However, it would become more complicated to disentangle the direct impact of the shock and the indirect effects stemming from policy uncertainty and default.

1.1 Model Description

Households. The representative household maximizes the following utility function:

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t\left[\log\left(C_t\right)-\left(1+\varphi\right)^{-1}H_t^{1+\varphi}\right]\right] \tag{1}$$

subject to the budget constraint:

$$\int_0^1 P_{H,t}(i)C_{H,t}(i)di+\int_0^1 P_{F,t}(i)C_{F,t}(i)di+\mathbb{E}_t\left[\rho_{t,t+1}X_{t+1}\right]$$
$$=W_tH_t+\mathcal{Y}_t-\left(T_t-S_t\right)+X_t$$

where C_t is consumption, H_t is hours, β is the household discount factor, φ is the inverse of the Frisch elasticity of labor supply, P_t is the price index. The variables $C_{H,t}(i)$ and $C_{F,t}(i)$ denote consumption of domestically produced and imported varieties with $i\in[0, 1]$, while $P_{H,t}(i)$ and $P_{F,t}(i)$ are the corresponding price indices. The household has access to a portfolio of state-contingent claims X_{t+1} priced with the nominal stochastic discount factor $\rho_{t,t+1}$. Finally, the household receives the hourly nominal wage W_t and firm profits $\mathcal{Y}_t$, while it has to pay new lump-sum taxes $(T_t - S_t)$.

Aggregate consumption is defined as

$$C_t\equiv\left[(1-\omega)^{\frac{1}{\sigma}}C_{H,t}^{\frac{\sigma-1}{\sigma}}+\omega^{\frac{1}{\sigma}}C_{H,t}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

where aggregate consumption of domestic goods $C_{H,t}$ consists of varieties

$$C_{H,t}\equiv\left[\int_0^1 C_{H,t}(i)^{\frac{\gamma-1}{\gamma}}di\right]^{\frac{\gamma}{\gamma-1}}$$

and aggregate consumption of foreign goods $C_{F,t}$ consists of varieties

$$C_{F,t}\equiv\left[\int_0^1 C_{F,t}(i)^{\frac{\gamma-1}{\gamma}}di\right]^{\frac{\gamma}{\gamma-1}}.$$

The parameter $\omega\in(0, 1)$ controls the import weight of consumption, $\sigma > 0$ is the elasticity between domestic goods and imports, and $\gamma > 1$ is

the price elasticity of demand across varieties. Finally, the consumer price index is

$$P_t \equiv \left[(1-\omega)P_{H,t}^{1-\sigma} + \omega P_{F,t}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}.$$

Intertemporal consumption smoothing combined with the presence of state-contingent assets implies:

$$\rho_{t,t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-1}\frac{P_t}{P_{t+1}}. \tag{2}$$

Following Uribe (2006), we can use this expression to define the yield on a nominal risk-free domestic-currency bond as $R_t \equiv \frac{1}{\mathbb{E}_t\left[\rho_{t,t+1}\right]}$.

Foreign households face a symmetric problem:

$$\rho_{t,t+1} = \beta\left(\frac{C_{t+1}^*}{C_t^*}\right)^{-1}\frac{P_t^*}{P_{t+1}^*}\frac{E_t}{E_{t+1}}. \tag{3}$$

where C_t^* and P_t^* denote consumption and price level for the foreign country, respectively, and E_t is the nominal exchange rate, defined as the price of foreign currency in terms of domestic currency. Combining the intertemporal optimality conditions (2) and (3) leads to the risk-sharing condition $\frac{C_t}{C_t^*} = vQ_t$, where the real exchange rate $Q_t \equiv \frac{P_t^* E_t}{P_t}$ corresponds to the price of foreign consumption in terms of domestic consumption, while the constant $v \equiv \left(\frac{C_{-1}}{C_{-1}^*}\right)\left(\frac{P_{-1}}{E_{-1}P_{-1}^*}\right)$ captures initial conditions.

Firms. The representative monopolistically competitive firm i faces sticky prices *a la Calvo* with probability of adjustment $(1-\theta)$ and a downward-sloping demand curve arising from the household optimization problem. Specifically, the demand function at time $t+k$ for a firm $j \in [0,1]$ that last adjusted prices k periods ago is given by:

$$Y_{t+k|t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t+k}}\right)^{-\gamma}\left((1-\varpi)\left(\frac{P_{H,t+k}}{P_{t+k}}\right)^{-\sigma}C_{t+k} + \varpi\left(\frac{\frac{P_{H,t+k}}{E_{t+k}}}{P_{t+k}}\right)^{-\sigma}C_{t+k}^*\right)^{-\gamma} \tag{4}$$

where we took into account that prices are set in the domestic currency.

A firm i that can change its price at time t chooses the optimal price $P_{H,t}(i) = \tilde{P}_{H,t}(i)$ to maximize the expected present discounted value of profits by using the household stochastic discount factor $\rho_{t,t+k}$ and taking into account that, in every period, there is a probability θ that it will not be able to adjust the price:

$$\max_{P_{H,t}(i)} \mathbb{E}_t \left[\sum_{k=0}^{\infty} \theta^k \rho_{t,t+k} \mathcal{Y}_{t+k|t}(i) \right]$$

$$= \max_{P_{H,t}} \mathbb{E}_t \left[\sum_{k=0}^{\infty} \theta^k \rho_{t,t+k} \left(P_{H,t}(i) Y_{t+k|t}(i) - \mathcal{C}\left(Y_{t+k|t}(i) \right) \right) \right]$$

where the cost function $\mathcal{C}\left(Y_{t+k|t}(i)\right) = W_{t+k} Y_{t+k|t}(i)$ depends on the price chosen at time t as exemplified above.

Because all firms that adjust their prices at time t face the same optimization problem, they all choose the same optimal price $\tilde{P}_{H,t}(i)$. Thus, the domestic price index evolves as:

$$P_{H,t}^{1-\gamma} = (1-\theta) \tilde{P}_{H,t}^{1-\gamma} + \theta P_{H,t-1}^{1-\gamma}$$

where we have taken into account that, in every period, a randomly selected fraction $(1-\theta)$ is chosen to re-optimize the price, while the rest of the firms leave their prices unchanged.

Policymakers. The fiscal authority issues one-period bonds with price I_t^{-1}. These bonds are risky because, in every period, the government might default on a fraction D_{t+1} of the outstanding debt. Thus, government debt evolves according to the following law of motion:

$$I_t^{-1} B_t = B_{t-1} (1 - D_t) - T_t + S_t.$$

We can rewrite the government budget constraint as a fraction of GDP:

$$b_t = \left(\frac{Y_t}{Y_{t-1}} \right)^{-1} I_{t-1} \Pi_t^{-1} b_{t-1} (1 - D_t) - \tau_t + s_t$$

where $b_t \equiv \frac{I_t^{-1} B_t}{Y_t P_{H,t}}$, $\tau_t \equiv \frac{T_t}{Y_t P_{H,t}}$ and $s_t \equiv \frac{S_t}{Y_t P_{H,t}}$. As in Bianchi and Ilut (2017), the term s_t reflects a persistent shock to spending. Here, we model the shock as Markov-switching process $s_t = s_{\xi_\tau^s}$ controlled by

a transition matrix $\mathcal{P}^s$. Modeling the shock as a Markov-switching process allows us to easily break the orthogonality between shocks and policy behavior.

The term τ_t reflects the systematic component of taxation. For simplicity, we assume that τ_t only responds to the debt-to-GDP ratio, but richer policy rules could be considered:[1]

$$\left(\tau_t - \tau\right) = \delta_{\xi_t^p}\left(b_{t-1} - b\right)$$

where τ and $b \equiv \frac{\tau}{1-\beta}$ are the steady-state values for the tax-to-GDP and debt-to-GDP ratios. The parameter controlling the response of taxation to debt, $\delta_{\xi_t^p}$, can change over time and is controlled by the Markov-switching variable ξ_t^p with transition matrix $\mathcal{P}^p$.

The central bank moves the policy rate according to a modified Taylor rule:

$$\frac{R_t}{R} = \left(\frac{\Pi_{H,t}}{\Pi_H}\right)^{\phi_{\pi,\xi_t^p}} \left(\frac{E_t}{E}\right)^{\phi_{e,\xi_t^p}} \tag{5}$$

where R is the steady-state gross nominal interest rate, $\Pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$ is the domestic gross inflation rate, Π_H is the steady-state gross domestic inflation rate, E is the steady-state exchange rate. As for the fiscal rule, the Taylor-rule parameters are allowed to change over time based on the Markov-switching variable ξ_t^p.

A nonarbitrage condition pins down the return on government bonds:

$$I_t \mathbb{E}_t\left(1 - D_{t+1}\right) = \frac{1}{\mathbb{E}_t\left[\rho_{t,t+1}\right]} = R_t .$$

This implies that the sovereign yield is higher than the risk-free rate R_t by an amount that reflects the probability and the size of default.

1. See Bianchi and Ilut (2017).

Table 1. Partition of the Parameter Space

	Active Fiscal (AF) ($\delta_b < \beta^{-1}-1$)	*Passive Fiscal (PF)* ($\delta_b > \beta^{-1}-1$)
Active Monetary ($\phi_{\pi,\xi_t^p} > 1, \phi_e > 0$)	No Solution	**Determinacy**
Passive Monetary ($\phi_{\pi,\xi_t^p} < 1, \phi_e = 0$)	**Determinacy**	Indeterminacy

Source: Author's research.
Partition of the parameter space according to the existence and uniqueness of a solution in a model without regime changes.

Market clearing. The good market clears as

$$Y_t = (1-\varpi)\left(\frac{P_{H,t}}{P_t}\right)^{-\sigma} C_t + \varpi\left(\frac{P_{H,t}}{P_{F,t}}\right)^{-\sigma} C_t^*$$

where we have used the assumption that $P_{F,t} = E_t P_t^*$. This holds approximately given that the domestic country is small.[2] Market clearing in the asset market implies:

$$\mathbb{E}_t\left[\rho_{t,t+1} X_{t+1}\right] - X_t = I_t^{-1} B_t - B_{t-1}\left(1 - D_t\right) + P_{H,t} Y_t - P_t C_t.$$

Finally, market clearing in the labor market requires $H_t = \int_0^1 H_t(i)di = \int_0^1 Y_t(i)di = Y_t \Delta_t$, where Δ_t is a measure of price dispersion that is equal to 1 up to a first-order approximation around a zero-inflation steady state.

1.2 Conditionally Linear Model

Before discussing policy changes, we present the linearized system of equations conditional on being in a certain regime. The private-sector equilibrium conditions lead to a linearized Euler equation and an expectation augmented Phillips curve:

2. See Kriwoluzky and others (2015) and De Paoli (2009).

$$y_t = E_t y_{t+1} - \bar{\omega}\left(r_t - E_t \pi_{H,t+1}\right)$$

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa\left(\varphi + \bar{\omega}^{-1}\right) y_t$$

where $\bar{\omega} \equiv 1 + \omega(2-\omega)(\sigma - 1)$ and $\kappa \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta}$.

Because of the assumption of complete international markets, domestic output is tightly linked to the behavior of the real exchange rate q_t:

$$y_t = \frac{\bar{\omega}}{1-\omega} q_t$$

where $q_t = (1-\omega)(e_t - p_{H,t})$, with e_t the nominal exchange rate.

The linearized government budget constraint reads:

$$b_t = \left(\frac{b}{\beta}\right)\left(i_{t-1} - \pi_{H,t} - d_t - y_t + y_{t-1}\right) + \left(\frac{1}{\beta}\right) b_{t-1} - \tau_t + s_t$$

with τ_t controlled by the linearized fiscal rule:

$$\tau_t = \delta_{b,\xi_t^p} b_{t-1}$$

where, to keep notation simple, we now use τ_t and b_t to denote linear deviations from the corresponding steady states.

The monetary-policy rule reads:

$$r_t = \phi_{\pi,\xi_t^p} \pi_{H,t} + \phi_{e,\xi_t^p} e_t$$

while the sovereign yield is pinned down by:

$$i_t = r_t + E_t d_{t+1}.$$

Thus, the expected size of the default determines the sovereign yield spread.

1.3 Monetary-fiscal Policy Mix and Default

Before describing the regime changes that we allow for, we illustrate the consequences of explicitly modeling the behavior of the fiscal authority. If we substitute the tax rule in the linearized law of

motion for the debt-to-GDP ratio and isolate the resulting coefficient for lagged debt, we get:

$$b_t = (\beta^{-1} - \delta_{b,\xi_t^p})\, b_{t-1} + ...$$

This expression makes clear that debt stability can be achieved through the behavior of the fiscal authority by making sure that the process for the debt-to-GDP ratio is mean reverting. This requires the coefficient $\delta_{b,\xi_t^p} > 1-\beta^{-1}$. In the language of Leeper (1991), fiscal policy is in this case passive, in the sense that it passively accommodates the behavior of the monetary authority by making sure that debt is always on a stable path. If the fiscal authority violates this condition, we say that it is active.

Similarly, we can distinguish between active and passive monetary policy. In a closed economy, the distinction revolves around the Taylor principle, i.e., the response of the monetary-policy rate to inflation has to be more than one-to-one in order for monetary policy to be active: $\phi_{\pi,\xi_t^p} > 1$. In an open economy as the one presented above, monetary policy can be active if the central bank targets the exchange rate. In other words, monetary policy is active as long as the response to deviations of the nominal exchange rate to the target is larger than zero (Benigno and others, 2007): $\phi_{e,\xi_t^p} > 0$. This is consistent with the fact that an exchange-rate target requires the central bank to commit to return the price level to its original value following any shock. Thus, exchange-rate targeting can be thought of as a form of price-level targeting. This result has the important implication that the properties of existence and uniqueness of a solution described above extend to the case of an open economy in which the central bank reacts to the exchange rate instead of reacting to inflation. Accordingly, passive monetary policy arises if $\phi_{\pi,\xi_t^p} < 1$ and $\phi_{e,\xi_t^p} = 0$.

For a closed economy, in absence of regime changes, Leeper (1991) shows that the distinction between active and passive policies leads to a partition of the parameter space in four areas depending on the existence and uniqueness of a solution. The same partition exists in an open economy, once we recognize that monetary policy can be active as a result of its response to the exchange rate. Thus, a unique solution arises when monetary policy is active and fiscal policy is passive (AM/PF), or in the symmetric case of passive monetary policy and active fiscal policy (PM/AF). When both authorities are conducting passive policies (PM/PF) we have multiple solutions. Finally, when both

authorities are conducting active policies, no stable solution exists. These regions are summarized in table 1.

The first determinacy region, Active Monetary/Passive Fiscal (AM/PF), is the most familiar one. The Taylor principle is satisfied and the fiscal authority moves taxes in order to keep debt on a stable path: $\psi_{\pi,\xi_t^p} > 1$ or $\psi_{e,\xi_t^p} > 0$ and $\delta_{b,\xi_t^p} > \beta^{-1} - 1$. This last condition guarantees that the coefficient $\beta^{-1} - \delta_{b,\xi_t^p}$ is smaller than one, so that debt is mean reverting. Therefore, we can think of fiscal policy as passive to the extent that it passively accommodates the behavior of the monetary authority ensuring debt stability. We can think about this policy mix as a monetarily-led regime. The second determinacy region, Passive Monetary/Active Fiscal (PM/AF), is less familiar and corresponds to the case in which the fiscal authority is not committed to stabilizing the process for debt: $\delta_{b,\xi_t^p} < \beta^{-1} - 1$. Now it is the monetary authority that passively accommodates the behavior of the fiscal authority, allowing inflation to move in order to stabilize the process for debt: $\psi_{\pi,\xi_t^p} < 1$ and $\psi_{e,\xi_t^p} = 0$. As we shall see, under this regime, fiscal imbalances can have an impact on the macroeconomy as agents understand that they will not be followed by future offsetting changes in the fiscal variables. We can think about this policy mix as a fiscally-led regime.

To gain the intuition about why when both authorities are active (AM/AF) no *stationary* equilibrium exists, suppose that inflation is above target and that the central bank tries to lower it by increasing the policy rate more than one-to-one in response to the observed deviation. This action prompts an increase in the real interest rate, a contraction in output and, consequently, an increase in the debt-to-GDP ratio. This increase in the debt-to-GDP ratio would require an increase in taxation, but agents know that this is not going to happen because the fiscal authority is active. Therefore, the adjustment has to come through an increase in inflation that triggers an even larger increase in the interest rate and so on. Clearly, the economy is on an explosive path and, if this situation were to persist, no *stationary* solution would exist. Thus, we can think about this policy mix as a conflict regime in which the two authorities fail to coordinate which other.

As explained in Bianchi and Melosi (2017b), if the conflict regime is expected to eventually end, the model can still admit a stable and unique rational-expectations equilibrium. The model can present temporary explosive dynamics, but as long as these are not expected to last for too long, a stationary solution would still exist. This is the key insight that allows us to solve the model allowing for periods during

which the monetary and fiscal authorities are implementing policies that are not compatible in the long run.

We use the solution algorithm proposed by Farmer and others (2009). This method requires the solution to satisfy mean square stability: First and second moments need to be stationary when taking into account the possibility of regime changes. However, quite importantly, the solution method does not impose that all regimes taken in isolation must be stationary, allowing for temporary explosive dynamics. Given that agents form expectations by taking into account the possibility of regime changes, their expectations are still finite at every horizon, even when the economy is temporarily on an explosive path because of the conflict between the two authorities. As we shall see, the properties of the solution depend on agents' expectations about the way the conflict between monetary and fiscal authorities will be resolved.

The other important change with respect to most of the literature that studies monetary-fiscal policy interaction is that the model presented above also allows for default. As we shall see, the possibility of default can exacerbate the effects of a conflict between the monetary and fiscal authorities. To see why, let's consider a simplified version of default. We assume that if default occurs, this will be equal to the ratio between the past stock of debt (in deviations from steady state) and the steady-state debt-to-GDP ratio. In other words, $d_t = b_{t-1}/b$ if a default occurs. In the linearized budget constraint, we then have:

$$b_t = \left(\frac{b}{\beta}\right)\left(i_{t-1} - \pi_{H,t} - d_t - y_t + y_{t-1}\right) + \beta^{-1} b_{t-1} - \tau_t + s_t$$

$$= \left(\beta^{-1} + P_{t-1}\left(d_t > 0\right) - \delta_{b,\xi_t^p}\right) b_{t-1} + \left(\frac{b}{\beta}\right)\left(r_{t-1} - \pi_{H,t} - d_t - y_t + y_{t-1}\right) + s_t$$

where $P_{t-1}(d_t > 0)$ is the probability of default at time t conditional on the information at time $t-1$. In deriving the second expression, we have used the fact that $i_{t-1} = r_{t-1} + E_{t-1} d_t = r_{t-1} + \frac{P_{t-1}\left(d_t > 0\right) b_{t-1}}{b}$. Thus, the possibility of default makes the process for debt more unstable during regular times and calls for stronger fiscal interventions. Obviously, if default in fact occurs $d_t = \frac{b_{t-1}}{b}$, the process for debt gets reset:

where we have assumed that, in case of default, there is no response to debt ($\delta_{b,\xi^P_t} = 0$). Thus, when default does not interact with the lack of fiscal discipline, it can be considered as a regime change that implies a zero net gain. During regular times debt accumulates faster, but once default in fact occurs, debt gets reset to a value that exactly compensates for the faster accumulation.

In this paper, we do not model a cost of default. There is a vast literature that discusses why default is costly. Introducing a cost of default would be relevant to explain why countries are reluctant to default and help matching actual data. However, it would not affect the discussion that we want to put forward in this paper. First, we want to argue that default cannot be the solution of a sovereign debt crisis if it does not address the causes of the crisis. Second, cosmetic defaults, i.e., defaults that only imply repudiating debt without a policy reform, can be costly if combined with policy uncertainty because they imply faster debt accumulation. The fiscal burden, in turn, creates inflationary pressure that jeopardizes the ability of the central bank to control inflation.

1.4 Policy Changes

We study a situation in which the economy is subject to persistent changes in the level of spending. Specifically, the spending shock s_t can assume two values, high or low, controlled by the transition matrix $\mathcal{P}^s : s_t = s_h$ if $\xi^s_t = h$, $s_t = s_l$ if $\xi^s_t = l$. We then study the effects of this shock for different scenarios regarding policymakers' behavior.

We assume that when spending is low, there are no incentives for policymakers to deviate from fiscal discipline. Thus, conditional on spending being low, policymakers implement an exchange-rate-targeting regime. The central bank moves the nominal interest rate to stabilize the exchange rate around its target value and the fiscal authority takes care of debt stability. When spending is high, policymakers might deviate from exchange-rate targeting. This assumption is supposed to capture the idea that high spending requires the fiscal authority to increase the level of taxation and this might be perceived as not politically feasible or popular. Thus, when spending is high, a conflict between the two authorities could arise: The central bank wants to keep the exchange rate stable or inflation low, but the fiscal authority is not willing to move taxes to stabilize debt. From this situation, three scenarios can occur: Default, switch to a fiscally-led regime, or return to fiscal discipline in the form of the

exchange-rate-targeting regime. In the rest of the paper, we consider different scenarios with respect to the relative probability of these events.

We parameterize the different regimes as follows. Under the *exchange-rate-targeting regime*, the central bank implements an active monetary policy by moving the nominal interest rate to stabilize the exchange rate around its target value ($\psi_{e,\xi_t^p} > 0$) and the fiscal authority implements a passive fiscal rule ($\delta_{b,\xi_t^p} > \beta^{-1} - 1$). This can be considered a monetarily-led regime, in the sense that the monetary authority is the leading authority. A conflict between the two authorities arises when fiscal policy moves to an active rule ($\delta_{b,\xi_t^p} > \beta^{-1} - 1$), while monetary policy keeps responding to the exchange rate. This leads to a sovereign debt crisis regime in which debt is on an unstable path. This *crisis regime* can be followed by a return to the exchange-rate-targeting regime, by a default, or by a switch to a *fiscally-led regime* in which the monetary authority abandons exchange-rate targeting to accommodate the behavior of the fiscal authority.

We assume that a default can occur only after a conflict between the monetary and fiscal authorities arises. When default occurs, we assume that this is large enough to bring the debt-to-GDP ratio back to the steady state as in Uribe (2006).[3] Specifically, when default occurs, its size is endogenously pinned down by the following equilibrium condition:

$$1_{\xi_t^p} b_t + \left(1 - 1_{\xi_t^p}\right) d_t = 0.$$

Note that when a default does not occur, $1_{\xi_t^p} = 0$ and $d_t = 0$, while when a default occurs, d^* is such that the debt-to-GDP ratio is back to its steady state, $1_{\xi_t^p} = 1$ and $b_t = 0$. We also assume that, under this regime, the response of the monetary and fiscal authorities does not change with respect to the conflict regime.

The joint evolution of policymakers' behavior and the discrete preference shock is controlled by the combined chain $\xi_t \equiv \left[\xi_t^p, \xi_t^s\right]$. As explained above, the probabilities of moving across the policy regimes are not invariant with respect to the level of spending. This feature of the model is obtained by introducing two transition matrices, $\mathcal{P}_l^p$

3. We also experimented with other specifications that involve default on a fixed amount plus a state-dependent amount of debt. These specifications are useful to make sure that default is always on a positive amount of debt when simulating the model, but they do not change the insights presented below. Thus, in the benchmark version of the model, we opted for this traditional formulation.

and $\mathcal{P}_h^p$; that control the transition probabilities during low and high spending, respectively. The overall transition matrix $\mathcal{P}$ is obtained by combining the transition matrices $\mathcal{P}_l^p$; $\mathcal{P}_h^p$; and $\mathcal{P}^s$s:

$$\mathcal{P} = \begin{bmatrix} p_{ll}^s \mathcal{P}_l^p & \left(1 - p_{hh}^s\right)\mathcal{P}_l^p \\ \left(1 - p_{hh}^s\right)\mathcal{P}_h^p & p_{hh}^s \mathcal{P}_h^p \end{bmatrix}.$$

The benchmark model is solved with the following transition matrices for the policy regimes:

$$\mathcal{P}_l^p \begin{bmatrix} & E & C & D & F \\ E & 1 & 1 & 1 & .01 \\ C & & & & \\ D & & & & \\ F & & & & .99 \end{bmatrix} \text{ and } \mathcal{P}_h^p = \begin{bmatrix} & E & C & D & F \\ E & .96 & .05 & & \\ C & .04 & .85 & 1 & \\ D & & .05 & & \\ F & & .05 & & 1 \end{bmatrix}.$$

Table 2. Calibration

Policy Regime	$\mathbf{1}_{\xi_t^p}$	ϕ_{e,ξ_t^p}	ϕ_{π,ξ_t^p}	$\delta b_{,\xi_t^p}$
ER targeting (E)	0	0.5	0	0.07
Crisis (C)	0	0.5	0	0
Default (D)	1	0.5	0	0
Fiscally-led (F)	0	0	0.68	0

Parameter	*Value*	*Parameter*	*Value*	*Parameter*	*Value*
ω	0.28	φ	4	p_{ll}^s	0.98
σ	1.50	β	0.99	p_{hh}^s	0.99
θ	0.875	b/4	50%	s_t	-0.04
γ	11			s_h	0.02

Source: Author's calculations.
Parameter values used to calibrate the benchmark model used for the simulations presented in the paper.

These transition matrices capture a series of intuitive properties of the model. As explained above, crises emerge only when spending is high. The probability of entering a sovereign crisis when spending is high is 4 percent. From the crisis, there is the probability (5 percent) of moving to the exchange-rate-targeting regime, experiencing default, or moving to the fiscally-led regime. To capture the idea of a cosmetic default, we assume that, after a default, the economy goes back to the crisis regime, in which fiscal policy is not behaving in a way consistent with long-run fiscal sustainability. If instead policymakers move to the fiscally-led regime, they are expected to remain in such regime for at least the whole remaining duration of the high-spending period. Once spending becomes low, policymakers move back to the exchange-rate regime with 1 percent probability. When spending is low, policymakers never deviate from the exchange-rate regime if they were following such regime in the past. Finally, policymakers move immediately to the exchange-rate-targeting regime if a change from high to low spending just occurred and they were not following the fiscally-led regime.

1.5 Calibration

We calibrate the model by using Chilean data whenever possible. A full estimation of the model using Chilean data proved challenging because of data availability, especially when it comes to fiscal aggregates. Nevertheless, we consider a full estimation exercise as an interesting direction for future research.

The calibration of the model is summarized in table 2. We assume a small Frisch elasticity of labor supply by setting $\varphi = 4$. We also tried $\varphi = 2$, with no significant change in the results. We set the trade-price elasticity to 1.5 and we assume $\omega = 0.28$, a value in line with the average export-to-GDP ratio of Chile for the post-1970s period. We set $\gamma = 11$ implying a 10 percent steady-state markup. We choose a moderate steady-state debt-to-GDP ratio: 50 percent.

For the policy parameters, we follow the work of Bianchi and Melosi (2017a), and Bianchi and Ilut (2017), who estimate policy rules for the United States. For the parameter controlling the response of taxation to debt, we set $\delta_{b,\xi_t^p} = .07$ under passive fiscal policy and $\delta_{b,\xi_t^p} = 0$ under active fiscal policy. Passive monetary policy is obtained by setting $\phi_{\pi,\xi_t^p} = .68$; while active monetary policy is obtained with $\phi_{\pi,\xi_t^p} = .5$. We also studied specifications in which the central bank reacts to inflation or nominal depreciation of the exchange rate under

the active fiscal rule. The results are qualitatively in line with what is presented below.

1.6 Solving the MS-DSGE Model

The model can be solved with any of the solution methods developed for Markov-switching DSGE models. We use the solution method of Farmer and others (2009). It is worth emphasizing that, in our model, agents form expectations while taking into account the possibility of regime changes. They understand that, when spending is high, policymakers might deviate from the exchange-rate-targeting regime and that this might trigger a default or a switch from the exchange-rate-targeting regime in favor of the fiscally-led regime. In other words, our approach allows us to model recurrent crises and defaults and to capture the impact of different exit strategies for policymakers' behavior during a crisis. The solution can be characterized as an MS-VAR:

$$S_t = c\left(\xi_t, \theta, \mathcal{P}\right) + T\left(\xi_t, \theta, \mathcal{P}\right) S_{t-1} + R\left(\xi_t, \theta, \mathcal{P}\right) Q\left(\theta^v\right) \varepsilon_t \tag{6}$$

where θ, θ^v, and S_t are vectors that contain the structural parameters, the stochastic volatilities, and all the variables of the model, respectively. The appendix provides more details about the linearization and the solution algorithm.

The behavior of the economy at each point in time depends on the structural parameters (θ), the regime in place (ξ_t), and the probability of moving across regimes ($\mathcal{P}$). Thus, the properties of one regime depend not only on the structural parameters describing that particular regime but also on what agents expect is going to happen under alternative regimes and on how likely it is that a regime change will occur in the future. In other words, agents' beliefs about future regime changes matter for the law of motion governing the economy.

2. Results

In what follows, we present a series of results based on the benchmark calibration presented in table 2. We start by discussing the implications of the fiscal authority deviating from fiscal discipline. This leads to a sovereign debt crisis. We argue that a cosmetic default does not represent a solution to the crisis. In subsection 2.2, we show that fiscal inflation is always present, even when the economy

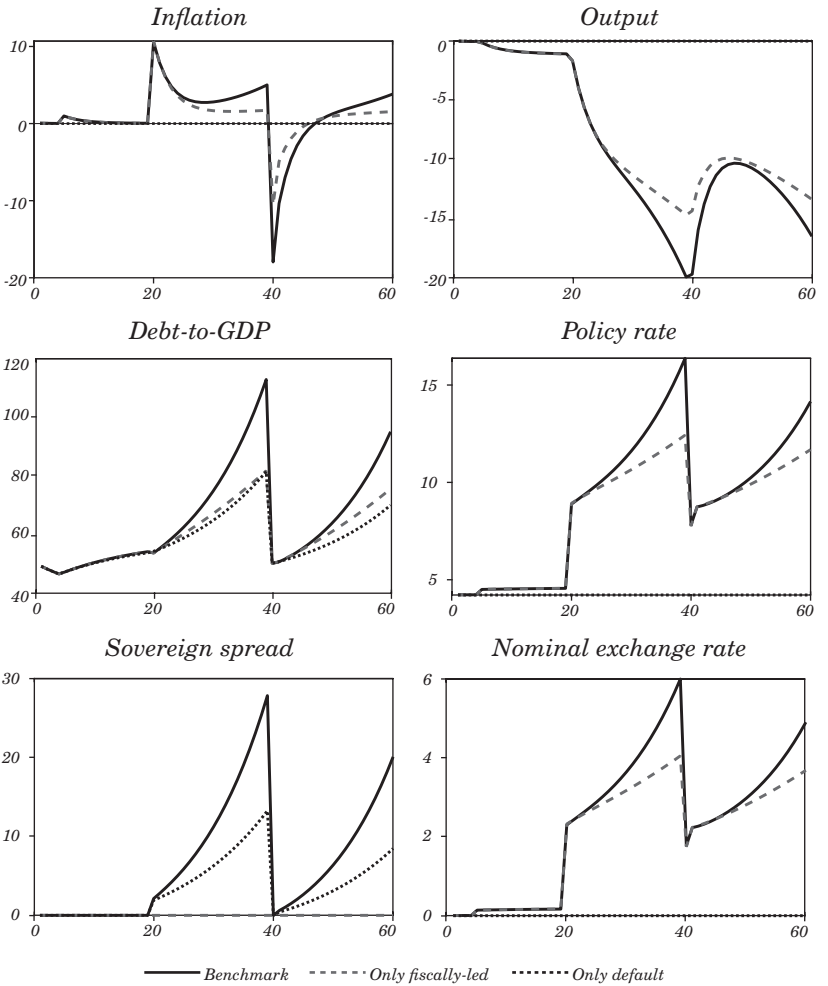
is following the exchange-rate-targeting regime, because agents anticipate the possibility of future deviations. Consistently with this result, we discuss how a sovereign crisis can arise as a result of a loss of confidence about future fiscal policy. Finally, we discuss when default is more likely to resolve a sovereign debt crisis.

2.1 Sovereign Crises and Cosmetic Defaults

We start by considering a sovereign crisis triggered by a deviation from fiscal discipline. This is a useful exercise because many of the results that will follow can be understood in light of the findings presented here. We consider the following simulation. At time zero, spending is low and policymakers follow the exchange-rate-targeting policy mix. In period 3, the economy moves from the low-spending regime to the high-spending state. Initially, policymakers keep following the exchange-rate regime. In period 20, the fiscal authority starts deviating from passive fiscal policy, while the monetary authority remains committed to stabilizing the exchange rate. As explained above, this corresponds to the crisis regime because both authorities are implementing active policies and such situation cannot continue indefinitely, given that the economy is on an explosive path. In period 40 the economy goes into default and then returns to the crisis regime until the end of the simulation.

Figure 1 reports the results for the benchmark model (solid line) and for two alternative specifications that are useful to understand the key mechanisms at play. These alternative specifications imply the same sequence of events, but different agents' beliefs about the way the crisis is going to be resolved. In the first counterfactual scenario (dashed line), agents expect that the crisis regime can only be followed by a return to fiscal discipline or to a shift to the fiscally-led regime. Note that in this scenario, default comes as a surprise. In the second alternative scenario (dotted line), agents expect that the crisis can only be followed by a return to fiscal discipline or default. In other words, agents attach zero probability to a shift to the fiscally-led regime.

Figure 1. Fiscal Inflation and Cosmetic Defaults



Source: Author's research.

The figure reports three simulations based on the same sequence of events but under different assumptions about agents' beliefs. We start the simulation assuming that spending is low and that policymakers follow the exchange-rate-targeting policy mix. In period 3, the economy moves from the low-spending to the high-spending state. Initially, policymakers keep following the exchange-rate regime. In period 20, the fiscal authority starts deviating from passive fiscal policy, while monetary remains active. Therefore, the economy enters the crisis regime. In period 40 the economy goes into default and then returns to the crisis regime until the end of the simulation. Three alternative scenarios about agents' beliefs are considered. The first scenario (solid line) corresponds to the benchmark model in which agents expect that a crisis can lead to both default and a switch to the fiscally-led regime. In the second scenario (dashed line), agents expect that the crisis regime can only be followed by a return to fiscal discipline or to a shift to the fiscally-led regime. Note that, in this scenario, default comes as a surprise because agents form expectations thinking that this event will not occur. In the third and last scenario (dotted line), agents expect that the crisis can be only be followed by a return to fiscal discipline or default.

We shall start with the benchmark case. As soon as policymakers increase spending, the economy slightly slows down and inflation experiences a modest increase. As studied in detail in the next subsection, this is because now that spending is high, agents attach a larger probability to the possibility of a change in policy. However, these effects are modest when compared to the consequences of a deviation from fiscal discipline that implies a conflict between the monetary and fiscal authorities. Once the fiscal authority starts deviating from the passive rule, inflation jumps because agents understand that the possibility of moving to the fiscally-led regime just went up. At the same time, agents take into account the possibility of a default and this leads to an increase in the sovereign spread and a faster debt accumulation. Agents understand that under the fiscally-led regime the fiscal burden is relieved via an increase in inflation and a large depreciation. This creates inflationary pressure and a nominal depreciation. The central bank acts against the depreciation of the currency by increasing the short-term interest rate, causing a recession and a real appreciation.

These dynamics gain momentum as more time is spent in the crisis regime. The output loss is large and increasing over time. This spiral of debt accumulation and increasing output losses persists until the economy enters default. Default determines a temporary recovery in the economy because it lowers the inflationary pressure stemming from the existing fiscal burden. However, given that after the default the economy returns to the crisis regime, the recovery does not last, the debt-to-GDP starts increasing again and so does inflation. In other words, the economy experiences a *cosmetic default*: a drop in the fiscal burden that does not resolve the actual cause of the sovereign crisis and a lack of coordination between the monetary and fiscal authorities.

To understand the interaction between the possibility of moving to the fiscally-led regime and default, it is useful to analyze the behavior of the economy in the two alternative scenarios presented in figure 1. We start by considering the "only-default" case, in which agents believe that the conflict between the two authorities can lead to default, but not to a switch to the fiscally-led regime (dashed line). In this case, there is no drop in output or increase in inflation. This is because, in this model, default in itself is not costly. From the agents' point of view, Ricardian equivalence holds: a default comes with an equal reduction in the future fiscal burden. We could easily introduce an exogenous cost of default as done in the sovereign-debt literature but, for the mechanism that we aim to highlight here, such change would not make a difference. What matters is that default implies a faster debt accumulation because of the increase in the sovereign

spread. The larger spread, in turn, reflects the size of the eventual default that keeps increasing with time.

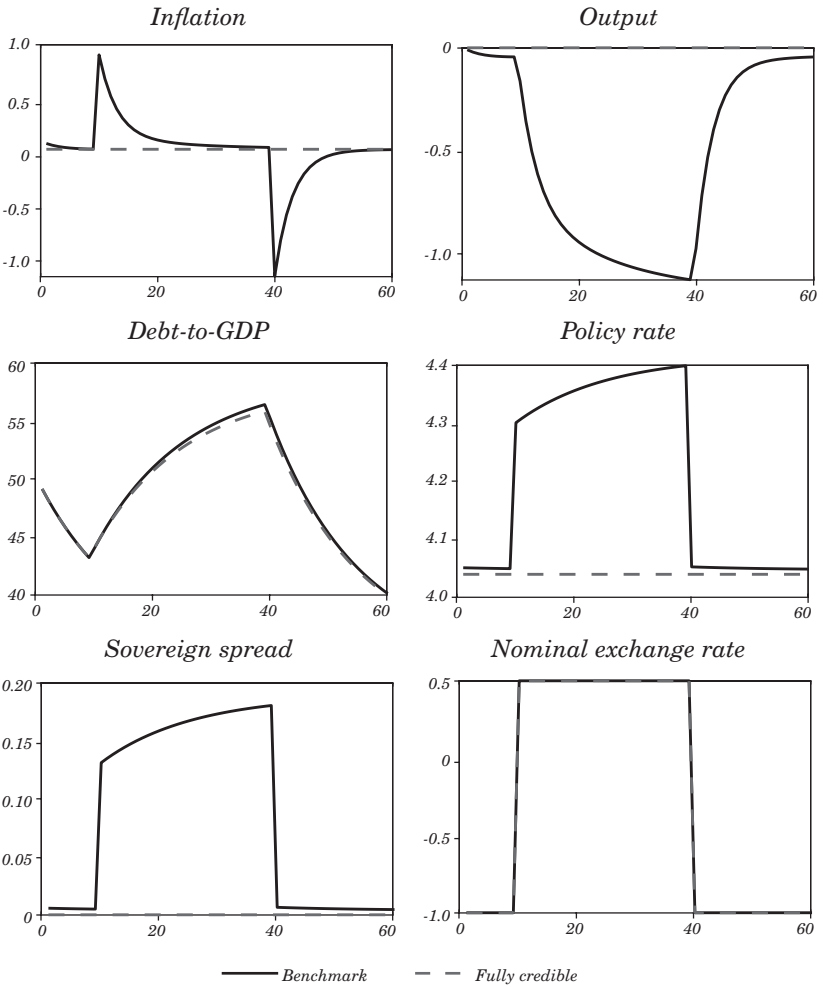
Now we shall consider the "only-fiscally-led" case, in which agents believe that the crisis cannot result in a default, but only in a switch to the fiscally-led regime. As before, high spending with no fiscal adjustment implies debt accumulation. However, now the large debt accumulation translates into stagflation because the expectation of moving to the fiscally-led regime implies inflationary pressure and a nominal depreciation. The central bank tries to contrast the devaluation, with a consequent increase in real interest rates. This contributes to further debt accumulation in a way similar to what is shown in Bianchi and Melosi (2017a). Note that because agents do not anticipate the possibility of a default, there is no increase in the sovereign spread. Thus, while the increase in the debt-to-GDP ratio is similar in magnitude to the previous case, the mechanism is quite different. In the only-default scenario, the increase is driven by the lack of fiscal adjustment and the increase in the sovereign spread. In the only-fiscally-led scenario, the increase is driven by the fall in output and the lack of fiscal adjustment.

In the "only-fiscally-led" scenario default comes as a surprise. Like in the benchmark scenario, default implies a partial relief in output dynamics because the amount of debt that needs to be stabilized is largely reduced. The drop in inflation is not large enough to bring the price level back to its pre-crisis value. This explains why the exchange rate and output do not jump back to their pre-crisis values. In a sense, the losses experienced during the crisis have memory, despite the fact that default brings the debt-to-GDP ratio back to its steady-state value. Intuitively this happens because the initial inflationary pressure was driven by a stock of debt that was large with respect to a larger GDP. The drop in the debt-to-GDP ratio removes part of the inflationary pressure, but with respect to a smaller level of output. Finally, even in this second alternative scenario, the default is just cosmetic. It does not resolve the underlying fiscal issues. Stagflation resumes after a short period of time, as the debt-to-GDP ratio starts increasing again.

We are now ready to understand how default and the possibility of moving to the fiscally-led policy mix interact with each other. Output losses are visibly larger in the benchmark case when compared to the only-fiscally-led case. This is because the possibility of default leads to larger debt accumulation as a consequence of the increase in the sovereign spread. Thus, while default in itself is not costly in this model, the possibility of default is. Furthermore, not only are output losses larger, but also the crisis accelerates over time. This can be seen both in

the dynamics of inflation and output. Inflation, instead of stabilizing on a higher value as in the only-fiscally-led case, presents a hump shape. Symmetrically, the output loss increases with an accelerating pace. Thus, the lack of a clear resolution to the debt crisis leads to increasingly larger output losses as debt keeps growing at an increasing rate.

Figure 2. The Effects of High Spending during Regular Times



Source: Author's research.
The figure considers a simulation in which policymakers always follow the exchange-rate-targeting policy mix and spending moves from low to high (in period 10) and back from high to low (in period 40). The simulation is conducted for the benchmark model in which policy changes can occur (solid line) and for an alternative model in which the exchange-rate-targeting regime is assumed fully credible and always in place.

The current framework could be extended in a number of directions. For example, while short-lasting deviations from fiscal responsibility might not be problematic, prolonged deviations might lead to a progressive deterioration in agents' beliefs about the effective ability of policymakers to implement the necessary fiscal adjustments in a way similar to what is studied in Bianchi and Melosi (2013). Such framework would lead to a progressive deterioration of agents' confidence about future policymakers' behavior as opposed to jumps as modeled in this paper. However, the key message of the paper would not change: Lack of coordination between the monetary and fiscal authorities lead to stagflation and the possibility of sovereign debt crises.

2.2 Output Losses from Fiscal Inflation

As a second exercise, we focus on the behavior of the economy when no crisis occurs but agents understand that high spending might trigger a crisis in the future. For example, agents might think that political pressure might prevent the high level of taxation necessary to finance the larger spending level. We consider the benchmark model and an alternative calibration in which agents are fully confident that policymakers will always behave according to the exchange-rate-targeting regime. In other words, the exchange-rate-targeting regime is the only possible policy mix and it is therefore perceived to be in place for the infinite future. We call this scenario fully credible exchange-rate targeting. It is worth mentioning that this corresponds to a traditional small open economy DSGE model with fixed coefficients in which the monetary authority targets the exchange rate.

Figure 2 shows the behavior of the main variables as the economy moves between low spending and high spending. Under the benchmark scenario, when the economy enters a period of high spending, agents understand that the probability of policymakers deviating from the exchange-rate-targeting regime just went up. This causes inflationary pressure and a nominal depreciation. The central bank increases the policy rate to counteract the depreciation. This results in a recession and a real appreciation. Note that policymakers are still following the exchange-rate-targeting regime. Stagflation is driven by the expectation that a crisis might occur in the future. To see this, note that under the alternative scenario in which the exchange-rate-targeting regime is fully credible, Ricardian equivalence holds and we do not see any effect of the change in spending on the real economy.

The effects of the risk of entering a crisis are asymmetric. When spending is low, output is still below trend. This is so because of two reasons. First, agents do not expect policymakers to abandon the regime when spending is low. Thus, there is no deflationary pressure that the central bank might try to counteract by lifting the economy. Second, agents are forward-looking and they anticipate the poor economic performance associated with high spending. Thus, unlike most models studied in the literature, fiscal inflation is not neutral, in the sense that we never have beneficial effects on real activity arising from fiscal inflation if the central bank remains committed to stabilizing the exchange rate (or any other active monetary-policy rule). This result derives from the realistic assumption that policymakers have incentives to deviate from active fiscal stabilization only when spending is high, because high spending requires increasing taxation. Thus, policy uncertainty leads to both a more volatile environment and output losses. On the one hand, the economy is not insulated with respect to fiscal imbalances. On the other hand, fiscal imbalances do not act symmetrically. Summarizing, even when no crisis occurs, the lack of a fully credible commitment to the exchange-rate regime represents a drag on the economy. To insulate the economy from fiscal disturbances, policymakers need to keep the level of spending under control or provide credible plans for how high spending will be financed.

2.3 Confidence Crisis

The previous section has shown that the current framework is able to generate inflationary pressure even when policymakers implement a passive fiscal policy. Agents take into account the possibility that when spending is high policymakers might eventually abandon the necessary policy of high taxation. In this section, we go one step further and show that a sovereign crisis with large increases in inflation can occur even when fundamentals are strong as a result of a shift in agents' beliefs.

In order to do so, we modify the benchmark model in a parsimonious way. We assume that during the crisis regime, the behavior of policymakers is unchanged with respect to the exchange-rate-targeting regime, whereas agents' beliefs about future policies experience the same change assumed in the benchmark model. This implies that the expectations of a default or of a switch to the fiscally-led regime present a discrete jump as in the benchmark model despite the fact that policymakers' behavior is unchanged. How should we interpret this

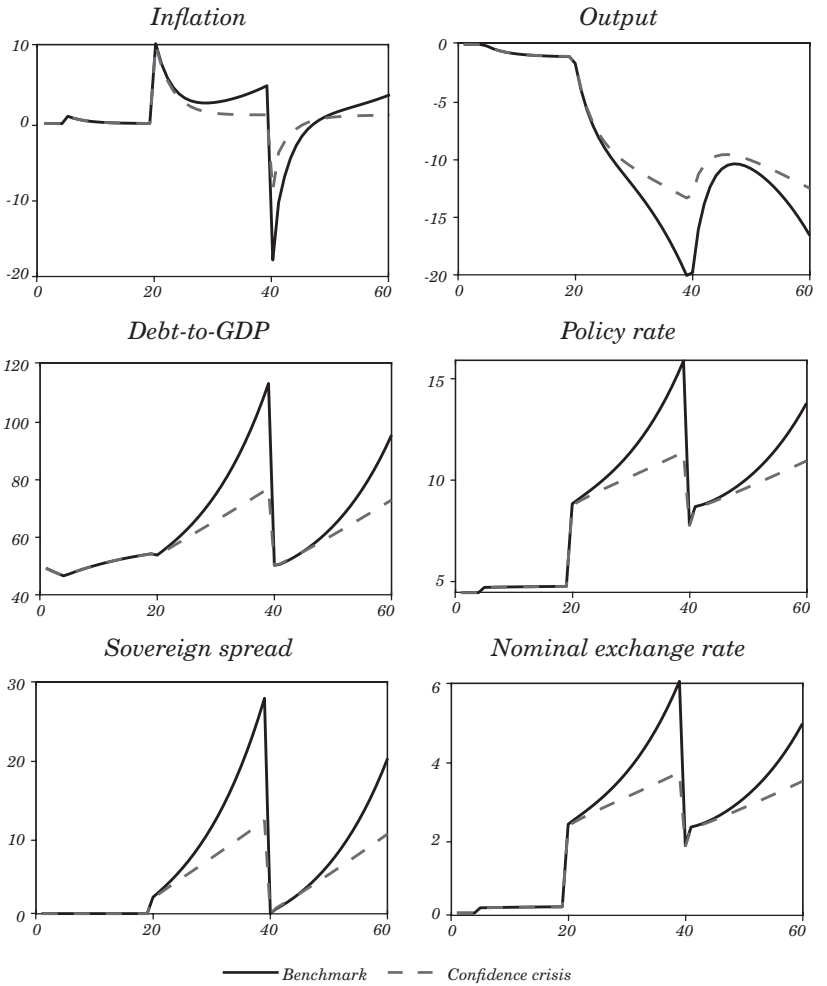
scenario? In the benchmark model, agents become more pessimistic about long-run fiscal sustainability because of a change in the current fiscal stance. However, in reality, agents' expectations about future fiscal developments can change even as a result of announcements, news, or political events such as a change in the ruling party. Countries around the world present a plethora of such situations: A new party wins the elections and spreads jump to reflect markets' expectations about the policies that such party is expected to implement.

Figure 3 revisits the benchmark simulation of subsection 2.1 under these modified assumptions. The solid line corresponds to the benchmark case studied before. The dashed line considers the alternative scenario in which the crisis originates from a lack of confidence with respect to future fiscal behavior, without a change in current policymakers' behavior. As in the benchmark case, entering the crisis determines a large jump in inflation and an immediate depreciation. The real exchange rate appreciates as a consequence of the high inflation. As in the benchmark case, the high spread and the contraction in real activity determine a large accumulation of debt. This is despite the fact that policymakers are actually increasing the level of taxation as the debt-to-GDP ratio increases. Policymakers' actions are not enough to prevent the increase in debt, but they are able to prevent the explosive dynamics observed under the benchmark case. Thus, there is no acceleration in the downward spiral of large debt accumulation and stagflation dynamics.

The fact that a crisis can arise from lack of confidence about long-run fiscal sustainability highlights the importance of policymakers' communication. The key mechanism is similar to what we illustrated for the benchmark model: If agents start expecting that a switch to a fiscally-led regime will be implemented eventually to curb the fiscal burden, inflationary pressure arises today. In this situation, monetary-policy interventions prevent a full depreciation of the nominal exchange rate, thus causing a real appreciation and a recession.

Interestingly, this exercise shows that an economy can end up in a situation in which debt keeps increasing despite the fact that stabilizing fiscal policies are in place. This is important because the level of taxation necessary to prevent accelerating increases in the debt-to-GDP ratio can become very large. In this model, there is no explicit feedback from the level of taxation to the switch to fiscally-led regime. But in reality, high levels of taxation might be politically unsustainable and lead to a switch to the fiscally-led regime, thus making the initial deterioration in confidence self-fulfilling.

Figure 3. The Effects of a Confidence Crisis



Source: Author's research.

The figure compares a sovereign debt crisis under the benchmark model (solid line) with an alternative scenario in which the crisis is triggered by loss of confidence about future policymakers' behavior (dashed line). Spending is initially low and policymakers follow the exchange-rate-targeting policy mix. In period 3, the economy moves from the low-spending to the high-spending state. Initially, policymakers keep following the exchange-rate regime and agents are confident that they will keep doing this in the future. In period 20, agents become pessimistic about future policymakers' behavior and expect that a default or a switch to the fiscally-led regime might occur in the future. Thus, the economy enters the crisis regime. In period 40, the economy goes into default and then returns to the crisis regime until the end of the simulation. In the benchmark scenario, policymakers deviate from fiscal stabilization, while in the confidence crisis policymakers keep following the same rule.

2.4 When a Default can Resolve a Crisis

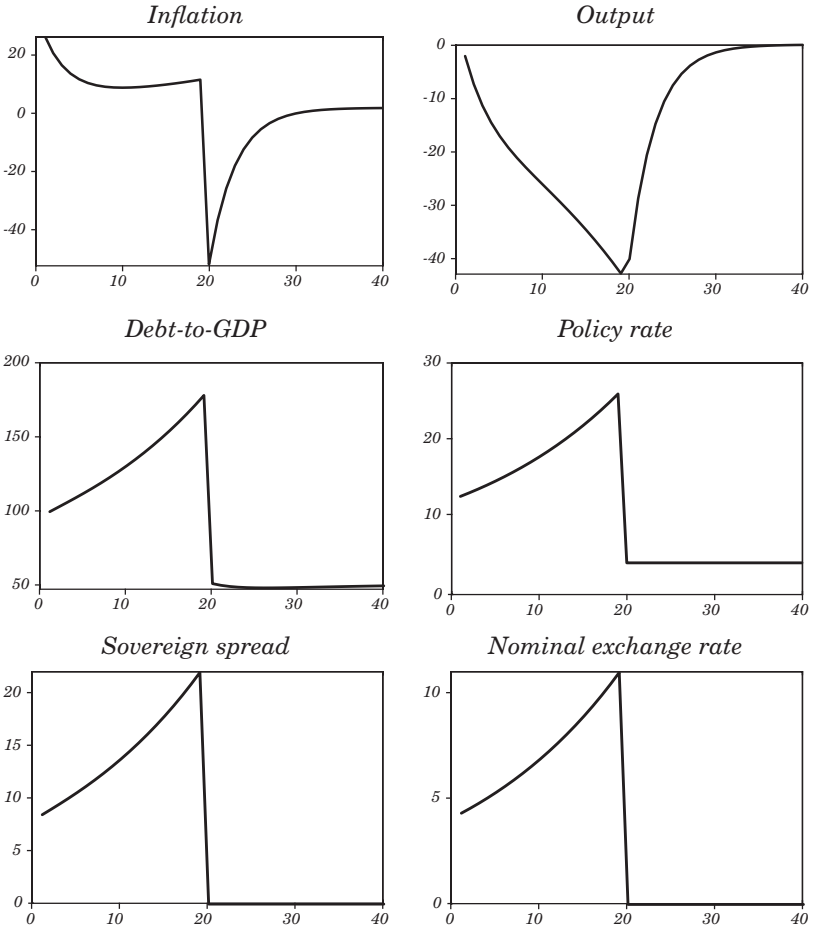
In this section, we discuss when a default is more likely to resolve a sovereign debt crisis. Intuitively, a default can facilitate a resolution of a sovereign debt crisis if the original sin that led to the crisis is not related to future policymakers' behavior. Moreover, as we argued above, a default cannot be the solution to the fiscal burden arising from future fiscal developments. Thus, a default is more likely to pave the way to fiscal discipline if the reason why the economy entered a sovereign debt crisis is related to an exogenous exceptional event, such as an unusually large recession or a rare disaster. Admittedly, the occurrence of one of these circumstances is not common. Nevertheless, it is instructive to review this thought experiment.

To capture this idea, we modify the benchmark model in the following way: We assume that the economy is currently in a sovereign debt crisis with a large stock of debt (100 percent of GDP). From the crisis regime, the economy can move to the fiscally-led regime, in which case the stock of debt will be stabilized with inflation, or enter default and then move to the exchange-rate-targeting regime, in which case default will be used to erase the fiscal burden. We do not explicitly model what caused the large debt accumulation in the first place because it is not relevant for the results discussed below. What is instead important is that we remove the persistent shocks to government spending and the possibility of moving away from fiscal discipline once the economy enters the exchange-rate-targeting regime. These changes are supposed to capture the idea that there is no systemic problem of long-run fiscal sustainability, but rather a contingent issue caused by the exceptionally large stock of debt. Summarizing, the transition matrix controlling regime changes is now given by:

$$\mathcal{P} = \mathcal{P}^p = \begin{bmatrix} & E & C & D & F \\ E & 1 & & 1 & 0 \\ C & & .96 & & \\ D & & .02 & & \\ F & & .02 & & 1 \end{bmatrix}$$

Note that both the exchange-rate-targeting regime and the fiscally-led regime are now absorbing states and that we do not have discrete shocks to spending anymore. Once the current crisis is resolved, the economy will remain in one of the two absorbing regimes and no further crises will arise.

Figure 4. Non-Cosmetic Defaults



Source: Author's research.
We consider a case in which the economy is currently in a sovereign crisis due to a large debt accumulation that occurred in the past, as opposed to a systematic fiscal issue. From the crisis regime the economy can move to the fiscally-led regime or to the default regime and from there to the exchange-rate-targeting regime. The economy experiences default in period 20 and then moves to the exchange-rate-targeting regime.

Figure 4 presents the results for a simulation in which the economy inherits a large stock of debt (100 percent of GDP) and for the first 20 quarters the economy is in the crisis regime. As before, this means that the fiscal authority refuses to make the necessary fiscal adjustments, while the monetary authority insists on a stable exchange rate. During

the crisis period, the economy behaves in a way that is very similar to what was described before. The possibility of moving to the fiscally-led regime creates inflationary pressure that the central bank tries to counteract to avoid a depreciation of the exchange rate. Once again, the economy enters a spiral of inflation, contractions in real activity, and further debt accumulation. In period 20, the economy enters default and then moves to the exchange-rate-targeting regime. Unlike the benchmark scenario studied above, now when the economy enters default, the spiral of stagflation and debt accumulation ends. This is because in this case the economy does not just experience a cosmetic default. Instead, the default paves the way to a shift to the exchange-rate-targeting regime. The sovereign spread goes to zero, debt jumps to its steady-state value, and the economy progressively recovers.

What about a shift to the fiscally-led regime? In this case, such regime change might be perceived as very costly. First, such shift implies abandoning the exchange-rate target. Furthermore, a shift to the fiscally-led regime makes the economy more volatile. In the future all fiscal disturbances will affect the macroeconomy, while under the exchange-rate-targeting regime the macroeconomy is insulated against fiscal disturbances. Bianchi and Melosi (2017b) discuss how these issues can be circumnavigated by implementing a shock-specific rule that boils down to generating enough inflation to stabilize the existing stock of debt without affecting future fiscal discipline. However, if policymakers lack the ability to communicate a credible plan for future inflation and debt stabilization, default might be the only remaining option.

The analysis here is simplified in a number of dimensions. In practice, it can be hard to establish whether the current fiscal situation is in fact the result of a purely exogenous event. Furthermore, a default might create expectations of future defaults, while here we assume that, once the existing stock of debt is stabilized, no further fiscal imbalances arise. Finally, as mentioned repeatedly in the paper, default is not costly in this model. Nevertheless, the simple simulation presented here presents a case in which a country might prefer default over moving to a fiscally-led regime. Changing the policy mix implies a persistent shift in agents' expectations about future policymakers' behavior. In fact, a switch to the fiscally-led regime works in curbing the fiscal burden only if it is perceived to be very persistent. Instead, default does not require a change in expectations about future policymakers' behavior.

3. The Chilean Experience

In this section, we review some key moments of the Chilean economic history and explain how they can be mapped into the model presented above. Caputo and Saravia (2018), whom I use as main reference here, provide a more comprehensive exposition of Chilean economy history. A full estimation of the model proved challenging due to data availability and because the model is to some extent stylized. However, as we shall see, the model can still be useful to interpret different moments of Chilean economic history.

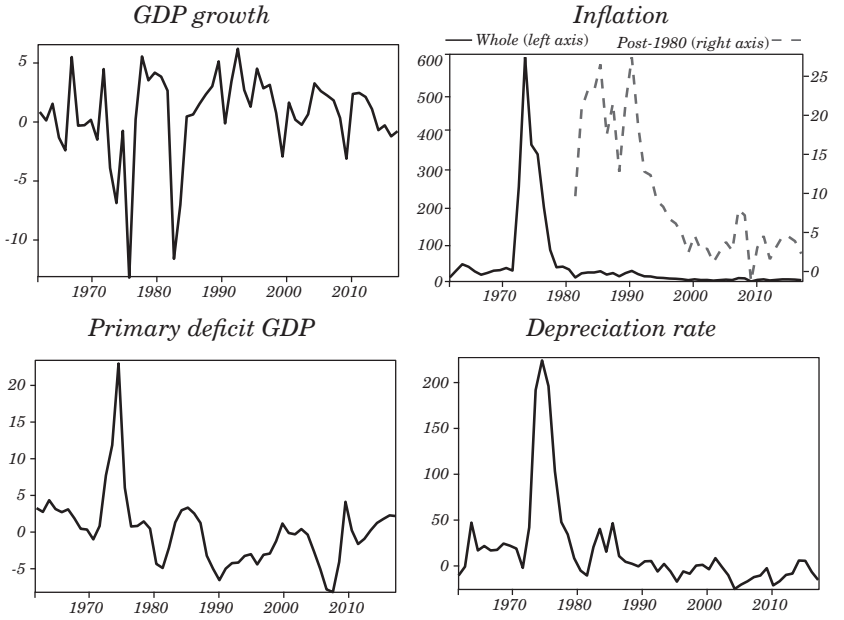
As guidance for our discussion, figure 5 reports GDP growth, inflation, primary deficit-to-GDP ratio, and the depreciation rate against the dollar. All data are at annual frequency and expressed in percentage points. For inflation, we report the series for the whole sample (solid line and scale on the left axis) and for the post-1980s period (dashed line and scale on the right axis) to facilitate the analysis for the post-1980s period, given that the hyperinflation of the 1970s is an order of magnitude larger than what was experienced over the rest of the sample. We cover the period from 1960 to 2018.

From fiscal inflation to fiscal hyperinflation (1960–1973) The Chilean economy had been struggling with the problem of controlling high inflation rates since before the period considered in this paper. Quite interestingly, this was not because of a lack of understanding about the origins of inflation. Already in 1955, the consulting firm Klein-Saks had brought to the attention of the government the tight connection between high fiscal deficits and inflation. In the late 1950s, Alessandri's administration tried to remedy these issues by introducing fiscal adjustments and a fixed exchange-rate regime. These policies were initially successful in lowering inflation to single digits, but the success did not last. Already in the early 1960s, primary deficits jumped back to values around 3 percent of GDP, thus creating significant inflationary pressure. Consistently with the predictions of the model, lack of credibility about the commitment to fiscal discipline makes a fixed exchange rate unsustainable. Thus, following a balance of payments crisis, the fixed exchange rate was abandoned.

Frei's administration took over in 1964 and started implementing a vast series of reforms. The administration took a pragmatic approach to the goal of curbing inflation. From a fiscal point of view, deficits were progressively reduced. Accordingly, inflation started drifting down. However, the adjustment eventually failed in part because of a policy of constant devaluation that put upward pressure on inflation, as

shown in the lower-right panel of figure 5. In other words, the nominal anchor represented by the nominal exchange rate was abandoned and not adequately replaced by an alternative one. As explained by Caputo and Saravia (2018), extraordinary transfers, defined as additional obligations not accounted in the central government primary deficit, kept increasing over this period. These extraordinary transfers represent an additional fiscal burden and create inflationary pressure. As a result of the hyperinflation, the peso experienced a very large devaluation.

Figure 5. Chilean Macroeconomic Data



Source: Author's research.

The figure reports the growth rate of GDP per capita, inflation, the primary deficit-to-GDP ratio, and the depreciation rate of the Chilean peso against the U.S. dollar. All variables are computed at annual frequency and expressed in percentage points. For inflation, we report the series for the whole sample (solid line and scale on the left axis) and for the post-1980s period (dashed line and scale on the right axis) to facilitate the analysis for the post-1980s period, given that the hyperinflation of the 1970s is an order of magnitude larger than what was experienced over the rest of the sample.

It is well known that the period that followed was one of great political instability. President Allende took office in 1970 and his administration ended in 1973 following a military coup. Allende's administration implemented an aggressive fiscal expansion. The primary deficit reached unprecedented levels. Initially, the fiscal expansion led to an increase in output with no significant increase in inflation. This was in part due to price controls. However, the successive acceleration in fiscal deficits led to hyperinflation. In 1973, the primary deficit-to-GDP ratio reached 23 percent, and inflation took off and reached a staggering 600 percent. This also came with a contraction in output, consistently with what was shown before. However, it is important to keep in mind that this was a period of great turmoil. This implies that some of the output losses experienced during these years cannot be captured by a simple economic model that abstracts from the consequences of a severe political conflict.

Ending hyperinflation (1974–1981) General Pinochet took power in September 1973 after a military coup. Pinochet's administration implemented a stabilization policy. Note that the primary deficit-to-GDP ratio declined abruptly from 22.5 percent of GDP in 1973 to a 0.4 percent in 1975. The result was accomplished by a combination of cuts to transfers and tax increases. The government also proceeded to liberalize the prices that were previously regulated. Despite the change in the conduct of fiscal policy, inflation remained extremely high. The fact that the change in fiscal stance did not immediately lead to a drop in inflation can be interpreted in light of the results of subsection 2.3: High inflation can arise despite the current fiscal stance if agents are not confident about future fiscal interventions. The high levels of inflation persisted even though the economy experienced a large contraction due to external shocks and fiscal consolidation. In the model, a large recession induces inflationary pressure by increasing the fiscal burden as a result of the increase in the debt-to-GDP ratio.

In the late 1970s, the effort on the fiscal side was combined with a change in the conduct of monetary policy. The goal was to provide a nominal anchor for inflation expectations. Specifically, the central bank started targeting a known devaluation rate and eventually moved to a fixed exchange-rate target regime in June 1979. In the context of the model presented above, such change indicated a shift to active monetary policy, while the policy of primary surpluses indicated a change to passive fiscal policy. Thus, the economy effectively moved to an exchange-rate-targeting regime that then morphed into a fixed exchange-rate regime. The change in the policy mix led to a

stabilization of inflation, that in 1981 fell to a single digit value (9.53 percent). Importantly, and consistently with the model, the stabilization of inflation involved a change in both monetary and fiscal policy. By 1980, the government was running a large primary surplus.

Debt crisis and its aftermath (1982–1988) The fixed exchange-rate regime came to an abrupt end in the early 1980s. A fixed exchange rate implies tieing domestic monetary policy to foreign monetary policy. In the early 1980s, President Reagan provided the necessary political support for the Fed Chairman Paul Volcker to engineer a drastic change in the conduct of monetary policy. A prolonged period of low real interest rates came to an end. Bianchi and Ilut (2017) interpret these events in light of a shift in the monetary-fiscal policy mix in the United States. This change had severe repercussions on the world economy, with a sharp increase in world interest rates. Chile, like many other countries around the world, found itself in a difficult situation, and expectations about the sustainability of the fixed exchange rate suddenly shifted. As in the model, such shift in expectations contributed to an economic slowdown and an increase in inflation. The fixed exchange-rate regime was abandoned in 1982.

The Chilean government moved quickly to rescue the banking sector that had contracted obligations in U.S. dollars. Even if these interventions were operationally conducted by the central bank, the policies were actually sustained by the fiscal authority. The implied increase in the fiscal burden created inflationary pressure. As argued above, in this situation a cosmetic default would not be able to solve the financial crisis. Instead, the possibility of a cosmetic default exacerbates the vicious circle of stagflation and debt accumulation arising from the crisis. In light of this result, it is extremely interesting that the Chilean government moved forcefully in the direction of removing default as a possible outcome of the crisis. A very rigid and unpopular fiscal plan was put into place to sustain the cost of rescuing the private sector. These policies, even if not popular, were arguably better suited to deal with the underlying cause of the inflationary pressure and created the basis for the subsequent conquest of inflation. Nevertheless, until the early 1990s, inflation remained high, in part reflecting policy uncertainty linked to the return to democracy in 1989.

The conquest of Chilean inflation (1989–2018) The governments that followed the return to democracy maintained a conservative fiscal stance, with a sequence of primary surpluses meant to pay the obligations contracted by the government to cover the losses of the private sector in the early 1980s. This conservative fiscal policy

was combined with an exchange-rate-targeting policy implemented by a now independent central bank (1989). The two policies led to a progressive reduction of inflation, consistently with the implications of a monetarily-led policy mix.

The Asian crisis came to challenge the sustainability of the exchange-rate-targeting regime. Thus, in September 1999, the central bank moved to an inflation-targeting regime. Note that this regime, if combined with a low-inflation target, effectively delivers exchange-rate stability without the constraints of a formal exchange-rate-targeting regime. Importantly, while the central bank was undergoing this transition, the fiscal authority implemented an equally important change. The government introduced a fiscal rule meant to stabilize spending over the business cycle and guarantee long-run fiscal sustainability. The rule implies that the government runs primary surpluses during expansions and use the corresponding savings to mitigate recessions.

As predicted by the model, a now independent central bank was able to attain stable inflation at the moment the fiscal authority provided the necessary fiscal backing. Furthermore, the exchange rate has been quite stable over the past twenty years, despite the fact that the central bank is not explicitly targeting it. This suggests that an inflation-targeting monetary-policy rule can be quite successful in delivering a stable exchange rate. In fact, inflation targeting might be better suited to achieve a stable exchange rate given that it is a more flexible policy regime. Countries often choose an exchange-rate monetary rule to acquire credibility. But, as shown in this paper, such policy can quickly become unsuccessful if not supported by a credible fiscal policy. The experience of Chile confirms that a stable macroeconomic environment requires coordination between the monetary and fiscal authorities.

4. Conclusions

In this paper, we studied the interaction between the monetary and fiscal authorities in a small open economy in presence of default. Fiscal inflation arises whenever the commitment of the fiscal authority to stabilize debt is not fully credible. Deviations from fiscal discipline can arise from various events. For example, an unusually large recession might limit the ability or willingness of the fiscal authority to raise large primary surpluses. We decided to focus on a situation in which fiscal inflation stems from high levels of spending. This is arguably

a situation that has been relevant for several countries at different points in time. Unlike the case in which fiscal inflation arises from an exceptional event, this scenario is likely to lead to prolonged and repeated periods of economic and financial turmoil because the roots of fiscal inflation are systemic.

We discussed that if the fiscal authority deviates from fiscal discipline and the central bank tries to rein in inflation and a devaluation, the economy enters a sovereign debt crisis characterized by a spiral of debt accumulation, recession, and further debt accumulation. Importantly, a cosmetic default does not represent a solution to the sovereign debt crisis. A cosmetic default is unable to stop the vicious circle of debt accumulation and stagflation because it does not resolve the underlying fiscal issues that are creating inflationary pressure. In fact, the possibility of a cosmetic default exacerbates the vicious circle because it determines an increase in sovereign spreads and, as a result, faster debt accumulation.

The analysis presented in the paper could be extended in a number of directions. First, it would be interesting to go beyond the assumption of complete markets. Removing this assumption would not change the key lessons of the paper, but it would rather make the model more realistic and suitable for a structural estimation. Second, default could be made costly, in a way to account for the fact that countries are reluctant to declare default. This change would arguably reinforce the results of the paper because it would make the role of the fiscally-led regime even more prominent. Third, it would be interesting to explicitly model the feedback from the level of taxation to the probability of moving away from fiscal discipline. Right now the model captures this link by making the probability of moving away from fiscal discipline dependent on the level of spending, but more sophisticated formulations could be considered. Even in this case, the results presented in this paper would still hold, but new interesting results would arise such as self-fulfilling sovereign crises and policy changes.

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APPENDIX

1. THE MODEL

In this appendix, we present the model equations for the model used in the paper.

A. Nonlinear First-Order Condition

1. Household:

$$\rho_{t,t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-1}\frac{P_t}{P_{t+1}}.$$

2. Risk-free rate:

$$R_t \equiv \frac{1}{E_t\left[\rho_{t,t+1}\right]}$$

3. Risk-sharing:

$$\frac{C_t}{C_t^*} = vQ_t = \frac{vP_t^*\chi_t}{P_t}$$

where $v = \left(\frac{C_{-1}}{C_{-1}^*}\right)\left(\frac{P_{-1}}{\chi_{-1}P_{-1}^*}\right)$ reflects initial conditions and it is normalized to 1.

4. Labor supply:

$$\frac{W_t}{P_t} = \frac{C_t}{N_t^{\varphi}}$$

5. Taylor rule:

$$R_t = \beta^{-1}\Pi_{H,t}^{\phi_{\pi,\xi_t^p}} E_t^{\phi_{e,\xi_t^p}}$$

6. Government budget constraint as in Bianchi-Ilut:

$$I_t^{-1}B_t = B_{t-1}\left(1 - D_t\right) - T_t + S_t$$

where S_t is a spending shock with mean zero.

7. Fiscal rule in terms of debt-to-GDP (with debt at market value):

$$\tau_t - \tau = \delta_b \left(\frac{I_{t-1}^{-1} B_{t-1}}{Y_{t-1} P_{t-1}^H} - \frac{\tau}{\frac{1}{\beta} - 1} \right)$$

$$\tau_t - \tau = \delta_b \left(b_{t-1} - b \right)$$

with $\tau_t = \frac{T_t}{Y_t P_t^H}$ and $b = \frac{\tau}{\frac{1}{\beta} - 1}$ is the steady-state value of the debt-to-GDP ratio.

B. Linearized Model

The model is linearized with respect to taxes, government expenditure, and debt, whereas it is log-linearized with respect to all the other variables. We obtain a system of equations:

1. Linearized system of equations:

$$y_t = E_t y_{t+1} - \bar{\omega} \left(r_t - E_t \pi_{H,t+1} \right)$$

where $\bar{\omega} \equiv 1 + \omega(2 - \omega)(\sigma - 1)$.

2. New-Keynesian Phillips curve:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa \left(\varphi + \bar{\omega}^{-1} \right) y_t$$

where $\kappa \equiv \frac{(1 - \beta\theta)(1 - \theta)}{\theta}$.

3. Real exchange rate and production under complete markets:

$$y_t = \frac{\bar{\omega}}{1 - \omega} q_t.$$

4. Real and nominal exchange rate:

$$q_t = (1 - \omega) \left(e_t - p_{H,t} \right).$$

5. Government budget constraint:

$$b_t = \left(\frac{b}{\beta} \right) \left(i_{t-1} - \pi_{H,t} - d_t - y_t + y_{t-1} \right) + \left(\frac{1}{\beta} \right) b_{t-1} - \tau_t + s_t.$$

where we linearize with respect to the fiscal variables and log-linearize with respect to the other variables. For simplicity, we now use lower case letters x_t to denote linear or log-linear deviations from steady state.

6. Fiscal rule:

$$\tau_t = \delta_b b_{t-1}.$$

7. Sovereign-bond yield:

$$i_t = r_t + E_t d_{t+1}.$$

8. Monetary policy:

$$r_t = \phi_{\pi,\xi_t} \pi_{H,t} + \phi_{e,\xi_t} e_t.$$

9. Default:

$$1_{\xi_t} b_t + \left(1 - 1_{\xi_t}\right) d_t = 0.$$

10. Definition of inflation:

$$\pi_{H,t} = p_{H,t} - p_{H,t-1}.$$

11. Expectation error for inflation:

$$\eta_{\pi,t} = \pi_{H,t} - E_{t-1}\pi_{H,t}.$$

12. Expectation error for output:

$$\eta_{y,t} = y_{H,t} - E_{t-1} y_{H,t}.$$

13. Expectation error for default:

$$\eta_{d,t} = d_t - E_{t-1} d_t.$$