Monetary Policy and Sovereign Risk in Emerging Economies (NK-Default)*

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Abstract

This paper develops a New Keynesian model with sovereign default risk. Inflation is set by forward-looking firms, monetary policy is an interest rate rule, and the fiscal government borrows externally, long-term, with an option to default. In this framework, default risk creates inflation pressures through an expectations channel, and tight monetary policy disincentivizes fiscal overborrowing. The model sheds light on temporary inflation events in emerging market data, short-lived spikes in inflation, spreads, and domestic policy rates. As spreads rise, firms increase their prices in expectation of higher future inflation during defaults. Monetary policy tightens, which reduces inflation and helps bring spreads down by disciplining government borrowing. These monetary-fiscal interactions imply that delivering the flexible price allocation may not be optimal for monetary policy.

Keywords: sovereign default, inflation, open economy, New Keynesian theory
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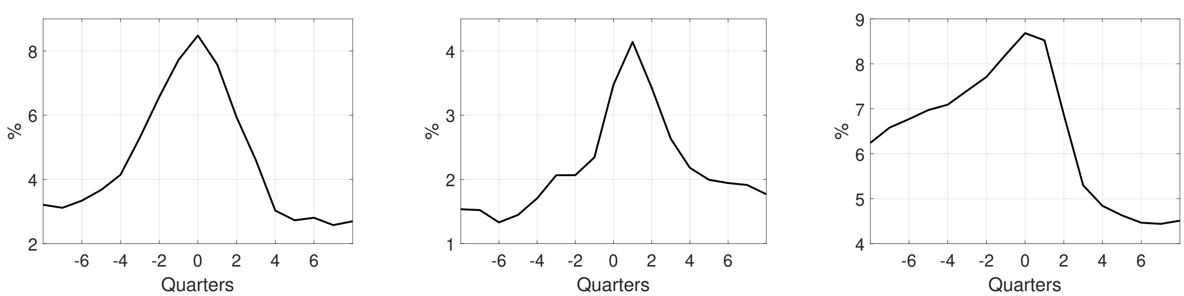
1 Introduction

Since the early 2000s, many central banks in emerging markets have successfully reduced inflation to single-digit levels and achieved policy independence from central governments. As in advanced economies, monetary policy in many emerging markets now largely consists of setting domestic nominal interest rates to target inflation. However, the open economy New Keynesian monetary model, a main toolkit for emerging market central banks, abstracts from sovereign risk, which is a major source of economic fluctuations in these countries. For example, the influential paper by Galí and Monacelli (2005) analyzes monetary policy under perfect financial markets. To bridge this gap, this paper develops a New Keynesian model that integrates sovereign default and investigates the interplay between monetary policy and sovereign risk. Our findings indicate that sovereign risk affects not only real economic activity but also acts as a critical amplifier of inflation.

One motivation for our work is the empirical regularity that in emerging markets inflation co-moves positively with sovereign risk. We illustrate this pattern in Figure 1, which shows the time path for inflation, sovereign spreads, and nominal rates during *inflation events*, for eight emerging markets inflation targeters over the last two decades.[1] During these events, inflation temporarily rises about 4.5%, sovereign spreads increase by about 2.3%, and central banks increase nominal rates to combat inflation. Notably, the elevated inflation is only temporary, and all variables returned to lower levels within about a year. We use our model to shed light on the co-movements between inflation and sovereign risk and perform counterfactual analyses to understand the role of default risk in shaping inflation dynamics.



(a) Inflation (b) Spread (c) Nominal Rate

Figure 1: Temporary Inflation Events

In our framework, as in standard New Keynesian models, inflation is determined by firms' forward-looking pricing decisions, which relate current inflation to firms' marginal cost and expectations of future inflation. Monetary policy follows an interest rate rule that targets inflation. As in sovereign default

[1] The events are constructed with data from Brazil, Chile, Colombia, Mexico, Peru, the Philippines, Poland, and South Africa. Spreads are from dollar-denominated government bonds relative to U.S. bonds. Further information on the sample, variables, and construction of these events is in Section 4.1.

models, the government chooses how much to borrow and whether to repay its debt or default. The risk of default plays a crucial role in exacerbating inflation and amplifying monetary distortions because it increases inflation expectations. Default events are associated with elevated inflation because of lower productivity and loose monetary policy. With a high risk of default, therefore, firms tend to increase their prices in anticipation of future inflation.

Monetary policy affects consumption and inflation, as standard, but in our model it also alters borrowing incentives for the government and therefore default risk. Default risk is reduced with tight monetary policy because monetary distortions act as additional costs on government borrowing. Our integrated *NK-Default* framework can rationalize the inflation event paths found in the data and sheds light on the sources of elevated inflation. Through counterfactual experiments, we determine that default risk accounts for about 45% of the increased inflation.

Our small open economy model consists of households, firms, a monetary authority, and a government that borrows internationally. Households value the consumption of foreign and domestic final goods. Consumption is determined through an intertemporal condition that responds to domestic interest rates, set by monetary policy, and sovereign default risk, which changes expectations of future consumption. Households supply labor to firms that produce varieties of domestic intermediate goods and set their prices under monopolistic competition. The intermediate goods firms are subject to productivity shocks and face frictions in setting their prices, in the tradition of Rotemberg (1982). Final domestic goods firms are competitive and use intermediate goods varieties to produce domestic output, which is consumed by domestic households and exported to the rest of the world. The monetary authority sets a local currency, nominal interest rate, using an interest rate rule subject to monetary policy shocks. Our baseline monetary rule targets inflation deviations from target, but we also consider alternative rules. As in standard New Keynesian models, the interaction of monetary policy and firms' pricing frictions generates monetary distortions which consist of deviations of inflation from target and inefficient levels of production, which we label as monetary wedges.

The government borrows internationally by issuing defaultable long-term bonds denominated in foreign currency, and transfers the proceeds from these operations to households. Default leads to a reduction in productivity and temporary exclusion from financial markets. The focus on foreign currency debt allows us to abstract from the better-understood fiscal-monetary interaction whereby inflation can reduce the real value of local currency debt. The price of bonds compensates risk-neutral lenders for time-varying default risk. Default risk is a crucial fiscal outcome that affects real and monetary variables.

In this environment, we identify two main monetary-fiscal interactions. First, default risk amplifies monetary frictions by increasing inflation and worsening monetary wedges. When default risk is high, it triggers expectations of future high inflation and recession. High expected inflation tends to increase current inflation through the pricing decisions of firms. Low expected future consumption lowers current consumption through households' intertemporal consumption-smoothing condition, which results in depressed production and a worsening of the monetary wedge now. These effects highlight the significance of default risk for monetary outcomes, and we refer to this channel as *default amplification*. Second, tight monetary policy can reduce default risk, as monetary distortions tend to disincentivize government borrowing. The key is that the government internalizes the costs of default amplification for the private economy and can relax the monetary distortions by reducing default risk. We show that monetary friction leads to borrowing wedges in the optimal borrowing condition of the government, which reduce sovereign borrowing incentives and enforce *monetary discipline*, resulting in lower default risk in equilibrium. Moreover, lowering default risk is useful in our model because the government tends to over-borrow and experience excessively frequent costly defaults.[2]

We establish that monetary policy interacts with sovereign risk both theoretically, in simplified versions of our model, and quantitatively, in our general model parameterized to emerging market data. Our theoretical results isolate the default amplification and monetary discipline mechanisms in a tractable setting with preferences that are separable and quasi-linear with respect to foreign goods consumption. We show that if default events are associated with high inflation and low consumption, high default risk leads to increases in current inflation and a worsening of the monetary wedge, our default amplification mechanism. We then analyze the consequences of monetary policy on default risk by studying a one-time deviation from a constrained efficient economy. The deviation involves monetary frictions and fiscal overborrowing. Here, we establish our disciplining result: tight monetary policy lowers default risk. The reason is that tight monetary policy lowers domestic consumption and increases the monetary wedge, which, in turn, the government can counter by lowering borrowing and default risk. The disciplining result shows that the standard prescription for monetary policy to neutralize pricing frictions with a *strict inflation targeting* regime is not optimal in our environment with default risk. In fact, our third theoretical result is that the constrained efficient outcome can be implemented by a monetary policy rule that targets default risk, the *default risk monetary rule*, as it can neutralize not only the overborrowing but also the pricing frictions.

For our quantitative results, we parameterize the NK-Default model to the data of 8 emerging market inflation targeters. We show that the model produces patterns for spreads, inflation, and nominal domestic rates that resemble the data. In particular, our model delivers the key positive comovement

[2]With long-term debt, the government tends to over-borrow because of the adverse effects of debt dilution, the negative impact on legacy lenders' repayment prospects from subsequent new issuance.

of spreads, which reflect default risk, with inflation and nominal rates. We also provide empirical evidence of the disciplining mechanism using panel data by projecting sovereign spreads on monetary policy shocks, recovered from estimated monetary policy rules. We find that, in the data as in the model, contractionary monetary shocks lower sovereign spreads. Moreover, our estimated interest rate rules demonstrate that policy rates tend to react positively to inflation, in accordance with the statutory mandate of inflation targeting central banks. Finally, we use our model to study the temporary inflation events. We find that the model can replicate the paths of inflation, output, nominal rates, and spreads with a combination of low productivity shocks and expansionary monetary shocks. Using a reference model without default, we measure the contribution of default risk for these dynamics and find that default risk accounts sizable portion of the increased inflation during these events.

Finally, we assess quantitatively the welfare implications of different monetary policy rules. We compare welfare outcomes relative to a strict inflation targeting regime, one that achieves the flexible price equilibrium. Under our baseline parameterization of the interest rate rule that responds to deviations of inflation from target, welfare is lower than under strict inflation targeting. However, welfare can be higher if the rule puts a large enough weight on inflation deviations. We also assess the default risk monetary rule and find it to be highly beneficial, yielding higher welfare than strict inflation targeting, because the volatility of both spreads and inflation plummets under this rule.

Related Literature. Our project builds on two distinct strands of the literature on the macroeconomics of emerging markets: the sovereign default literature and the New Keynesian open economy theory. Our government's problem resembles the standard sovereign default model, in the tradition of Eaton and Gersovitz (1981), as in Aguiar and Gopinath (2006) and Arellano (2008) but with long-term debt, as in Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012). We expand this framework to incorporate production and an import-export structure. Our domestic monetary environment is close to the workhorse framework of Galí and Monacelli (2005). One methodological difference between our project and standard monetary models is that we use global methods rather than local approximations around the steady state to compute the model.

The literature on sovereign default has recently turned to questions raised by nominal rigidities. Several papers have considered environments with defaultable sovereign debt and downward rigidity of nominal wages. Na, Schmitt-Grohé, Uribe, and Yue (2018) first introduced this friction in a model of sovereign default and emphasized that exchange rate pegs are costly because they prevent devaluations that would adjust real wages to their efficient level. Optimal policy in their environment delivers the joint incidence of devaluations and defaults. Bianchi, Ottonello, and Presno (2023) study the role of downward rigidity of nominal wages for procyclical fiscal policies, which result from a tradeoff between fiscal policy stimulating demand but possibly increasing default risk.[3] Our project shares the emphasis in these papers on the interaction between sovereign risk and nominal rigidities but differs in important ways. First, price frictions in our model arise from optimal, forward-looking price-setting by firms, which results in a standard New Keynesian Phillips Curve, where expectations of future inflation matter for current inflation and output. These papers, in contrast, directly impose that nominal wages are downward rigid and abstract from the role of inflation expectations in affecting current inflation and output. Second, our modeling of monetary policy focuses on a positive theory that resembles the practice of central banks in many emerging markets, which set interest rates to target inflation.[4]

A large literature, following Calvo (1988), studies the incentives of governments to reduce the real value of debt denominated in local currency, by engineering higher-than-expected inflation. Aguiar, Amador, Farhi, and Gopinath (2013) analyze the tradeoffs generated by monetary policy credibility in a model of self-fulfilling default crises and show that monetary policy credibility helps suppress self-fulfilling debt crises but hinders the benefits of state-contingent payments induced by inflation.[5] Hur, Kondo, and Perri (2018), Galli (2020), and Hurtado, Nuño, and Thomas (2023), build models with local currency debt and default and a discretionary choice of inflation, whereas Du, Pflueger, and Schreger (2020), Sunder-Plassmann (2020) and Engel and Park (2022) analyze how default and inflation incentives shape the composition of sovereign debt between local and foreign currency. In contrast with these papers, we emphasize the joint dynamics of endogenous inflation and sovereign risk, with a monetary authority that uses interest rate rules in the context of foreign currency debt, hence abstracting from the incentives of using monetary policy to inflate away the debt.[6] Related, in recent work Espino, Kozlowski, Martin, and Sanchez (2024) study monetary policy as arising from the classic incentives to finance fiscal deficits with seigniorage and its interactions with sovereign default risk also with foreign currency debt. We view these papers as complementary to ours and important, especially for emerging markets that have not been able to achieve central bank independence.

An important result of our paper is that monetary policy can discipline the overborrowing incentive of the fiscal government. Aguiar, Amador, Hopenhayn, and Werning (2019) sharply illustrate that sovereign default models with long-term debt feature overborrowing, because of the debt dilution suffered by legacy lenders, and that the exclusive use of short-term debt can produce the constrained ef-

[3]Other papers that have incorporated downward nominal wage rigidity and sovereign default risk include Bianchi and Mondragon (2022) which studies roll-over crises, De Ferra and Romei (2023) on monetary unions, and Bianchi and Sosa-Padilla (2023) which considers the stabilizing role of reserves.

[4]For the countries in our sample, the statutory objectives assigned by the legislature to central banks center on controlling inflation and are stated in their legal mandates and public statements of goals.

[5]Concerning the multiplicity of equilibria and the role inflation can play in selecting among them, Corsetti and Dedola (2016) focus on unconventional monetary policy whereas Bacchetta, Perazzi, and Van Wincoop (2018) analyze how interest rate rules can be used to prevent the self-fulfilling crises in the environment of Lorenzoni and Werning (2019).

[6]In a previous working paper version, we have briefly considered the local currency debt case, which results in no substantive changes to our conclusions when the monetary authority follows an interest rate rule.

ficient outcome. In this context, Hatchondo, Martinez, and Sosa-Padilla (2016) show that adding no-dilution covenants to long-term contracts can substantially improve outcomes. In our work, we show that a monetary policy rule can provide an alternative avenue for disciplining. We show that, under certain conditions, it is possible to design a monetary policy rule that targets default risk as to achieve the constrained efficient outcome.

The idea that monetary policy faces a tension between addressing pricing distortions and financial frictions, a thread running through our paper, is shared by a few other recent works. Itskhoki and Mukhin (2022) study the role of optimal monetary policy in fostering international risk sharing. Their result that, under certain conditions, a policy that pegs the exchange rate can address both frictions resembles our result that an interest rate rule that targets default risk can address both the monetary frictions and over-borrowing incentives. Aoki, Benigno, and Kiyotaki (2018) study a model of a small open economy with a frictional banking sector and revisit the role of monetary and macroprudential policy. They find, like us, that strict inflation targeting is dominated by policy regimes that occasionally aim to impact financial conditions.

Finally, our model's implications for exchange rates and international capital flows raise a natural comparison with the work on capital controls, exchange rates, and financial frictions in small open economies, such as Farhi and Werning (2016), Fanelli (2017), Devereux, Young, and Yu (2019), Itskhoki and Mukhin (2021), Ottonello (2021), and the handbook treatment in Bianchi and Lorenzoni (2022).

2 Model

We consider a small open economy consisting of households, final goods producers, intermediate goods producers, a monetary authority, and a government conducting fiscal policy. There are three types of goods: final domestic goods, domestic intermediate goods varieties, and foreign imported goods. The final good is produced using all varieties of differentiated intermediate goods, and it is consumed by both domestic and foreign households. Production of intermediate goods requires labor.

Foreign demand for domestic goods (export demand) is given by

$$X_t = \left(\frac{P_t^d}{\varepsilon_t P_t^*} \right)^{-\rho} \xi,$$

where P_t^d is the price of domestic goods in local currency, P_t^* the price of foreign goods in foreign currency, ξ the level of overall foreign demand, ρ the export elasticity, and ε_t the nominal exchange rate, domestic currency units per foreign currency unit. An increase in ε_t represents a depreciation of the home currency. We assume that the law of one price holds, so we can write the price of the foreign good in local currency as $P_t^f = \varepsilon_t P_t^*$. The terms of trade e_t equal

$$e_t = \frac{P_t^f}{P_t^d} = \frac{\varepsilon_t P_t^*}{P_t^d}. \tag{1}$$

Hence, the foreign demand for domestic goods is a constant elasticity function of the terms of trade and the level of overall foreign demand ξ:

$$X_t = e_t^{\rho} \xi. \tag{2}$$

We normalize the foreign price level P_t^* to one in all periods, thus abstracting from inflation dynamics abroad.

2.1 Households

Identical households consume domestic goods C_t, foreign goods C_t^f, and supply labor N_t. Their preferences are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(C_t, C_t^f, N_t),$$

where $u(C_t, C_t^f, N_t)$ is the per-period utility function and β is the discount factor of households.

Households choose consumption, labor supply, and holdings of domestic bonds B_t^d, taking prices and policies as given. Domestic bonds are denominated in local currency and can only be traded by domestic households. Households own all domestic firms and receive their profits Ψ_t. They also earn labor income $W_t N_t$ and receive government transfers T_t. Their budget constraint is given by

$$P_t^d C_t + (1+\tau_f) P_t^f C_t^f + q_t^d B_{t+1}^d \leq W_t N_t + B_t^d + \Psi_t + T_t$$

where q_t^d is the nominal price of domestic discount bonds and τ_f is a constant consumption tax on imports. We can characterize households' choices with the following optimality conditions:

$$-\frac{u_{N,t}}{u_{C,t}} = w_t, \tag{3}$$

$$\frac{u_{C^f,t}}{u_{C,t}} = (1+\tau_f) e_t, \tag{4}$$

$$u_{C,t} = i_t \beta \mathbb{E}_t \left[\frac{u_{C,t+1}}{\pi_{t+1}} \right]. \tag{5}$$

The real wage is $w_t = W_t / P_t^d$, the gross domestic goods inflation, hereafter *inflation*, is $\pi_t = P_t^d / P_{t-1}^d$, and the gross, nominal domestic interest rate is the yield of the discount bond price $i_t \equiv 1/q_t^d$.

2.2 Final Goods Producers

The final good Y_t is produced using a unit measure of differentiated intermediate goods y_{jt}, $j \in [0,1]$, under perfect competition, with $Y_t = [\int_0^1 y_{jt}^{\frac{\eta-1}{\eta}} dj]^{\frac{\eta}{\eta-1}}$, where η is the elasticity of substitution between intermediate goods. The problem of the final goods producers yields the standard demand schedule

$$y_{jt} = \left(\frac{p_{jt}}{P_t^d}\right)^{-\eta} Y_t, \tag{6}$$

where p_{jt} is the price of intermediate good j at time t. The price of domestic goods P_t^d is the price index $P_t^d = \left[\int_0^1 p_{jt}^{1-\eta} dj\right]^{\frac{1}{1-\eta}}$.

2.3 Intermediate Goods Producers

Each differentiated intermediate good is produced with labor n_{jt}, using a constant return to scale production function, given productivity z_t:

$$y_{jt} = z_t n_{jt} \tag{7}$$

Productivity depends on an aggregate shock, $\tilde{z}_t$, and the credit standing of the government in international markets, Θ_t, such that $z_t = z(\tilde{z}_t, \Theta_t)$. As discussed shortly, when credit standing is good, productivity is equal to the shock, and when credit standing is bad, productivity is lower, as in Arellano (2008) and Chatterjee and Eyigungor (2012).[7]

Intermediate goods firms are monopolistically competitive and set the prices of their products, taking as given the demand schedule (6). These firms face price-setting frictions in that they have to pay a quadratic adjustment cost when they do not increase their prices at the inflation rate $\overline{\pi}$, as in Rotemberg (1982). Taking as given the nominal wage W_t and the final good price P_t^d, an intermediate firm j chooses labor and its price to maximize the present discounted value of profits,

$$\max_{\{n_{jt}, p_{jt}\}} \mathbb{E}_0 \sum_t Q_{t,0} \left\{ p_{jt} y_{jt} - (1-\tau) W_t n_{jt} - \frac{\varphi}{2} \left(\frac{p_{jt}}{p_{jt-1}} - \overline{\pi} \right)^2 P_t^d Y_t \right\},$$

subject to the production function (7). Firms discount profits using the stochastic discount factor of households, $Q_{t,0} = \beta^t \frac{u_{C,t} P_0^d}{u_{C,0} P_t^d}$, and receive a labor subsidy τ. The first-order condition for each firm, after

[7]This assumption is motivated by the empirical evidence that sovereign defaults results in reductions in output and productivity, as documented in Bai and Zhang (2012), Mendoza and Yue (2012), Hébert and Schreger (2017), and Arellano, Bai, and Bocola (2020), among others.

imposing symmetry across all firms ($p_{jt} = P_t^d$), results in

$$(1-\tau)\frac{w_t}{z_t} = \frac{\eta-1}{\eta} + \frac{1}{\eta}\left\{\varphi\left(\pi_t - \overline{\pi}\right)\pi_t - \mathbb{E}_t\left[\beta\frac{u_{C,t+1}}{u_{C,t}}\frac{Y_{t+1}}{Y_t}\varphi\left(\pi_{t+1} - \overline{\pi}\right)\pi_{t+1}\right]\right\}. \tag{8}$$

This equation is a standard New Keynesian Phillips Curve (NKPC) that relates inflation to a measure of contemporaneous unit cost, $(1-\tau)w_t/z_t$, and expected inflation next period.

2.4 Government and External Debt

The government borrows internationally by issuing long-term bonds denominated in foreign currency, with an option to default. To keep long-term debt tractable, we employ the maturity structure used by Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012). The bond is a perpetuity that specifies a price q_t and a quantity ℓ_t such that the government receives $q_t \ell_t$ units of foreign currency in period t. In the following period, a fraction δ of the debt matures, and the government's debt is the sum of legacy debt that has not matured $(1-\delta)B_t$ and the new issuance ℓ_t such that $B_{t+1} = (1-\delta)B_t + \ell_t$. Each unit of outstanding bonds calls for a payment every period of $r + \delta$ for its coupons and maturing principal.[8]

The government can default on its debt and, depending on its default history, it is in good or bad credit standing, which is recorded by Θ_t. When the government pays its debt, $D_t = 0$, credit standing is good $\Theta_t = 0$, and the government can borrow and decide on the level of debt next period B_{t+1}. When the government instead chooses to default, $D_t = 1$, it avoids the debt payments but suffers a direct utility cost ν_t and a temporary bad credit standing, $\Theta_t = 1$. The utility costs ν_t are i.i.d. *enforcement shocks*. While in bad credit standing, the government loses access to financial markets and the productivity of domestic intermediate goods producers is depressed $z(\tilde{z}_t, \Theta_t = 1) \leq \tilde{z}_t$. Good credit standing is regained with probability ι, at which point the government reenters financial markets with no outstanding debt.

The government transfers to households the proceeds resulting from its trades in international financial markets, T_t. Conditional on having a good credit standing and repaying the debt, the government's budget constraint in local currency is

$$T_t + \tau W_t N_t = \varepsilon_t\left[q_t(B_{t+1} - (1-\delta)B_t) - (r+\delta)B_t\right] + \tau_f P_t^f C_t^f, \tag{9}$$

where the net capital inflow from debt operations is multiplied by the nominal exchange rate ε_t to convert it to domestic currency. When the government is in bad credit standing, its budget constraint has $B_t = B_{t+1} = 0$. The constant tax rates for labor and foreign goods consumption, τ and τ_f, are set as in

[8] Note that with this structure, the default-free bond price is equal to 1.

standard New Keynesian models to correct the markup in goods markets and allow for a static optimal tariff on imports in steady state, such that $1-\tau = \frac{\eta-1}{\eta}$ and $1+\tau_f = \frac{\rho}{\rho-1}$. Using the definition of the terms of trade (1), the government budget constraint in units of domestic goods is

$$t_t + \tau w_t N_t = e_t[q_t(B_{t+1} - (1-\delta)B_t) - (r+\delta)B_t] + \tau_f e_t C_t^f.$$

The government's objective is to maximize the present discounted value of the flow utility derived from consumption and labor by households, $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_g^t u(C_t, C_t^f, N_t)$. The government's discount factor β_g can differ, in general, from that of households, β. The government borrows from competitive, risk-neutral international lenders discounting the future at a foreign currency rate r. The bond price is such that they break even in expectation, thus receiving compensation for any expected losses from default:

$$q_t = \frac{1}{1+r}\mathbb{E}_t\left[(1-D_{t+1})(r+\delta+(1-\delta)q_{t+1})\right].$$

In states where the government does not default $D_{t+1} = 0$, each unit of the bond pays $r+\delta$ and the $1-\delta$ fraction, that does not mature and remains outstanding next period, has market value $(1-\delta)q_{t+1}$. In states in which the government defaults, the associated payoff for lenders is zero. We define the government spread as the difference between the yield-to-maturity of the bond and the international rate r, such that

$$\text{spread}_t = (r+\delta)\left(\frac{1}{q_t} - 1\right).$$

We let $\Phi_t = \mathbb{E}_t D_{t+1}$ denote the one-period-ahead probability of default.

2.5 The Monetary Authority

The monetary authority sets policy according to an interest rate rule. In our baseline *inflation targeting regime*, the nominal interest rate rule targets domestic goods inflation. The nominal domestic rate i_t depends on a long-run value $\bar{i}$, responds to the deviation of inflation from target, π_t relative to $\overline{\pi}$, and is subject to monetary shocks m_t

$$i_t = \bar{i}\left(\frac{\pi_t}{\overline{\pi}}\right)^{\alpha_P} m_t, \tag{10}$$

with $\alpha_P > 1$.

In the theoretical and quantitative analyses that follow, we will also consider a strict inflation targeting regime, under which the monetary authority sets the nominal rate to keep inflation on target at all times, $\pi_t = \overline{\pi}$, as well as a default risk targeting regime, under which monetary policy employs a rule which reacts to the default risk Φ_t directly.

2.6 Equilibrium

We consider a Markov Perfect Equilibrium, where the government takes into account that its default and borrowing policies affect the allocation of the domestic private economy and the monetary authority's response in the current period and in the future. The exogenous states are the productivity and monetary shocks, $s = \{\tilde{z}, m\}$, and the enforcement shock, ν. The endogenous states for the private and monetary equilibrium are the level of debt B, the credit standing Θ, and borrowing B'. Recall that the government chooses borrowing B' only when it has good credit.

When the government enters the period with good credit standing $\Theta_{-1} = 0$ and debt B, it chooses whether to default or repay the debt. The default decision determines the end-of-the-period credit standing Θ. If it enters the period with bad credit $\Theta_{-1} = 1$, the government draws a random variable Λ following a Bernoulli distribution. With probability ι, $\Lambda = 1$ and the government regains good credit $\Theta = 0$ if it chooses not to immediately default again. The evolution of credit standing is given by

$$H_\Theta(s, \nu, B, \Theta_{-1}) = \begin{cases} 0 & \text{if } (\Theta_{-1} = 0 \text{ and } D = 0) \text{ or} \\ & \quad (\Theta_{-1} = 1 \text{ and } \Lambda = 1 \text{ and } D = 0) \\ 1 & \text{otherwise .} \end{cases} \tag{11}$$

The private and monetary equilibrium, which we label $\Xi(S)$, depends on the shocks, the debt B, the credit standing Θ, and the government's borrowing choice B', because these variables affect government transfers and productivity in the current period. Let $S = \{s, B, \Theta, B'\}$ be the end-of-period state. The private and monetary equilibrium also depends on the government's equilibrium policy functions for default $D' = H_D(s', \nu', B')$, borrowing $B'' = H_B(s', B')$, and the corresponding credit standing $\Theta' = H_\Theta(s', \nu', B', \Theta)$, because of the forward-looking nature of the equilibrium.

Definition 1 (Private and Monetary Equilibrium)**.** *Given state S, the government policy functions for default $H_D(s', \nu', B')$, borrowing $H_B(s', B')$, credit standing $H_\Theta(s', \nu', B', \Theta)$, and the transfer function $t(S)$ consistent with the government budget constraint, the symmetric private and monetary equilibrium $\Xi(S)$ consists of*

- *Households' policies for domestic goods consumption $C(S)$, foreign goods consumption $C^f(S)$, labor $N(S)$, and domestic debt $B^d(S)$,*
- *Intermediate and final goods firms' policies for employment $n(S)$, inflation $\pi(S)$, final domestic goods output $Y(S)$, and exports $X(S)$,*
- *The wage $w(S)$, nominal domestic rate $i(S)$, and the terms of trade $e(S)$*

such that: (i) *the policies for households satisfy their budget constraint and optimality conditions (3), (4), (5);* (ii) *the policies of intermediate and final goods firms satisfy their optimization problem (6), (7), and (8);* (iii) *export demand (2) is satisfied;* (iv) *the nominal domestic rate satisfies the monetary authority's interest rate rule (10); and* (v) *labor, domestic goods, and domestic bond markets clear, and the balance of payments condition is satisfied.*

The labor market clears, with firms' labor demand equal to the labor supplied by households $n = N$. Domestic bonds are in zero net supply in the economy, reflected in the market clearing condition $B^d = 0$. The resource constraint for domestic goods requires that domestic final goods output equals domestic consumption plus exports and the pricing adjustment costs,

$$C(S) + X(S) + \frac{\varphi}{2}(\pi - \overline{\pi})^2 Y(S) = Y(S) \tag{12}$$

where aggregate output is given by $Y(S) = z(\tilde{z}, \Theta)\, N(S)$.

The balance of payments condition requires that net imports equal net capital inflows, which here equal the government transfer plus the labor subsidy,

$$e(S)C^f(S)(1 + \tau_f) - X(S) = t(S) + \tau w(S)N(S). \tag{13}$$

The presence of price rigidities leads to inefficient use of labor, as monopolistic firms set time-varying markups. We use a *monetary wedge* to measure these distortions in production, defined as

$$1 + \text{monetary wedge} \equiv \frac{z(\tilde{z}, \Theta)}{w(S)} = -\frac{z(\tilde{z}, \Theta)u_C(S)}{u_N(S)}. \tag{14}$$

This wedge captures deviations from production efficiency and depends on the dynamics of current and future inflation, as seen in the NKPC equation (8). Production efficiency requires the marginal product of labor, z, to be equal to the households' marginal rate of substitution between labor and consumption, $-u_N/u_C$.

2.7 Government Recursive Formulation

We now describe the recursive formulation of the government's problem. The bond price $q(s, B')$ compensates lenders for default risk. It depends on the shocks s and the borrowing level B', because these affect future probabilities of default. The bond price schedule that satisfies the break-even condition for lenders depends on the policy functions of the government for default, $H_D(s', \nu', B')$, and borrowing,

$H_B(s', B')$, as follows

$$q(s, B') = \frac{1}{1+r} \mathbb{E}\left[(1 - H_D(s', \nu', B'))(r + \delta + (1-\delta) q(s', H_B(s', B')))\right]. \tag{15}$$

Let $V(s, \nu, B)$ be the value to the government, including of the option to default, such that

$$V(s, \nu, B) = \max_{D \in \{0,1\}} \left\{ (1 - D) W(s, B) + D \left[W^d(s) - \nu \right] \right\}, \tag{16}$$

where $W(s, B)$ is the value under debt repayment and $W^d(s) - \nu$ is the value from defaulting, inclusive of the enforcement shock ν. The value of repaying is

$$W(s, B) = \max_{B'} \left\{ u(C, C^f, N) + \beta_g \mathbb{E} V(s', \nu', B') \right\}$$

subject to the private and monetary equilibrium $\Xi(S)$ with $S = \{s, B, \Theta = 0, B'\}$ and the bond price schedule (15). The defaulting value W^d net of the enforcement cost is given by

$$W^d(s) = u(C, C^f, N) + \beta_g \mathbb{E}\left[\iota V(s', \nu', B' = 0) + (1 - \iota) W^d(s') \right]$$

subject to the private and monetary equilibrium $\Xi(S)$ with $S = \{s, B = 0, \Theta = 1, B' = 0\}$. Once in default, the government regains access to the international financial markets with probability ι, without outstanding debt. The conditions for the private and monetary equilibrium are collected in Appendix A.1.

It is helpful to express the default decision of the government as a cutoff rule based on the enforcement shock ν. Given the i.i.d. nature of the enforcement shock, the default decision $D(s, \nu, B)$ can be characterized by a cutoff level $\hat{\nu}(s, B)$, at which the repayment value is equal to the default payoff, such that

$$\hat{\nu}(s, B) = W^d(s) - W(s, B),$$

and the sovereign is indifferent between the two options. Then $D(s, \nu, B) = 1$ whenever $\nu \leq \hat{\nu}(s, B)$ and zero otherwise. Let F_ν be the cumulative distribution function of ν. Then, the default probability equals $\Phi(s, B') = \mathbb{E}_{s'|s} F_\nu(\hat{\nu}(s', B'))$.

We can now define the recursive equilibrium of the economy.

Definition 2 (Equilibrium)**.** *Given the aggregate state $\{s, \nu, B\}$, a recursive equilibrium consists of government policies for default $D(s, \nu, B)$ and borrowing $B'(s, B)$, and government value functions $V(s, \nu, B)$, $W(s, B)$, and $W^d(s)$, such that*

- *Taking as given future policy and value functions, $H_D(s', \nu', B')$, $H_B(s', B')$, $V(s', \nu', B')$, $W(s', B')$, and $W^d(s')$, government policies for default and borrowing and value functions solve its optimization problem.*

- *Government policies and values are consistent with future policies and values.*

2.8 Government Borrowing

We now illustrate the forces shaping debt accumulation. We derive the government's optimality condition for borrowing, assuming that all functions in the government problem are differentiable.[9] Optimal borrowing satisfies the following Euler equation

$$u_{C^f}\left[q + \frac{dq}{dB'}\left(B' - (1-\delta)B\right)\right](1-\tau_m^X) - \tau_m^C = \beta_g \mathbb{E}(1-D')u'_{C^f}\left[r + \delta + (1-\delta)q'\right]\left(1 - \tau_m^{X'}\right), \tag{17}$$

which relates the marginal utility of foreign goods consumption across periods to the bond price schedule $q(s, B')$, future default and borrowing decisions D' and B'', future bond prices q', and the borrowing wedges τ_m^X and τ_m^C. Appendix A.2 reports the detailed derivation of this equation.

The borrowing wedges τ_m^X and τ_m^C arise exclusively due to monetary frictions and capture the Lagrange multipliers associated with the NKPC and domestic Euler equations in the government's problem. Without pricing frictions, these wedges are zero. These wedges depend on B' and are present in this Euler equation because the government internalizes the consequences of its borrowing and default decisions on monetary frictions.

Equation (17) reflects three major forces. The first is the incentive to smooth and tilt the time path of foreign goods consumption. This force is present in standard models without default risk, like Galí and Monacelli (2005), which exhibit the following undistorted international Euler equation

$$q\, u_{C^f} = \beta_g \mathbb{E}\; u'_{C^f}\left[r + \delta + (1-\delta)q'\right]. \tag{18}$$

Absent financial frictions, borrowing only smooths the marginal utility of foreign goods consumption against shocks and achieves the right tilting of consumption over time, given q and β_g.

The second force affecting borrowing in our model is the endogenous bond price schedule q and the presence of legacy long-term debt $(1-\delta)B$, as emphasized by Aguiar et al. (2019). Bond prices decrease with borrowing due to the increased risk of default, $\frac{\partial q}{\partial B'} \leq 0$, and a higher legacy debt $(1-\delta)B$ incentivizes borrowing because lower prices dilute this debt, $-\frac{\partial q}{\partial B'}(1-\delta)B \geq 0$. Moreover, with longer maturities for a given face value, the government rolls over only a fraction of debt and hence has less

[9] We do not require this assumption for the computation of the model, nor do we employ the Euler equation derived in this section for the numerical implementation.

incentive to reduce debt in order to secure a higher price for the new loans. Such debt dilution leads to *over-borrowing*, as established by Hatchondo et al. (2016). A lower discount for the government, $\beta_g < \beta$, also leads to over-borrowing, as discussed by Aguiar, Amador, and Fourakis (2020).[10]

The third force works through the borrowing wedges τ_m^X and τ_m^C and it is unique to our model with sovereign risk and monetary frictions. Positive borrowing wedges lower incentives to borrow. These wedges tend to be positive when the monetary wedge is high or expected inflation is high, because as shown in the appendix the wedges depend positively on the multipliers for the domestic Euler equation and the NKPC. Given monetary policy, as the government borrows more it tends to increase expected marginal utility, which decreases current consumption, increasing the monetary wedge. Also, higher borrowing tends to increase default risk and expected inflation, which in turn increases current inflation. These extra costs from borrowing in the form of worse monetary frictions are reflected on the borrowing wedges. In the next section, we provide a sharper characterization of these interactions between monetary frictions and default risk and relate them to our two main mechanisms, default amplification and monetary discipline.

3 Theoretical Characterizations

This section characterizes in more detail the interactions between monetary frictions and default risk in simplified versions of our framework. We show that default risk worsens monetary distortions by increasing inflation and monetary wedges. These monetary frictions in turn discipline the government's borrowing and lower default risk. We relegate all the proofs to Appendix B.

3.1 Default Amplification

To show that high default risk tends to increase inflation and induce inefficiently low production, we revisit the key equilibrium NKPC pricing condition

$$(\pi - \overline{\pi})\,\pi = \frac{\eta - 1}{\varphi}\left(-\frac{u_N}{zu_C} - 1\right) + \frac{\beta}{Yu_C}\,\mathbb{E}\left(Y'\,u'_C\left(\pi' - \overline{\pi}\right)\pi'\right), \tag{19}$$

where $'$ marks future variables. Inflation increases whenever future expected inflation π' or the marginal utility of consumption u'_C are high, or when the monetary wedge is low (i.e., $-u_N/zu_C$ is high).[11] Default risk impacts inflation by affecting these three main terms. Recall that, during a default event, productiv-

[10] Cuadra and Sapriza (2008) and Hatchondo, Martinez, and Sapriza (2009) motivate such discounting as arising from political turnover.

[11] We find that u'_C and Y' tend to move in opposite directions but that the net effect is dominated by the marginal utility term. Also, the covariance between $Y'u'_C$ and π' tends to be positive.

ity is reduced, which implies that inflation is high and consumption is low. Hence, if the risk of a default next period is high, expectations for future inflation and the marginal utility of consumption are high, which increase the expectation term on the right-hand side of the NKPC. Such *inflation expectation effect* from default risk gives firms incentives to increase their prices now, raising current inflation.

In response to these inflationary pressures, the monetary policy rule calls for higher interest rates and tight monetary policy. These high nominal domestic rates, however, depress consumption through the domestic Euler equation

$$u_C = i\beta\,\mathbb{E}\frac{u_C'}{\pi'}. \tag{20}$$

In turn, low domestic consumption tends to reduce production and increase the monetary wedge. All in all, high default risk can result in high inflation and monetary wedges, and tight monetary policy. We call this effect *default amplification*.[12]

To characterize formally the default amplification mechanism, we simplify the model by assuming that preferences are quasi-linear in foreign goods consumption and are given by

$$u(C, C^f, N) = \log C + C^f - \frac{N^{1+1/\zeta}}{1+1/\zeta}. \tag{21}$$

We evaluate the responses of the model to an increase in default risk $\mathbb{E}_{s'|s}F_\nu(\hat{v}(s', B'))$ from higher government borrowing B'. Under these preferences, the consumption of foreign goods fully adjusts to accommodate net capital inflows from debt operations. Higher borrowing affects the rest of the private and monetary equilibrium only through its impact on default risk and the expectation channels: high default risk is reflected in the expectation terms in the NKPC (19) and the domestic Euler equation (20). Let functions $F(s, B', \Theta)$ and $M(s, B', \Theta)$ encode these expectations, with

$$\begin{aligned} F(s, B', \Theta) &= \mathbb{E}\left[z(\tilde{z},' \Theta')N(S')u_C(S')\left(\pi(S') - \overline{\pi}\right)\pi(S')\right], \\ M(s, B', \Theta) &= \mathbb{E}\frac{u_C(S')}{\pi(S')}, \end{aligned}$$

where the future state $S' = (s', B', H_\Theta(s', \nu', B', \Theta), H_B(s', B'))$ depends on the future government policies and the evolution of credit standing. We assume that the functions $F(s, B', \Theta)$ and $M(s, B', \Theta)$, which the government takes as given, are differentiable and increase with borrowing, and then analyze how changes in borrowing affect the equilibrium using a first-order Taylor expansion.

Assumption 1 (Expectation Terms). *$\partial F(s, B', \Theta)/\partial B' \geq 0$ and $\partial M(s, B', \Theta)/\partial B' \geq 0$, and the parameters satisfy the restriction $a_0 \geq (\partial M(s, B', \Theta)/\partial B')/(\partial F(s, B', \Theta)/\partial B')$, with*

[12] We thank Luigi Bocola for his insightful discussion which led to much of this analysis.

$a_0 = \varphi / \left[(\eta - 1)(1 + (\alpha_c + \rho(1 - \alpha_c))/\zeta))\beta\bar{i}\overline{\pi}\right]$ *where* α_c *is the share of domestic consumption in output at the approximating point in the Taylor expansion.*

These assumptions ensure that expected inflation and the marginal utility of consumption rise with default risk as B' increases. These properties, which also hold in our full, quantitative model, feed through the equilibrium and affect current allocations and prices. The following proposition characterizes, up to first-order, the effects on default risk, inflation, the nominal domestic rate, and the monetary wedge from increased borrowing under Assumption 1, preferences given by (21), and when inflation is close to target.

Proposition 1 (Amplification)**.** *Higher borrowing increases default risk, inflation, the nominal domestic rate, and the monetary wedge.*

Borrowing more increases default risk, which in turn affects current inflation and the monetary wedge. High default risk increases expectations of future inflation and marginal utility. Given the stance of monetary policy, the NKPC calls for an increase in current inflation and the domestic Euler equation calls for a decline in current consumption, which increases the monetary wedge. The interest rate rule, in turn, increases the nominal domestic rate, and this monetary policy response dampens the increase in inflation but amplifies the increase in the monetary wedge.

This amplification effect of government borrowing on inflation and the monetary wedge in Proposition 1 crucially relies on the presence of default risk. In our simplified setup with quasi-linear preferences, it is easy to show that without default risk, higher borrowing would have no effect on inflation, the nominal domestic rate, domestic consumption, or output. In addition, in emphasizing the role of default risk, we abstracted from additional, more traditional channels through which government debt can impact the economy. For example, with preferences that feature sufficient complementarity between domestic and foreign goods consumption, high government borrowing may increase output because of an increased demand for domestic consumption, arising from an increase in imported consumption.

3.2 Monetary Discipline

In our framework, not only does default risk amplify monetary frictions, but monetary frictions affect in turn government borrowing and default choices. In particular, tight monetary policy reduces the government's borrowing incentives and lowers default risk. We call this mechanism *monetary discipline*. We further simplify the model, to characterize this mechanism precisely. We alter our environment such that our main frictions, namely pricing frictions and over-borrowing incentives, are only present in period 0, while from period 1 onward the economy's equilibrium is constrained efficient. We analyze the effects of different monetary policies in period 0 on monetary wedges and default risk, show that strict inflation targeting will not be optimal, and provide an alternative monetary policy rule that can approach arbitrarily close the constrained efficient outcome.

To set up the constrained efficient economy for periods $t \geq 1$, we restrict attention to the case of short-term debt $\delta = 1$ and a government as patient as households, $\beta_g = \beta$. The monetary authority eliminates any pricing frictions by setting nominal rates to deliver stable inflation at $\overline{\pi}$ for periods $t \geq 1$. In contrast, in period 0 we assume that $\beta_g < \beta$, which induces over-borrowing, and monetary policy is given by a set nominal rate i. We abstract from productivity shocks, $z_t = \overline{z}$ for any t, although default continues to reduce productivity, $z_d \leq \overline{z}$, and for tractability assume the exclusion from international financial markets caused by default is permanent. Default involves an enforcement shock ν with a cumulative distribution function F_ν and hazard function $h(\nu)$, which we assume is strictly increasing. These assumptions allow us to analyze the effects of a *one-time deviation* from a constraint-efficient environment. The following assumption summarizes the settings for this case:

Assumption 2 (One-time Deviation)**.** *For $t \geq 1$, the fiscal government is as patient as the household $\beta_g = \beta$ and the monetary authority implements strict inflation targeting, $\pi_t = \overline{\pi}$. In period 0, the government is less patient than households $\beta_g < \beta$ and the monetary authority sets the domestic nominal rate to a level i. Absent default, productivity is constant $z_t = \overline{z}$. Debt is short-term $\delta = 1$, financial market exclusion is permanent $\iota = 0$, the hazard function of the enforcement shock $h(\nu)$ is increasing in ν, and preferences are given by (21).*

Before analyzing policy options during the one-time deviation, we characterize the problem from $t \geq 1$ onward. In this reference model, pricing frictions are neutralized, and the government borrows and defaults in a constrained efficient manner. For this analysis, we rely on Aguiar et al. (2019), which characterizes constrained efficient borrowing in a sovereign default model and shows that it can be implemented with standard, defaultable short-term bonds. We therefore label this reference economy *constrained efficient*.

The constrained efficient economy. In this economy, the consumption-labor choices are undistorted, and monetary wedges are zero in all states. This implies that inflation is always at target and pricing frictions are neutralized. Furthermore, debt, borrowing, and default do not affect the optimal allocations for domestic consumption, labor, and terms of trade, $C^\star$, $N^\star$, and $e^\star$, which satisfy the following three equations,

$$
\begin{aligned}
C^\star + e^{\star\rho} &= \bar{z}N^\star \\
C^\star &= \frac{\rho}{\rho-1}e^\star \\
N^{\star 1/\zeta}C^\star &= \bar{z}.
\end{aligned}
$$

We can substitute these into the utility function and define $u^\star \equiv \log C^\star - \frac{(N^\star)^{1+1/\zeta}}{1+1/\zeta} + (e^\star)^{\rho-1}$. The government's problem for the constrained efficient economy reduces to

$$
W(B) = \max_{B'} \; u^\star - (1+r)B + q(B')B' + \beta\left\{\left[1 - F_\nu(\hat{\nu}(B'))\right]W(B') + \int^{\hat{\nu}(B')}(W^d - \nu)dF_\nu(\nu)\right\} \tag{22}
$$

subject to the bond price function $q(B') = 1 - F_\nu(\hat{\nu}(B'))$, and where the default cutoff $\hat{\nu}(B')$ satisfies $\hat{\nu}(B) = W^d - W(B)$.

The default value W^d is the present value of permanent financial autarky $W^d = u(C_d, C_d^f, N_d)/(1-\beta)$ subject to the resource constraint $C_d + e_d^\rho = z_d N_d$ and the balanced trade condition $e_d^\rho = e_d C_d^f$.

The optimal borrowing in the constrained efficient economy satisfies the following Euler equation

$$
1 - h(\hat{\nu}(B^\star))B^\star = \beta(1+r). \tag{23}
$$

and borrowing is at the constrained efficient level $B^\star$. Let $\Phi^\star \equiv F_\nu(\hat{\nu}(B^\star))$ be the equilibrium default risk in the constrained efficient economy.

To implement the inflation target $\overline{\pi}$, the nominal rate in the constrained efficient economy, $i^\star$, satisfies the domestic Euler equation,

$$
\frac{1}{C^\star} = \beta\frac{i^\star}{\overline{\pi}}\left[\frac{1-\Phi^\star}{C^\star} + \frac{\Phi^\star}{C_d}\right].
$$

These constrained efficient outcomes prevail for all $t \geq 1$.[13] These allocations matter for the economy in period 0 because of the expectation terms in the NKPC, the Euler equation, the bond price function, as well as the continuation utility.

A one-time deviation. We now study a one-time deviation from constrained efficiency. Recall that in period 0 monetary policy is given by the interest rate i and the government has a lower discount factor $\beta_g < \beta$. Inflation may deviate from the target, as called for the NKPC condition. In period 0, conditional

[13]See Appendix B.2 for a detailed characterization of the constrained efficient allocations.

on not defaulting, the government solves the following problem:

$$\max_{B',C,C^f,N} u(C,C^f,N) + \beta_g \left\{ \left[1 - F_\nu(\hat{\nu}(B'))\right] W(B') + \int^{\hat{\nu}(B')} (W^d - \nu) dF_\nu(\nu) \right\} \tag{24}$$

subject to the private equilibrium conditions, the bond price function, and monetary policy i which are summarized by:

$$\begin{aligned}
C + e^\rho &= \left[1 - \frac{\varphi}{2}(\pi - \overline{\pi})^2\right] zN && \text{(resource constraint)} \\
e^\rho &= e\left[C^f + (1+r)B - q(B')B'\right] && \text{(balance payments)} \\
C &= \frac{\rho}{\rho - 1} e && (\text{intra } C - C^f) \\
-\frac{u_N}{zu_C} &= 1 + \frac{1}{\eta - 1}\varphi(\pi - \overline{\pi})\pi && \text{(NKPC)} \\
\frac{1}{C} &= \frac{\beta i}{\overline{\pi}} \mathbb{E} u_{C'}(B') = \frac{\beta i}{\overline{\pi}} \left[\frac{1 - F_\nu(\hat{\nu}(B'))}{C^\star} + \frac{F_\nu(\hat{\nu}(B'))}{C_d}\right] && \text{(domestic Euler)} \\
q(B') &= 1 - F_\nu(\hat{\nu}(B')). && \text{(bond price)}
\end{aligned}$$

The expectation terms of this problem are those arising from the constrained efficient problem. The NKPC condition above reflects the fact that in period $t = 1$ and onward $\pi = \overline{\pi}$; the expected marginal utility $\mathbb{E}u_{C'}(B')$ is the weighted average of marginal utility of future consumption without default $C^\star$ and in default C_d; the bond price function and the expected marginal utility use the cutoff function $\hat{\nu}$ for an arbitrary state B'; and the continuation value function is also that of the constrained efficient problem for an arbitrary state.[14] Unlike the case of the constrained efficient economy, the private equilibrium now depends on borrowing and default risk, through the expectations of terms that enter into the domestic Euler equation and bond price function.

We are now ready to characterize the way in which monetary policy, the nominal rate i, impacts the equilibrium in the one-time deviation economy. Consider a candidate nominal rate such as the solution of the government problem, program (24), delivers strict inflation targeting $\overline{\pi}$ in period 0. Denote such nominal rate in period 0 by i^{ST}. With strict inflation targeting, the monetary wedge is zero and domestic consumption and labor are efficient, $(C^{ST} = C^\star, N^{ST} = N^\star)$. Optimal borrowing, however, B^{ST}, is different from the constrained efficient borrowing since the government has an over-borrowing incentive and satisfies

$$1 - h(\hat{\nu}(B^{ST}))B^{ST} = \beta_g(1+r). \tag{25}$$

[14] With some abuse of notation, in equations (resource constraint) through (bond price), we highlight the Markov aspect of the problem. The future functions are written for arbitrary B' and are viewed as functions for the government. Of course, all the contemporaneous variables will also be functions of the optimal borrowing choice B', but they are chosen as part of the maximization program.

The government discounts the future more heavily, at $\beta_g < \beta$ and such impatience leads to overborrowing by the government, $B^{ST} > B^{\star}$. Overborrowing is costly for households and lowers their welfare level. These results are summarized in the next lemma.

Lemma 1. *Under Assumption 2, the monetary authority can deliver strict inflation targeting, $\pi = \overline{\pi}$, in period 0. If it does so, default risk is higher, and households' welfare is lower than in the constrained efficient outcome, $\Phi^{ST} > \Phi^{\star}$, $W^{ST} \leq W^{\star}$.*

The lemma shows that it is possible for the monetary authority to eliminate domestic pricing frictions in period 0 through strict targeting inflation, but that the resulting welfare level is lower than the constrained efficient case, since the government borrows and defaults too much. The monetary authority, however, can set nominal rates at different levels and affect the economy's outcomes including borrowing and default risk.

Before we explore these effects, it is useful to analyze the effects of default risk on the private economy and, in particular, on pricing frictions. The next lemma shows that, given a monetary policy i, higher default risk increases the monetary wedge.

Lemma 2. *Under Assumption 2, higher default risk Φ increases the monetary wedge $-zu_C/u_N$, when the monetary wedge is positive.*

This result is similar to the amplification result in Proposition 1, but derived for the one-time deviation economy under assumptions on the environment summarized in Assumption 2. Higher default risk increases the future marginal utility of consumption since the expectation in (domestic Euler) places more weight on default states, in which consumption is lower, $C_d \leq C^{\star}$. In response to this low expected future consumption, current consumption, C, declines. Low C also leads to a real appreciation, e decreases, which in turn reduces exports. Labor is lower because of lower demand for both domestic consumption and exports. As a result, the monetary wedge increases and domestic production is more distorted.

We now characterize equilibrium default risk and monetary wedges for alternative monetary policies in period 0. We find that tighter monetary policy disciplines the fiscal government to borrow less. The following proposition summarizes our disciplining result

Proposition 2 (Discipline)**.** *Under Assumption 2, if $i > i^{ST}$, the monetary wedge is positive, and default risk is lower than under strict inflation targeting.*

The higher policy rate, $i > i^{ST}$, depresses the domestic economy and generates a positive monetary wedge through standard channels in open economy New Keynesian models. It decreases the consumption demand for domestic goods through the domestic Euler and the demand for exports through the resulting exchange rate appreciation, both of which reduce output. The government internalizes its borrowing on default risk $\Phi = F_v(\hat{v}(B'))$, expected marginal utility $\mathbb{E}u_{C'}$, domestic consumption C, and the multiplier on (domestic Euler) κ. Its Euler equation for optimal international borrowing reflects such effects, and in this case is

$$1 - h(\hat{v}(B'))B' - \kappa \frac{1}{1 - F_v(\hat{v}(B'))} \left(\frac{\partial \mathbb{E}u_{C'}(B')}{\partial B'} \frac{u_C}{\mathbb{E}u_{C'}(B')} \right) = \beta_g(1+r). \tag{26}$$

The government faces an additional cost of borrowing, relative to the case of strict inflation targeting, as $\kappa \left(\frac{\partial \mathbb{E}u_{C'}(B')}{\partial B'} \frac{u_C}{\mathbb{E}u_{C'}(B')} \right) > 0$ from Lemma 2 because increasing B' increases default risk and the monetary wedge. The additional cost lowers incentives to borrow and, therefore reduces default risk.

Proposition 2 illustrates a trade-off for monetary policy. Strict inflation targeting eliminates pricing frictions, but at the cost of inefficiently high borrowing by the government. Alternatively, a higher policy rate, $i > i^{ST}$, induces lower default risk, closer to its efficient level, but at the cost of distorting domestic production. A natural question is whether alternative monetary policy rules could deliver a better outcome or eliminate the trade-off.

Next, we propose an alternative interest rate rule that does delivers better outcomes. The rule targets default risk and dictates increasing nominal rates when default risk rises. We will show with this rule, which we label the *default risk monetary rule*, monetary policy can achieve both efficient default risk and a near-zero monetary wedge. Because of the disciplining effects of high domestic interest rates, this rule discourages excessive borrowing and default risk. We show below that the default risk monetary rule can be designed to deliver both efficient default risk and efficient production.

Proposition 3 (Default Risk Monetary Rule)**.** *A monetary policy rule of the form $i = \bar{i}\ \Phi^{\ \alpha_D}$ can achieve the constrained efficient default risk $\Phi^\star$ and an arbitrary small monetary wedge of size $\varepsilon > 0$, with a positive coefficient α^D.*

Here is the sketch of the proof. Under the default risk monetary rule, monetary policy responds to the equilibrium default probability $\Phi = F(\hat{v}(B'))$, which depends on the fiscal borrowing choices. The government internalizes these effects, giving rise to the following international Euler equation

$$1 - h(\hat{v}(B'))B' - \kappa \frac{1}{1 - F_v(\hat{v}(B'))} \left[\frac{\partial \mathbb{E}u_{C'}(B')}{\partial B'} \frac{u_C}{\mathbb{E}u_{C'}(B')} + \alpha_D u_C \frac{f_v(\hat{v}(B'))}{F_v(\hat{v}(B'))} \right] = \beta_g(1+r).$$

The optimal borrowing condition is modified relative to the standard case, condition (26), with an additional term, $\alpha_D u_C f_v(\hat{v}(B'))/F_v(\hat{v}(B'))$. This additional term reflects the increased costs of borrowing from tighter monetary policy, which matters through its effects on the multiplier on the domestic Euler equation κ.

Our approach for implementing the constrained efficient borrowing is to set α_D such that the optimal borrowing condition for the government is the constrained efficient one, condition (23). This implementation requires setting α_D to satisfy the following condition

$$\frac{\kappa}{1-\Phi^{\star}}\left[\frac{\partial \mathbb{E}u_{C'}}{\partial B'}\frac{u_C}{\mathbb{E}u_{C'}\left(B^{\star}\right)}+\alpha_D u_C \frac{f_v{}^{\star}}{\Phi^{\star}}\right]=\left(\beta-\beta_g\right)(1+r).$$

The multiplier κ and the marginal utility u_C in this equation are pinned down by the monetary wedge of size ε. The default risk monetary rule can implement a monetary wedge ε by the appropriate choice of $\bar{i}$ because of its effects through the domestic Euler equation. By setting $\bar{i} \to i^{\star}/\Phi^{\star\alpha_D}$ the rule can deliver a monetary wedge of $\varepsilon \to 0$. Inflation, as determined by the NKPC condition, is close to target when $\varepsilon \to 0$. Hence, by targeting only default risk, the optimal monetary rule is able to eliminate two frictions, by achieving both a near-efficient domestic production and constrained efficient external borrowing.

3.3 Alternative Rules

We now discuss briefly the implications of two alternative monetary rules for government borrowing and pricing frictions. Consider an exchange rate devaluation target as a candidate alternative policy. Namely, suppose that the central bank targets a nominal devaluation rate $\text{dev}_t = \frac{e_t}{e_{t-1}}\pi_t$. As is known in the literature, an appropriately chosen devaluation target, dev_t, can replicate the strict inflation targeting outcome and eliminate monetary distortions.[15] A policy rule of this form, however, does not affect the government's borrowing incentives in our environment. For any devaluation target pursued by the monetary policy, the Euler equation of international borrowing is $1-h(\hat{v}(B'))B' = \beta_g(1+r)$. Monetary policy in the form of exchange rate targets, therefore, cannot affect borrowing incentives.

We can also consider our baseline rule (10), which targets inflation. The international Euler condition in this case is given by equation (26). With a standard rule that targets inflation, the coefficient on inflation α_P controls the monetary wedge and at the same time matters for borrowing through its effect on κ. A higher α_P will tend to sharpen the trade-off discussed above for the monetary authority: increases of the monetary wedge versus reducing overborrowing. As a result, setting how responsive the interest rate rule is to inflation, setting α_P, is insufficient to address both frictions simultaneously.[16]

We conclude this section with a summary of our findings thus far. We have shown that, in a simplified version of our model, high default risk can induce higher inflation and positive monetary wedges because it affects expectations of future inflation and consumption. Tight monetary policy, in turn, can

[15] For example, Na et al. (2018) show that an appropriately chosen nominal depreciation rates after default can eliminate the distortions of downward nominal wage rigidities.

[16] A knife-edge case under which the inflation targeting rule could potentially address both frictions is one where $\alpha_P \to \infty$ and $\bar{i} \to \infty$.

discipline the government's over-borrowing incentives and curb default risk. We also showed that a monetary rule that targets default risk can alleviate the tradeoff for monetary policy. In deriving these results, we focused on an economy where default risk affects inflation and monetary wedges only through the expectations channel and abstracted from shocks and preferences that are concave in imported consumption. In the next section, we analyze our general model and show numerically that our key theoretical results are present and shape much of the quantitative outcomes.

4 Quantitative and Data Analysis

This section contains the quantitative analysis of our model and its mapping to the data. We start by describing key patterns in emerging market data. We document comovements of inflation, nominal domestic rates, and spreads, discuss properties of temporary inflation events, and provide evidence of the key disciplining mechanism in the model. We then describe the parameterization of the model, analyze decision rules and impulse response functions, and compare the model's predictions to the data. In drawing our lessons, we also compare our baseline NK-Default model to a reference model without default risk, consider alternative assumptions about outcomes during default, and analyze the welfare implications of various monetary policy rules.

4.1 Emerging Market Inflation Targeters Data

Several emerging markets successfully adopted inflation targeting as their monetary policy regime in the early 2000s.[17] We analyze data from these countries and document stylized facts on the volatility and comovements of inflation, spreads, and domestic nominal rates. We also compile an event analysis around periods of elevated inflation and provide some evidence for our disciplining and amplification mechanisms.

Stylized Facts. We collect data on inflation, spreads, nominal domestic rates, and output for eight emerging markets that are inflation targeters. The sample of countries consists of those included in the JP-Morgan Emerging Market Bond Index (EMBI) that have also successfully adopted inflation targeting. The data start in 2004, by which point all countries considered had adopted the monetary policy regime, and run through 2019.

Table 1 reports key statistics on the joint behavior of these series using quarterly data. Inflation is measured by the Consumer Price Index (CPI) and computed as the log difference in the index relative

[17] See Roger (2009) and Ha, Kose, and Ohnsorge (2019) for more details on the implementation and performance of inflation targeting in emerging markets.

	Mean		Std. Dev. Rel. Output		Correlation with Spread		
	Inflation	Spread	Inflation	Spread	Inflation	Domestic Rate	Output
Brazil	5.6	2.8	0.6	0.3	0.5	0.6	−0.3
Chile	3.2	1.4	0.8	0.2	0.4	0.2	−0.6
Colombia	4.3	2.3	0.9	0.5	0.6	0.4	−0.3
Mexico	4.1	2.2	0.4	0.3	0.2	0.1	−0.5
Peru	2.9	2.0	0.5	0.3	0.5	0.1	0.0
Philippines	3.9	2.1	1.4	0.8	0.6	0.6	−0.5
Poland	2.1	1.1	0.9	0.4	0.4	0.2	−0.4
South Africa	5.0	2.2	1.2	0.5	0.5	0.1	−0.7
Mean	3.9	2.0	0.8	0.4	0.5	0.3	−0.5

Table 1: Emerging Market Inflation Targeters, Key Statistics

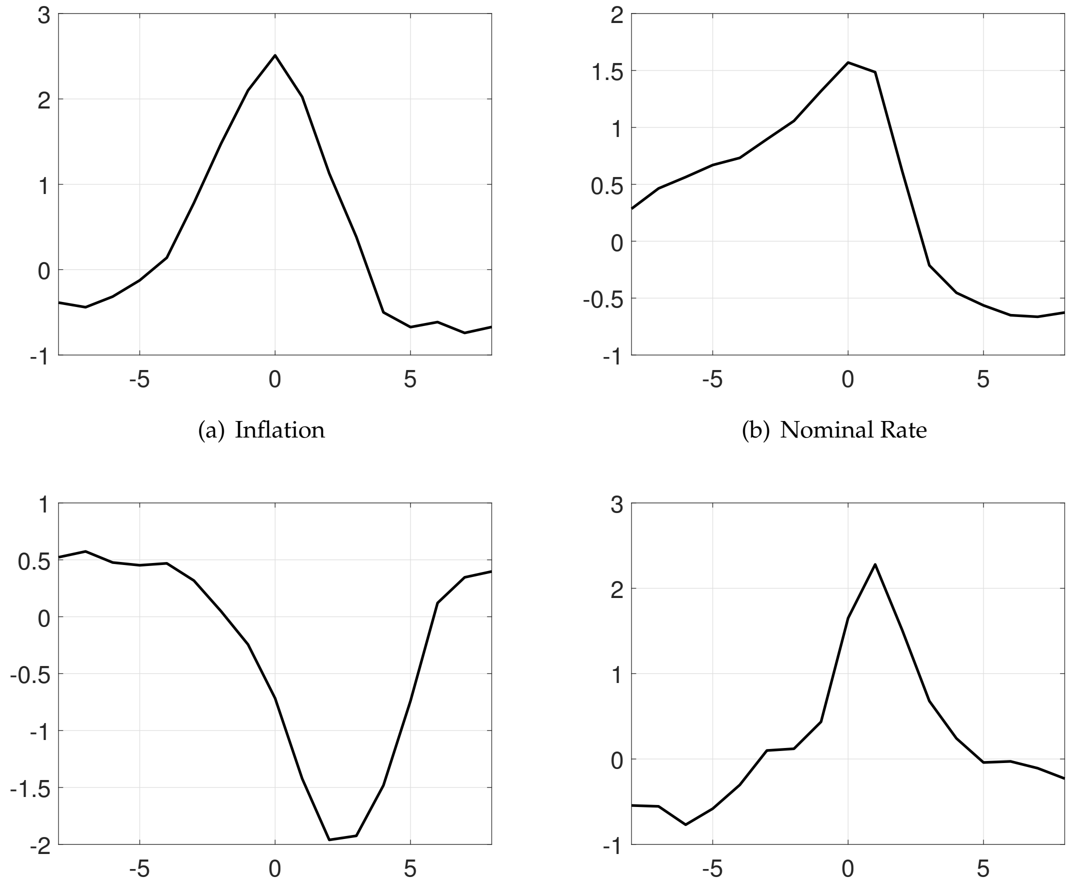
Note: Quarterly data, 2004Q1–2019Q4. "Inflation" is CPI four-quarter log difference. "Spread" is the JP Morgan EMBI+ Spread. "Output" is four-quarter log difference of real GDP. See Appendix D for the construction of our sample.

to four quarters prior. Spreads are measured as the difference in yields between foreign currency government bonds of these emerging markets, as captured by the EMBI index, and a U.S. government bond of comparable duration. Domestic nominal rates are the nominal policy rates of Central Banks, and output is the four-quarter difference in log real Gross Domestic Product. Appendix D reports detailed definitions and sources for the data.

We highlight several findings. Inflation is low on average and relatively stable. Mean inflation across these countries ranges from 2.1% to 5.6%, with an overall average of 3.9%. The standard deviation of inflation relative to that of output ranges from 0.4 to 1.4, with an average across countries of 0.8. This stable inflation contrasts sharply with the historical experience of these countries, with episodes of very high and volatile inflation. Emerging markets bond spreads are on average 2% and with an average standard deviation of 0.9%, which is 0.4 relative to that of output.

We also report correlations of spreads with inflation, nominal domestic rates, and output. Spreads are negatively correlated with output, with an average correlation of −0.5 in this sample. Correlations of spreads with nominal rates and inflation are positive, on average 0.3 and 0.5, respectively. Note that domestic nominal rates are denominated in local currency whereas government spreads are in foreign currency, so that the correlation is not driven by a common domestic inflation or exchange rate factor but instead likely reflects the relationship between inflation and default risk.[18]

[18]For a similar time period, we found a wide range of correlations between inflation and spreads for non-inflation targeters emerging countries: the correlation is −3% for Argentina, −4% for Bulgaria, and 51% for Ecuador. Therefore, we conclude that the positive correlation between inflation and spreads may not be unique to inflation targeting emerging countries.



(a) Inflation (b) Nominal Rate

(c) Output (d) Spread

Figure 2: Temporary Inflation Events

Note: Average paths around spikes in inflation, in excess of two standard deviations, based on the nine events in our emerging markets sample. All series are standardized country-by-country so that units on the vertical axes are standard deviations, and zero is the sample average. Appendix D describes our sample.

Temporary Inflation Events. Although the emerging markets in our sample have successfully kept average inflation low, these countries have experienced several events, over the last 20 years, during which inflation rose temporarily by a few percentage points. Importantly, these *temporary inflation events* have been relatively subdued, and inflation returned to lower levels shortly after the monetary authority tightened policy. We illustrate the dynamics of key variables during these events and rely on these findings for the quantitative analysis of our model.

We classify a country as experiencing an inflation event if inflation is unusually high, defined as two standard deviations or more above its mean. We center the events around the peak in inflation, where the standard deviation is calculated country by country, and analyze dynamics two years before and after this peak. Figure 2 plots average paths across the 9 events we found in our dataset for inflation dynamics, domestic nominal rates, spreads, and output, starting 8 quarters before the peak inflation and ending 9 quarters after the peak.[19] The underlying series are standardized country by country; therefore the units in the figure are standard deviations, and a value of zero means the series is at its average. The top left panel illustrates the tent-like shape of inflation during the event. Inflation starts slightly below its average level and increases close to 2.5 standard deviations at its peak, before returning to low levels. The 2.5 standard deviation increase corresponds to an average of 4.5 percentage points. The top right panel plots the domestic nominal rate, which increases by about 1.2 standard deviations and then falls at the end of the event. At its peak, the domestic nominal rate increase corresponds to 2.9 percentage points above its mean. Output, in the bottom left panel, starts above its average and falls about 2.5 standard deviations, corresponding to a 5.7 percentage points recession, before recovering towards the end of the event. The bottom right panel plots spread dynamics. Spreads also feature a tent-like shape, increasing about 2.5 standard deviations from start to peak, corresponding to about 2.3 percentage points, and falling back to their long-run average by the end of the event.[20]

These dynamics illustrate how emerging market inflation targeters have been successful at managing shocks that lead to temporarily high inflation. The resolution of these inflation episodes is impressive, as inflation decreased and returned to target in about a year with monetary tightening. We also find it noteworthy that spreads are high during these elevated inflation events. The standard, open economy New Keynesian model of Galí and Monacelli (2005) is silent about sovereign spreads, yet this empirical regularity in emerging markets is consistent with one of the main mechanisms in our NK-Default framework, that default risk can be an amplifying force for elevated inflation, a mechanism we explored theoretically in Section 3. In Appendix F, we also document that consistent with our amplifying mechanism, increases in spreads are associated with elevated survey-based inflation expectations for our sample of emerging market inflation targeters.

Disciplining Effect in the Data. In this subsection, we provide empirical evidence of the disciplining mechanism in our model, derived in Section 3, that tight monetary policy can reduce government spreads. As we illustrated above, unconditionally, nominal rates tend to rise with sovereign spreads, as seen by the overall positive correlation and during inflation events. This unconditional positive correlation is of course silent on the direct effect of monetary policy on spreads, which is the object of interest

[19] The events have the following peak dates: Brazil 2015Q4, Chile 2008Q3, Colombia 2008Q4 and 2015Q2, Mexico 2008Q4 and 2017Q4, Peru 2008Q4, Philippines 2008Q4, South Africa 2008Q3.

[20] Emerging markets are experiencing an ongoing inflation episode since 2021, which features dynamics similar to those documented here. Inflation increased substantially in all of our 8 countries and central banks responded by tightening aggressively, after which inflation fell and broadly returned to target by early 2024. Spreads spiked together with inflation and have since reverted. Appendix G contains more details.

for the disciplining effect.[21] To tease out the direct effect of monetary policy on spreads, we follow the monetary literature and first recover monetary shocks. We then project government spread on these estimated monetary shocks.

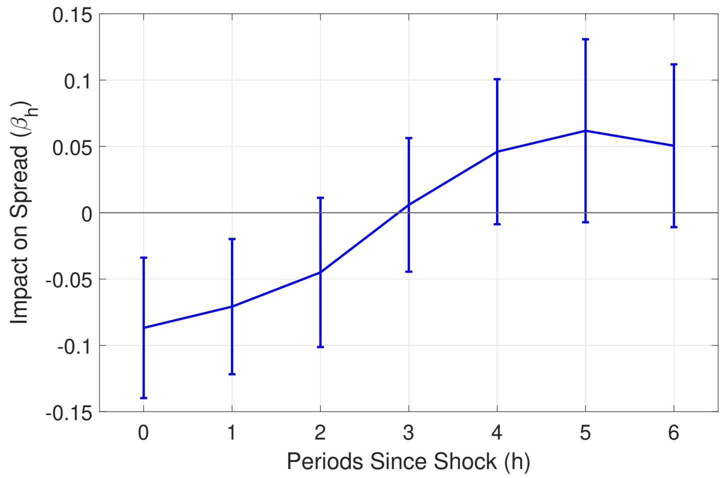


Figure 3: Projections of Spreads on Monetary Policy Shocks

Note: The figure plots the point estimates and 95% confidence intervals for the coefficients β_h in the equation (27). The coefficients are the projection estimates of sovereign spreads on monetary policy shocks.

For the first step, we recover monetary policy shocks by estimating the reaction function of the monetary authority's policy rates to inflation. In particular, for each country c, we recover the monetary shock $m_{c,t}$ by projecting policy rates on inflation and lag policy rates, such that $i_{c,t} = \alpha_c^0 + \alpha_c^1 i_{c,t-1} + \alpha_c^2 \pi_{c,t} + m_{c,t}$, where we allow the residuals to be autocorrelated. In estimating these regressions, we follow the literature and estimate them with monthly data. The coefficients α_c^2 are positive for all our countries and statistically significant for 6 of them. The finding that policy rates tend to react positively to inflation is consistent with the statutory inflation targeting regime of the countries in our sample.

We then estimate the effects of monetary shocks on spreads with a panel regression, where we project spreads on the estimated monetary policy shocks. For our baseline panel regression, we standardize all series at the country level. We project spreads for country c at time t on a vector of monetary shocks with L lags and additional controls $Z_{c,t}$

$$\text{spr}_{c,t} = \sum_{h=0}^{L} \beta_h m_{c,t-h} + \Gamma Z_{c,t} + \nu_{c,t}. \tag{27}$$

The coefficients of interest are the β_h's. We include in the controls $Z_{c,t}$ contemporaneous values for output

[21] The unconditional positive correlation of nominal rates and spreads can reflect a third factor affecting both. If, for example, low productivity is associated with increases in default risk and inflation, then a productivity-driven business cycle can rationalize the unconditional correlation.

growth and inflation, as well as nine lags for these variables. We set $L = 6$ for our baseline specification. The identifying assumption is that with these control variables, the coefficients β_h tease out the effects of monetary shocks on fluctuations in spreads. We also cluster standard errors across time and country.

Figure 3 plots the estimated coefficients β_h together with their 95% confidence band. Contractionary monetary policy shocks tend to decrease spreads. On impact, a positive monetary policy shock of one standard deviation decreases spreads by about 0.09 standard deviations. The effects are also persistent, as the point estimate is negative for three periods, but the significance decreases. Given these estimates and that the mean standard deviation of monetary shocks is 0.23 and that for spreads is 0.9, the median estimate for the first quarter of -0.07 implies an elasticity of -0.3: a 1% increase in monetary shocks decreases spreads by 0.3%. In Appendix E, we provide more details on our exercise and document the robustness of these results.

4.2 Functional Forms and Parameterization

We now present the parameterization of our quantitative model. We assume preferences are separable between a composite consumption good H and labor N. The per-period utility function is given by

$$u(C_t, C_t^f, N_t) = \log\left[H(C_t, C_t^f)\right] - \frac{N_t^{1+1/\zeta}}{1+1/\zeta},$$

where $H(C_t, C_t^f)$ is a CES composite of domestic goods C and imported goods C^f,

$$H(C_t, C_t^f) = \left(\theta C_t^{\frac{\omega-1}{\omega}} + (1-\theta)(C_t^f)^{\frac{\omega-1}{\omega}}\right)^{\frac{\omega}{\omega-1}}.$$

We can derive the Consumer Price Index (CPI) as the price of the bundle of domestic and foreign goods consumption, $P^{\text{CPI}} = P^d\left[\theta^\omega + (1-\theta)^\omega e^{1-\omega}\right]^{\frac{1}{1-\omega}}$, and the resulting CPI inflation, $\pi^{\text{CPI}} = \frac{P^{\text{CPI}}}{P^{\text{CPI}}_{-1}}$, where the subscript $_{-1}$ denotes the previous period's value. The rate of depreciation of the nominal exchange rate is

$$\frac{\varepsilon}{\varepsilon_{-1}} = \frac{e}{e_{-1}}\frac{P^d}{P^d_{-1}} = \frac{e}{e_{-1}}\pi, \tag{28}$$

which reflects inflation and the depreciation of the terms of trade.

The model features productivity, monetary, and enforcement shocks. We assume that the productivity and monetary shocks follow independent AR(1) processes, $\log \tilde{z}_t = \rho_z \log \tilde{z}_{t-1} + \sigma_z \varepsilon_{z,t}$ and $\log m_t = \rho_m \log m_{t-1} + \sigma_m \varepsilon_{m,t}$, with innovations $[\varepsilon_{z,t},\ \varepsilon_{m,t}] \sim \mathcal{N}(0, I_2)$. The productivity costs from default follow Chatterjee and Eyigungor (2012) such that $z(\tilde{z}, \Theta) = \tilde{z} - \max\left\{0, \lambda_0\tilde{z} + \lambda_1\tilde{z}^2\right\}$ if $\Theta = 0$, and $z(\tilde{z}, \Theta) = \tilde{z}$ if $\Theta = 0$. The enforcement shocks ν are i.i.d. and perturb the value of default. We integrate these shocks into our computational technique following Dvorkin, Sánchez, Sapriza, and Yurdagul (2021) and Mihalache (2020) such that ν follows a logistic distribution, where the parameter ϱ_D controls the relative importance of the shocks.[22]

Assigned Parameters		*Parameters from Moment Matching*	
Preferences	$\omega = 0.85, \theta = 0.73, \zeta = 0.33$	Discount factor	$\beta = 0.9954$
Varieties elasticity	$\eta = 6$	Interest rate rule	$\alpha_P = 1.47$
Export demand elasticity	$\rho = 5$	Inflation target	$\overline{\pi} = 1.011$
Price adjustment cost	$\varphi = 58$	Government discount factor	$\beta_g = 0.9807$
Productivity persistence	$\rho_z = 0.9$	Productivity volatility	$\sigma_z = 1.2\%$
Monetary shock	$\rho_m = 0.3, \sigma_m = 0.06\%$	Default costs	$\lambda_0 = -0.178, \lambda_1 = 0.20$
International rate	$r = 0.5\%$	Enforcement shock	$\varrho_D = 1e^{-4}$
Reentry probability	$\iota = 4.17\%$		
Debt duration	$\delta = 0.037$		

Table 2: Parameter Values

		Data	NK-Default
Means	CPI inflation	3.9	3.9
	Nominal domestic rate	5.7	5.6
	Spread	2.0	2.0
Standard Deviations	Output	2.3	2.2
	CPI inflation	1.8	1.9
	Spread	0.9	0.9
	Consumption aggregate	2.4	2.3
Correlation	(Output, Spread)	−42	−48

Table 3: Targeted Moments

We consider a quarterly model and set some parameters externally, based on prior studies, while others are determined internally as part of a moment-matching exercise. We first describe the parameters set based on direct measurement or previous work. In terms of preferences parameters, we set the elasticity of substitution between foreign and domestic goods in consumption ω to 0.85 following Corsetti, Dedola, and Leduc (2008), the weight of domestic goods in consumption θ set to induce an imports' share in the balanced-trade steady state of 29% based on our emerging market data, and the elasticity of labor supply ζ to $1/3$ as in Galí and Monacelli (2005). In terms of technology parameters, we set the domestic varieties' elasticity η to 6, which corresponds to a 20% markup, in line with the estimates in Edmond, Midrigan, and Xu (2023) and Díez, Fan, and Villegas-Sánchez (2021), the Rotemberg adjustment cost φ such that the frequency of price changes of roughly is once per year using the well-known equivalence between Calvo and Rotemberg pricing,[23] and the persistence of the productivity shock to 0.9 based on

[22]This computational technique consists of augmenting the model with taste shocks in the discrete choice tradition. Appendix H contains more details on the computational algorithm and simulation of the model.

[23]See, for example, Miao and Ngo (2021) for the mapping between the Calvo and Rotemberg parameters.

international business cycle studies. Other parameters we set are the export demand elasticity ρ to 5 based on Bajzik, Havranek, Irsova, and Schwarz (2020), the international interest rate r to 0.5 implying a 2% annual rate, consistent with U.S. Treasury yields, the probability of return to financial markets after default ι such the average length of market exclusion is 6 years, based on Cruces and Trebesch (2013), the debt decay parameters δ such that the duration of debt is 6 years, consistent with emerging markets data, the persistence and standard deviation of monetary shocks to 0.3 and 0.25%, respectively, based on our estimates of monetary shocks, and the intercept of the interest rate rule to satisfy the steady-state condition $\bar{i} = \overline{\pi}/\beta$. Finally, we normalize the level of export demand ξ to 1.

The second set of parameters is pinned down by a moment-matching exercise, such that our model replicates salient features of emerging market inflation targeters' data. These eight parameters are the discount factors of the private sector and that of the government, β and β_g, respectively, the inflation target $\overline{\pi}$, the interest rate rule coefficient α_P, the volatility of the productivity innovations σ_z, the parameters of the default cost function $\{\lambda_0, \lambda_1\}$, and the parameter governing the magnitude of the enforcement shock ϱ_D. We target average moments across our sample: averages of the means and standard deviations of CPI inflation and spreads, means of nominal domestic rate, standard deviations of output and consumption, and the correlation of spread with output.[24]

Most parameters affect all moments, yet some moments are more informative for setting certain parameters. The average CPI inflation rate in the data is the most influential for $\overline{\pi}$. The weight of inflation in the interest rate rule α_P heavily affects the volatility of inflation. The volatility of productivity shocks is the main driver of output volatility. The enforcement shock parameter ϱ_D and the productivity default cost parameters are crucial for the dynamics of spreads. The volatility of the enforcement shock informs the mean and standard deviation of spreads, while the productivity cost parameters shape the correlation of spread with output, in addition to their role in the volatility of spreads. The discount factor of the sovereign β_g affects the volatility of consumption while the discount factor of the private sector β controls the average real domestic rate. We collect the values of all the parameters in Table 2.

We note that the parameters of the interest rate rule, α_P and $\overline{\pi}$, are in line with external estimates. The value of α_P is well within the range of estimates in the reaction functions we recovered for the eight emerging markets. Moreover, the resulting average rate of annual inflation, in our quarterly model, given by $\overline{\pi}^4 \approx 4\%$, is in line with the announced inflation targets in the countries of our sample. For example, the Central Bank of Brazil pursued a 4.5% target before 2018 and 3% in recent years, while South Africa's target has been 4.5% since 2017. The targets for Colombia and Chile were at 3% since the

[24]We focus on CPI inflation because of data limitations with alternative price indices. With shorter available samples for indexes for producer (PPI) and service prices, we found that the correlations of these series with spreads are similar, although the PPI volatility is higher due to the influence of intermediate goods and commodity prices.

mid-2000s.

Table 3 reports the fit of the moment-matching exercise. Overall, we find that the model is able to replicate closely the targeted moments in the data. We compute model moments using a long simulated sample, from which we exclude default episodes and their associated international market exclusion spells, because none of the countries in our data sample outright defaulted during the sample period. CPI inflation, nominal domestic rates, and spreads are reported annualized. In the model and data, CPI inflation is about 3.9%, spreads are 2%, and nominal domestic rates are about 5.7%. The standard deviation of output is about 2.3%, of CPI inflation is 1.8%, while consumption is about 2.4%. The volatility of spreads is 0.9% in both the data and the model. Output is negatively correlated with spreads, with a correlation close to -0.42.

4.3 Policy Rules and Impulse Response Functions

To showcase the workings of the quantitative model, we describe policy functions and plot impulse response functions following monetary and productivity shocks. These enable us to illustrate how our main mechanisms, default amplification and monetary discipline, are operational in the quantitative model.

Policy Rules. Figure 4 presents policy rules as a function of debt B. To highlight the impact of default risk on policy functions, we plot two lines in each figure, a solid line for the variable of interest and a dotted line for the equilibrium, one-period-ahead default risk, using a second, right-side vertical axis. In the figures B is scaled by average annual exports and the functions are for the average values of the productivity and monetary shocks, with the focus on behavior conditional on not defaulting. As shown by the dotted lines in the plots, default probabilities increase with current debt B because debt due next period $B' = H_B(s, B)$ increases with B, which in turn makes future default more likely.

Default risk impacts domestic allocations in our model through two main channels. First, through an expectation channel: default risk alters the expectation terms of the domestic Euler equation and the NKPC. This channel was the focus of our theoretical analysis in Section 3, where we considered a utility function linear in imported consumption C_f, which rendered terms of trade independent of C_f. In our quantitative model, with preferences concave and non-separable in imported consumption, a second channel is active, as debt and default risk affect the terms of trade through their impact on capital flows and imported consumption. In describing the policy rules in Figure 4, we draw a distinction between two regions: a region with positive default risk for levels of B above 0.28, where the expectations channel is mostly at play, and another one with essentially no default risk, for lower debt levels, where the capital flows channel dominates.

Panel 4(a) illustrates a key mechanism in our model, the evolution of the monetary wedge across debt levels. The monetary wedge is high when the default risk is high. Moreover, it increases with B when default probabilities are positive. In this region, high default risk increases future expected marginal utility, and through the domestic Euler equation, it lowers current domestic consumption, as seen in Panel 4(e). Low demand for domestic consumption lowers output as well, as seen in 4(d) in the positive default risk region.

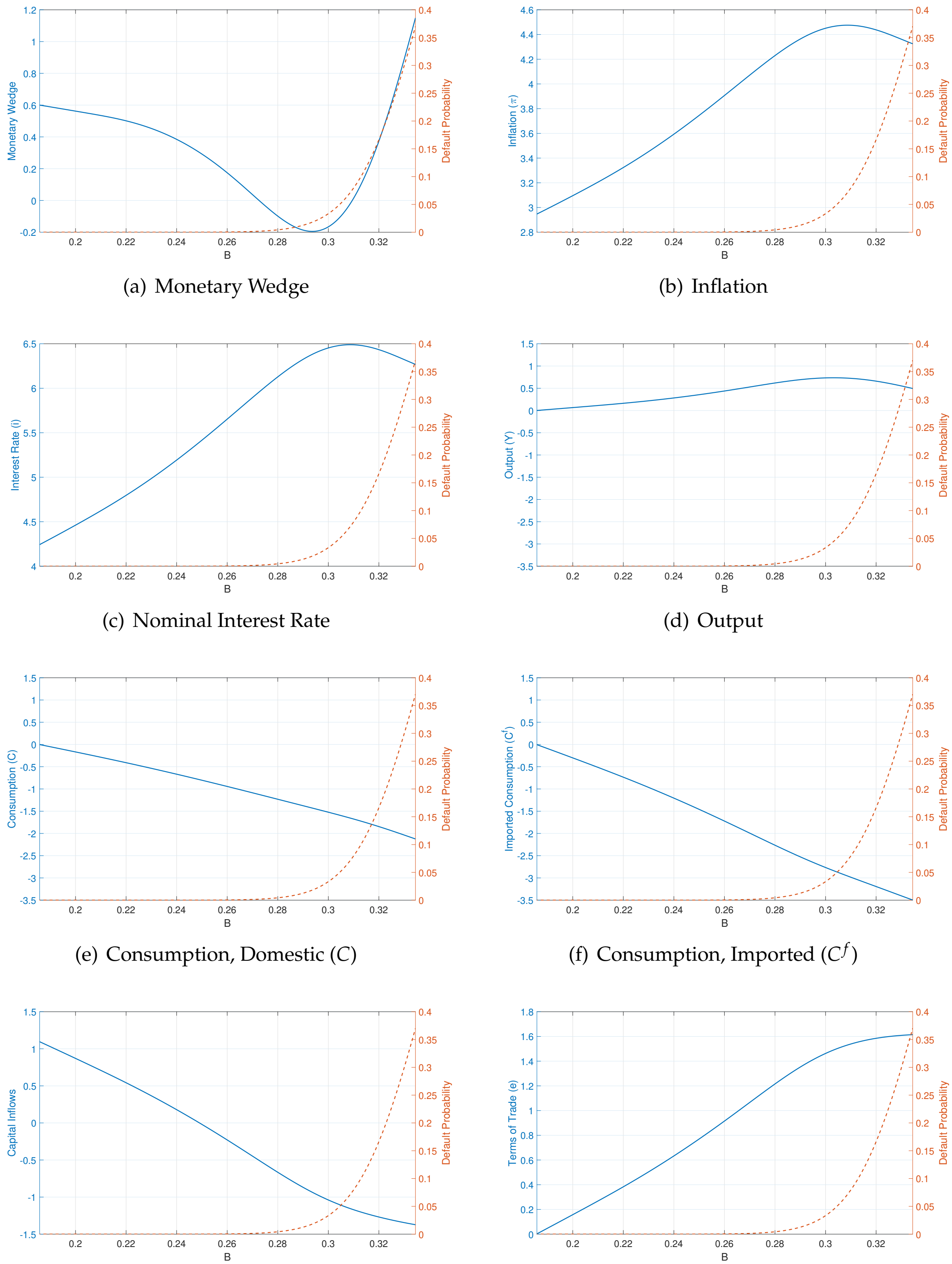
When default risk is high, inflation and nominal rates are also high. According to the NKPC equation (8), current inflation is negatively related to the monetary wedge and positively related to expected future inflation. In the low-default risk region, increases in debt lead to a depreciation of the terms of trade, which tends to increase employment and inflation. In the high default region, terms of trade movements are muted, and the monetary wedge rises. Overall, when comparing the high versus low default-risk regions of B, high default risk is associated with higher inflation, as shown in Panel 4(b). In response to high inflation, the monetary authority's interest rate rule calls for higher nominal rates, as captured in Panel 4(c).

Panel 4(g) plots the equilibrium capital inflows, given by $q(s, B')(B' - (1 - \delta)B) - (r + \delta)B$ in our model with long-term debt. We express these inflows in average annual export units. As default risk is reflected in the bond price schedule, government borrowing increases slower than current debt, and hence capital inflows decrease as a function of debt B, resulting in a decline in imported consumption C^f, as shown in Panel 4(f). In the region of low debt, with no default risk, this effect leads to a depreciation of the terms of trade 4(h), which boosts export demand and also modestly increases output.

Note that the patterns in the low default region mirror results in standard models in the literature. As Blanchard, Ostry, Ghosh, and Chamon (2017) discuss, in the workhorse open-macro model, a reduction in capital inflows is expansionary because it depreciates the exchange rate, the so-called *expenditure switching* effect. The novel finding in our model with default risk is that a reduction in capital inflows can be recessionary, as exemplified in the high default region. This is because a reduction in capital inflows due to high default risk leads to a reduction in domestic consumption demand through the expectation channel, which in turn depresses production.[25]

Impulse Response Functions. We can further explore the mechanisms driving our model by plotting impulse responses (IRF) for the main variables of interest, following monetary and productivity shocks. We construct the impulse response functions (IRFs) in our nonlinear model following Koop, Pesaran,

[25] Alternative financial frictions, such as the collateral constraint of Mendoza (2010), can also generate output contractions from reductions in capital flows.



(a) Monetary Wedge

(b) Inflation

(c) Nominal Interest Rate

(d) Output

(e) Consumption, Domestic (C)

(f) Consumption, Imported (C^f)

(g) Capital Inflows

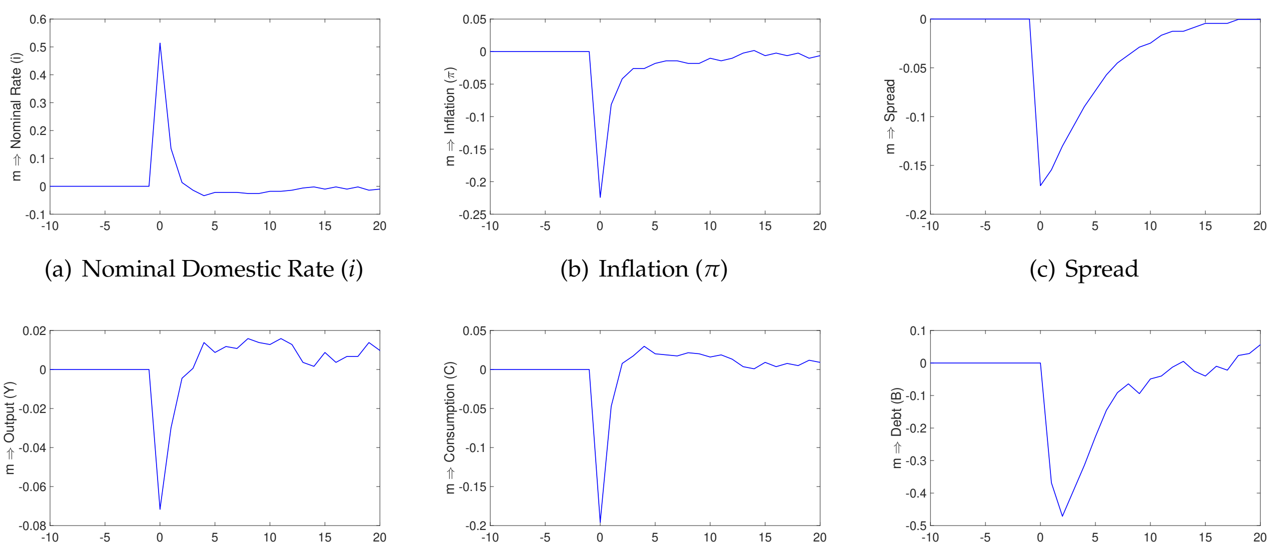
(h) Terms of Trade

Figure 4: Equilibrium Policy Functions

Note: Inflation and the nominal interest rate as expressed in percentage points. Output, domestic consumption, imported consumption, and the terms of trade are expressed as log point deviations from the level at the lowest B on the horizontal axes. Capital inflows and the debt level are scaled by average annual exports.

and Potter (1996). We simulate a panel of 200,000 units for 1,500 periods. For the first 1,450 periods, the shocks follow their underlying Markov chain so that the cross-sectional distribution converges to the ergodic distribution of the model. In period 1,451, the impact period (normalized to 0 in the plots), we shock all units of the panel by the same amount. From period 1,452 onward, shocks follow again their Markov chain processes. The impulse responses plot over time the cross-sectional average over units of the panel. The impulse responses are computed over all units, including those with defaults. Discarding defaults from the cross-sectional average does not alter the salient properties of the IRFs.

We start with IRFs of the monetary shock to illustrate the discipline force in our model, namely that a high nominal interest rate lowers default risk. The IRFs in Figure 5 are to a 0.85% contractionary m shock. An increase in the monetary shock leads to dynamics that are standard in the New Keynesian literature: temporary increases in the nominal rate and temporary decreases in inflation, output, and consumption. Monetary shocks in our NK-Default model, however, also impact the government's borrowing incentive. Contractionary monetary shocks encourages a reduction in external borrowing which reduces sovereign spreads, in line with the discipline mechanism.[26]



(a) Nominal Domestic Rate (i) (b) Inflation (π) (c) Spread

(d) Output (Y) (e) Consumption (C) (f) Debt (B)

Figure 5: Impulse Response Functions to Monetary Shocks

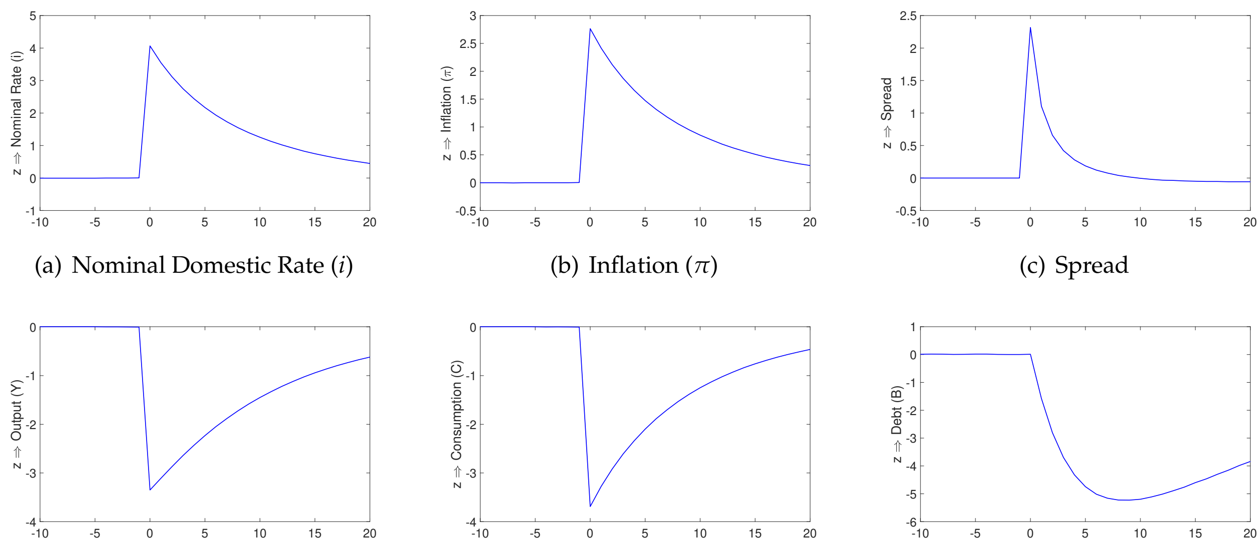
Note: Impulse response functions to a contractionary monetary shock m. All panels plot variables expressed as a percentage deviation from the sample average.

The responses in Panels 5(a) through 5(f) of Figure 5, imply that an increase in the monetary shock of about 0.85% decreases inflation by about 0.23%, output by 0.07%, and consumption by 0.2%. The tighter

[26] Note that in our model we have abstracted from firm credit frictions. If, as in the findings of Gertler and Karadi (2015), contractionary monetary shocks worsen these financial frictions and the resulting credit crunch reduces tax revenues, the decline in sovereign default risk could be dampened.

monetary policy reduces debt by 0.45% and spreads by about 0.17%. The responses on impact imply a negative elasticity of spread with respect to the monetary shock of about 20% (0.17/0.85), which is within the confidence band estimate of the empirical elasticity, in Figure 3 and Table 6 in the Appendix.

Figure 6 reports the IRFs with respect to the productivity shock. Output declines about 3.2%, with a contractionary productivity shock of comparable magnitude. Consumption declines somewhat more because as is typical in sovereign default models, low productivity tightens the bond price schedule because defaults are more likely in recessions, and with persistent shocks, low productivity makes future recessions more likely. The tight bond price schedule leads to higher spreads and a reduction in debt, which tends to increase the volatility of consumption. Spreads rise about 2.3%, and debt contracts slowly, by about 5.2% of its average value. Inflation rises about 2.8% on impact because of the high unit cost from low productivity and the increased default risk. The nominal domestic rate increases in response to the elevated inflation, about 4%. These dynamics illustrate that productivity shocks lead to a strong, positive comovement of spreads with inflation and nominal rates.



(a) Nominal Domestic Rate (i) (b) Inflation (π) (c) Spread

(d) Output (Y) (e) Consumption (C) (f) Debt (B)

Figure 6: Impulse Response Functions to Productivity Shocks

Note: Impulse response functions to a contractionary productivity shock, z. All panels plot variables expressed as a percentage deviation from the sample average.

4.4 Business Cycle Moments, Inflation Events, and the Reference Model

We now turn to our model's business cycle implications and compare them with the moments of a reference model without default risk. We also perform an event analysis to assess the contribution of default risk to the inflation events described in Section 4.1. We start by introducing a reference model without default.

NK-Reference. To isolate the interactions between monetary frictions and default risk, we compare our findings with a reference model, labeled *NK-Reference*, which is a version of the Galí and Monacelli (2005) model with nominal rigidities and without default. The equilibrium of the NK-Reference model is characterized by the same private and monetary equilibrium of our baseline NK-Default model from Definition 1 and summarized in the Appendix by equations (30–35), the international Euler condition (18), and an exogenous debt-elastic bond price schedule to close the model, as in Schmitt-Grohé and Uribe (2003). The debt-elastic bond price schedule is $q^{\text{ref}}(B)^{-1} = \beta + \Gamma\left[\exp(B - \overline{B}) - 1\right]$, with Γ set to 10^{-5}, which gives a very loose borrowing schedule, and $\overline{B}$ set to give the same average debt level as our baseline. We solve the NK-Reference model with a first-order log-linear approximation of the equilibrium conditions, keeping all parameter values the same.

Business Cycle Statistics. The first two columns of Table 4 report the first and second moments for the emerging market data and for simulated data from our baseline NK-Default model. The data consist of the series reported in Sections 4.1 and 4.2, for output, CPI inflation, nominal domestic rates, spreads, and aggregate consumption, as well as the trade-weighted nominal exchange rate depreciation. All moments are averages across the emerging markets in our sample and reported in percentage points.

Overall, the moments in the baseline model resemble those emerging market data. The mean CPI inflation, nominal domestic rate, and spread, as well as the volatility of inflation, output, and spreads are targets in our moment-matching exercise. The model delivers volatility of the nominal rate comparable to the data, whereas it underestimates the high volatility in nominal exchange rates, reflecting the common disconnect between exchange rates and fundamentals in much of international business cycle theory. Our model also produces the observed cyclicality of the trade balance: the average correlation of trade-balance-to-output with output is −24% in the data and −29% in the model.

The model delivers the key stylized fact that inflation positively correlates with spreads, close to 50% in the model and the data. In addition, the model generates a positive correlation between the nominal rate and the nominal depreciation rate with spreads. These correlations arise in our model because, across all state variables, namely, productivity shock z, monetary shock m, and debt B, inflation and spreads comove positively. These positive correlations are the implications of the amplification and disciplining mechanisms of our model. Finally, the model also delivers autocorrelations for output, inflation, spreads, and nominal domestic rates in line with those in the data.

We quantify our model's amplification mechanism, which relates default risk to elevated inflation expectations, by assembling survey data on inflation expectations available for five countries in our sample. As documented in Appendix F, we find that, in the data, a 1% increase in spreads is associated with an average 0.97% increase in inflation expectations for the following twelve months. The corresponding measure, in our baseline NK-Default model, is 1.14%, well within the 95% confidence interval of the estimated coefficient.

The third column of Table 4 reports the moments of the NK-Reference model, which is silent on default risk. Average CPI inflation and the nominal domestic rate are the same as in the benchmark. The standard deviations of CPI inflation and the nominal interest rate are, however, only about 60% of those in the NK-Default baseline. Default risk makes inflation more volatile because it affects expected future inflation and the monetary wedge, as discussed in Section 3. This comparison shows that an emerging market central bank targeting inflation must implement a more volatile interest rate policy due to sovereign default risk.

Temporary Inflation Events Revisited. We can employ the NK-Default and NK-Reference models to revisit the temporary inflation events discussed in Section 4.1. The main goals of this exercise are to evaluate the quantitative performance of our model in matching the observed dynamics and to assess the role played by default risk during such episodes.

To simulate the event, we start the model at the mean of the stationary distribution, with good credit standing, and feed in a sequence of productivity and monetary shocks. The shocks are chosen such that the resulting paths of inflation and nominal interest rate in our NK-Default model best fit the data in Figure 2. Note that in our non-linear model, with debt as a state variable, this procedure is reminiscent of the particle filtering problem over the entire path.

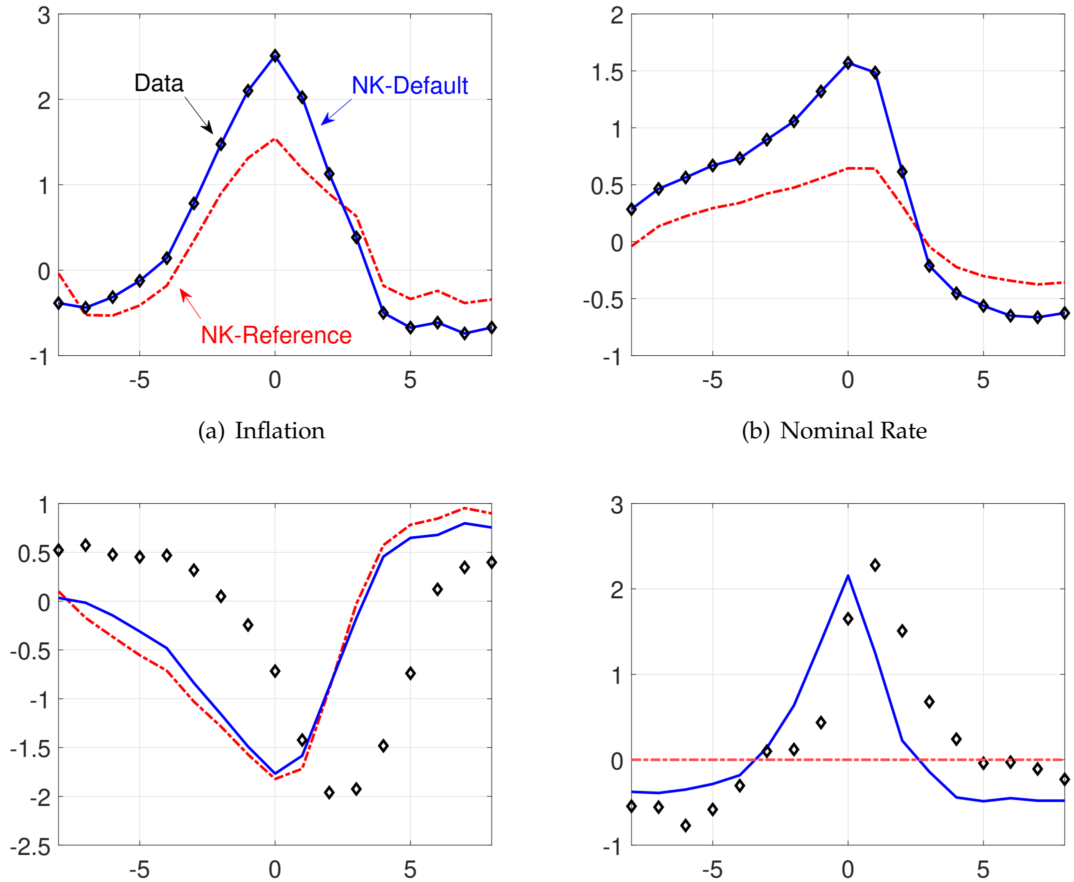
The solid blue lines in Figure 7 represent the resulting NK-Default paths for inflation, nominal rates, output, and spreads. The black diamond markers correspond to the data. All series are standardized, as previously described in Section 4.1. The NK-Default model replicates well the paths for inflation and the nominal rate, as seen in the top two panels of the Figure. Note that in our non-linear model with default risk, there is no guarantee that there exist shock paths that can deliver arbitrary paths for these variables, so we view this result as providing further validation of our model. Inflation increases temporarily, close to 2.5 standard deviations, in both model and data, and returns to low levels about a year after peaking. Nominal rates increase by 1.5 standard deviations as inflation picks up, and then they fall below their long-term average once inflation subsides. Figure 9 in Appendix C plots the resulting shock time paths. It shows that inflation events are driven by the interaction of low productivity and expansionary monetary policy shocks.

The model delivers comparable dynamics to the data for output and spreads, as illustrated in the

	Data	NK-Default	NK-Reference	NK-Default Alternative Rules: Strict Inflation	NK-Default Alternative Rules: Inflation-Default	Alternative Default
Mean						
CPI inflation	3.9	3.9	4.2	4.2	3.8	4.0
Nominal domestic rate	5.7	5.6	5.7	5.7	5.5	5.6
Spread	2.0	2.0	–	2.4	0.3	2.0
Standard Deviation						
Output	2.3	2.2	2.6	2.3	2.3	2.2
CPI inflation	1.8	1.9	1.1	0.2	0.3	1.9
Spread	0.9	0.9	–	0.7	0.04	0.9
Consumption aggregate	2.4	2.3	1.1	2.7	2.7	2.3
Nominal domestic rate	1.9	2.9	1.7	1.8	2.1	3.0
Depreciation rate	8.6	1.9	1.6	0.5	0.5	1.9
Correlations						
(Spread, Output)	−42	−48	–	−60	−49	−51
(Spread, CPI inflation)	46	56	–	−39	38	52
(Spread, Nom. dom. rate)	30	75	–	43	95	74
(Spread, Depreciation rate)	37	49	–	−39	−5	45
(CPI inf., Output)	−22	−9	−7	56	29	−9
(CPI inf., Nom. dom. rate)	59	88	90	−18	31	88
Autocorrelations (%)						
Output	84	69	70	70	72	69
CPI inflation	88	97	98	65	79	97
Spread	83	63	–	48	82	62
Nominal domestic rate	95	87	90	58	62	86

Table 4: Comparison of Moments Across Data and Models

Note: Business cycle moment for the data and five models: the baseline "NK-Default" model, the reference model without default risk "NK-Reference", two alternative monetary policy regimes "Strict Inflation Targeting" and "Inflation–Default" of Section 4.5, which also targets default risk, and the model with an alternative mechanism for high inflation during default "Alternative Default" of Section 4.6. Appendix D details the construction of our sample and the data moments.



(a) Inflation

(b) Nominal Rate

(c) Output

(d) Spread

Figure 7: Inflation Event Analysis

Note: Time paths for productivity z and monetary shocks m are set to fit the paths of inflation and the nominal rate. Shock paths are plotted in Figure 9 in the Appendix. The data is in black diamond markers, the same paths as in Figure 2.

bottom two panels of Figure 7. Output falls to about 2 standard deviations below average and spread increases by about 2 standard deviations, quickly returning to average levels within 6 quarters from the peak of inflation. In the data, nevertheless, the trough in output is about two quarters after the trough in the model.

We can leverage this event analysis to assess the contribution of default risk to these dynamics by comparing our NK-Default model to paths produced by the NK-Reference model without default risk. We feed the NK-Reference model the same time paths for productivity and monetary shocks and start the episode in the steady state. The resulting series are the dashed red lines in Figure 7. Without default risk, the increase in inflation during the event is more muted than in our NK-Default model. At its peak, the inflation spike is about two-thirds of that in the data and in our model. In contrast, the decrease in output in the NK-Reference model is comparable to that of the baseline model with default. The top right panel shows that the increase in nominal rates is smaller, reflecting the more muted rise in inflation. Finally, note that the NK-Reference model is silent on spread dynamics.

This model comparison during the event analysis shows that default risk is an important driver of inflation volatility, as it magnifies the consequences of shocks for inflation. The contribution of default risk for inflation is substantial for these events, about 45% at its peak. Low productivity and expansionary monetary shocks tend to raise default risk, which increases expected inflation. In turn, this higher expected inflation feeds into current inflation, via the firms' current pricing decisions, and calls for more aggressive monetary policy in the form of stronger responses of nominal domestic rates.

4.5 Alternative Monetary Rules and Welfare

We have shown that default risk alters monetary transmission through its amplification and disciplining mechanisms. In this section, we study the welfare implications of various monetary policy regimes.

We compare our baseline NK-Default model, with an inflation targeting monetary rule, to two different monetary policy regimes. The first alternative we consider is that of *strict inflation targeting*. Under this regime, the monetary authority sets nominal rates such that inflation π_t is at all times at the target level $\overline{\pi}$. Recall that this would be the optimal monetary regime for a model similar to ours, except without default risk. As in the theoretical analysis of Section 3, under strict inflation targeting, outcomes are those that would prevail under flexible prices.

The second alternative regime we consider is one under which the monetary policy is an augmented interest rate rule. Based on our theoretical analysis, we know that interest rate rules that respond to default risk can support better outcomes, therefore in this extension we propose a rule that responds to both inflation and default risk Φ_t. For the *inflation-default risk* regime, the interest rate rule is

$$i_t = \bar{i} \left(\frac{\pi_t}{\overline{\pi}}\right)^{\alpha_P} \left(\frac{\Phi_t}{\overline{\Phi}}\right)^{\alpha_D} m_t. \tag{29}$$

We focus on the case under which α_P is kept as in the baseline and where we fix a value for $\overline{\Phi}$ corresponding to a 0.25% annual default probability and an α_D of 8. We also vary both α_P and α_D and report the welfare consequences of these alternative parameter values. Note that this extended rule nests the NK-Default baseline rule, if α_P is the same and α_D is set to zero.

Business Cycle Moments. Before discussing the welfare properties of alternative regimes, we briefly review their associated business cycle moments, collected in Table 4. The second column corresponds to our NK-Default baseline model while the fourth and fifth columns report the values for strict inflation targeting and the inflation-default risk regimes, respectively. Under strict inflation targeting, the mean spread is roughly 40 basis points higher than in NK-Default while CPI inflation is substantially smoother. In this regime, the monetary discipline mechanism is disabled and as a result, spreads are higher due to more aggressive sovereign borrowing. This model exhibits two counterfactual negative correlations, between spreads and CPI inflation and between spreads and the domestic nominal rate. As producers' inflation is constant at target, all movements in CPI inflation are due to changes in the terms of trade. As a consequence, the correlation between spreads and CPI inflation reflects terms of trade movements alone.

Turning to the inflation-default regime, we find that spreads are significantly reduced by the presence of this additional term in the interest rate rule. One notable consequence of this additional monetary discipline is the much lower volatility of CPI inflation, about one-sixth, even though the α_P parameter is unchanged. This quantitative finding echoes Proposition 3 from our theoretical analysis of monetary discipline, where we found that optimal monetary policy can approach the constrained efficient outcome, with an arbitrarily small monetary wedge. Such an optimal monetary policy reduces both default risk and the monetary wedge, associated with inefficient movements in inflation.

Welfare. To assess the welfare consequences of these alternative monetary policy regimes, we consider the welfare of the domestic household at a key state in the model's state space: an initial debt level of zero ($B = 0$) and all shocks are at their median levels ($z = m = 1$), while the country enjoys good credit standing.[27]

Figure 8 compiles our findings. In both panels, we plot welfare relative to the strict inflation targeting

[27] These results are robust to evaluating welfare at the median debt level of the ergodic distribution of the NK-Default model.

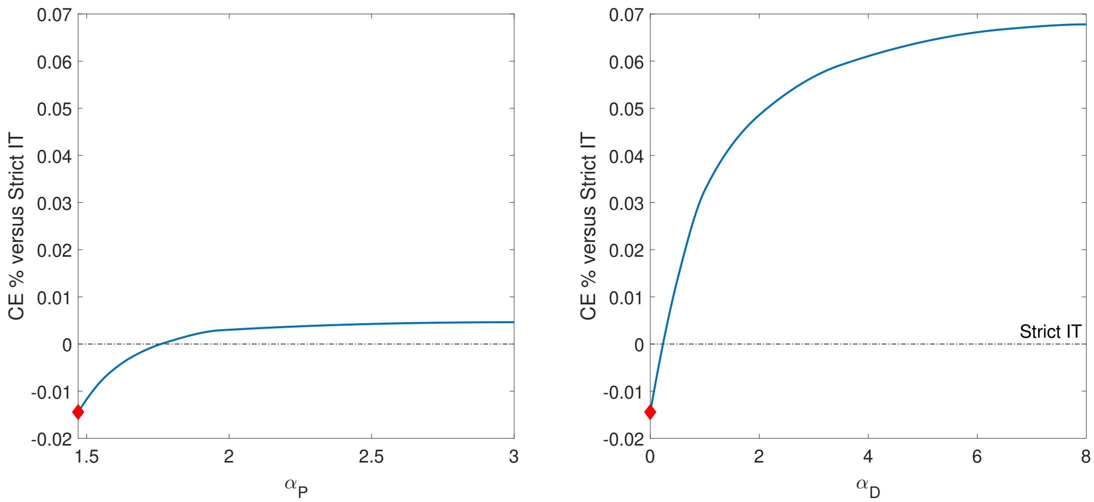


Figure 8: Welfare Comparison Across Monetary Policy Regimes

Note: Welfare gains expressed in consumption equivalent measures, percentage of implied consumption, relative to the *strict inflation targeting* regime, corresponding to the horizontal dashed black line at zero. The red diamond marks the level associated with our baseline NK-Default model. The left panel fixes $\alpha_D = 0$ and varies α_P. The right panel fixes $\alpha_P = 1.47$ as in our baseline parameterization, and varies α_D.

regime as a consumption equivalent percentage. In the left panel, we vary α_P, the coefficient controlling the response of domestic nominal rates to deviations of inflation from target, while keeping $\alpha_D = 0$. This left panel corresponds to the baseline inflation target rule in our NK-Default model. The red diamond marks the value from our baseline parameterization. With an α_P of 1.47, households prefer strict inflation targeting to the baseline rule, even at the cost of additional default risk. However, welfare increases in the α_P parameter and exceeds that of the strict inflation targeting regime at about $\alpha_P \approx 1.75$. As the monetary policy rule calls for more aggressive responses to inflation, the disciplining mechanism lowers spreads enough that, eventually, a regime exhibiting some inefficient production due to pricing frictions, but where default risk and spreads are low, is better than outcomes under strict inflation targeting. Eventually, the gains from sharper responses to inflation flatten out as α_P approaches 3.

The right panel of Figure 8 summarizes our findings for the inflation-default targeting regime. Here, α_P is kept fixed at 1.47 and the horizontal axis varies α_D, starting at its baseline value of 0. The potential for welfare gains from adopting this regime over strict inflation targeting is sizable. If the interest rate rule is responsive enough to default risk, for roughly $\alpha_D \geq 0.4$, households are better off under the inflation-default regime than under strict inflation targeting. As α_D approaches 8, welfare gains flatten out. In the limit, households would be willing to forego 6.5 basis points of their consumption on average in order to adopt the inflation-default interest rate rule over strict inflation targeting, a sizable magnitude compared to the typical welfare cost of business cycle calculations.

4.6 An Alternative Mechanism for High Inflation in Default

In our baseline model, monetary policy is always committed to its interest rate rule, even during defaults. A potential concern is that, if default is a time of fiscal distress, the monetary authority could be under pressure to abandon its commitment to target inflation. In this section, we consider the case where monetary policy is loose after default. Interestingly, this assumption also delivers high inflation during default, which is an important ingredient in our results. In our baseline, monetary policy always targets inflation and, during default, inflation is high because of productivity costs. In this alternative model, inflation is high during default because of loose monetary policy, from abandoning the baseline rule. To implement this alternative view, we assume that during default the monetary authority sets lower policy rates, such that

$$i_t = \left(\bar{i} - \Delta\right)\left(\frac{\pi_t}{\overline{\pi}}\right)^{\alpha_P} m_t$$

with $\Delta > 0$ during default ($\Theta = 1$) and zero otherwise. Now, the monetary authority is willing to miss the inflation target and run the economy hot during default.

In this alternative model we assume that there is no productivity loss in default, by setting $z = \tilde{z}$ in all states. Instead, we modify the utility cost of default, which in our baseline equals the enforcement shock, to depend on productivity following Bianchi, Hatchondo, and Martinez (2018).[28] The utility cost upon default is now $\tilde{\nu}(s, \nu) = \nu + \alpha_0 + \alpha_1 \log \tilde{z}$, where ν is the enforcement shock from the baseline model, and α_0 and α_1 are parameters set to target in this alternative model the standard deviation of the spread and the correlation of spread with output. We also set the parameter Δ to replicate mean inflation level in default at median $\tilde{z}$ of 5.3%, which is a little over 1% higher than the inflation level implied by $\Delta = 0$. This last target moment is motivated by the fact that our baseline model matches the empirical elasticity of inflation expectations with respect to spreads.

The right-most column of Table 4, labeled "Alternative Default," reports the moments resulting from these alternative assumptions about outcomes in default, allowing for a direct comparison of their counterparts under the baseline, in the second column. The two models are strikingly similar. As long as inflation is expected to be high during default, default amplification and monetary discipline continue to shape outcomes during normal market access.

Figure 10 in Appendix C illustrates that the IRFs with respect to monetary and productivity shocks are very similar to those in the baseline. These similarities imply that quantitatively, the monetary and disciplining mechanisms are comparable across models. In light of these findings, we conclude that our results require higher inflation in default and that default risk be countercyclical, but are otherwise

[28] As is well known in the sovereign debt literature, the model requires a cost of default that depends on productivity to match the countercyclicality of spreads, but the utility specification here neutralizes any direct effect on inflation through firms' pricing condition.

unaffected by the cause of elevated inflation in default, including loose monetary policy.[29]

5 Conclusion

We proposed a framework that combines two important aspects of current policy in emerging markets: sovereign risk in government debt and inflation targeting as monetary policy. It allowed us to identify novel mechanisms shaping the interplay of monetary policy, sovereign spreads, and domestic activity. We have employed our framework to study temporary inflation events in emerging markets, which have been accompanied by higher sovereign spreads and tighter monetary policy. We also provide support for the relevance of the mechanism of our model by combining empirical analysis using panel data of 8 emerging market inflation targeters with a quantitative evaluation of our model.

Our work also revisits the design of optimal monetary policy in emerging markets. Even though in our environment, it is possible for the monetary authority to deliver the flexible price allocation and to fully eliminate domestic distortions via strict inflation targeting, this is not optimal in the presence of default risk. This result is shared by recent work such as Aoki et al. (2018), who also study environments with pricing and financial frictions.

In first integrating a New Keynesian model with sovereign default, we have necessarily abstracted from important features that are affected by both nominal rigidities and sovereign risk. Some of these include unemployment, investment, the global financial cycle (Rey (2015)), the spillover of US monetary policies to emerging market economies (Kalemli-Özcan (2019)), or other financial stability policies such as capital controls. We conjecture that some of the policy implications may be substantially altered when analyzed in a New Keynesian framework with sovereign risk. Our framework may also be useful for the study of the recent episodes of high inflation episodes of 2021 and 2022 in advanced and emerging markets alike, which featured elevated sovereign debt. We leave these extensions for future work.

References

Aguiar, M., M. Amador, E. Farhi, and G. Gopinath (2013, 10). Crisis and commitment: Inflation credibility and the vulnerability to sovereign debt crises. Working Paper.

Aguiar, M., M. Amador, and S. Fourakis (2020). On the welfare losses from external sovereign borrowing. *IMF Economic Review 68*, 163–194.

[29]The sovereign default literature has proposed other sources of costs of default, including reductions in imported intermediate goods (Mendoza and Yue (2012)) and domestic credit crunches (Bocola (2016)). These alternative costs would tend to increase the marginal unit cost of firms, and therefore are likely to generate higher inflation, as in our baseline model.

Aguiar, M., M. Amador, H. Hopenhayn, and I. Werning (2019). Take the short route: Equilibrium default and debt maturity. *Econometrica 87*(2), 423–462.

Aguiar, M. and G. Gopinath (2006). Defaultable debt, interest rates and the current account. *Journal of International Economics 69*(1), 64–83.

Aoki, K., G. Benigno, and N. Kiyotaki (2018, 10). Monetary and financial policies in emerging markets. Working paper, Princeton University.

Arellano, C. (2008). Default risk and income fluctuations in emerging economies. *American Economic Review 98*(3), 690–712.

Arellano, C., Y. Bai, and L. Bocola (2020). Sovereign default risk and firm heterogeneity. Working Paper.

Bacchetta, P., E. Perazzi, and E. Van Wincoop (2018). Self-fulfilling debt crises: What can monetary policy do? *Journal of International Economics 110*, 119–134.

Bai, Y. and J. Zhang (2012). Financial integration and international risk sharing. *Journal of International Economics 86*(1), 17–32.

Bajzik, J., T. Havranek, Z. Irsova, and J. Schwarz (2020). Estimating the armington elasticity: The importance of study design and publication bias. *Journal of International Economics 127*, 103383.

Bianchi, J., J. C. Hatchondo, and L. Martinez (2018). International reserves and rollover risk. *American Economic Review 108*(9), 2629–2670.

Bianchi, J. and G. Lorenzoni (2022). The prudential use of capital controls and foreign currency reserves. In G. Gopinath, E. Helpman, and K. Rogoff (Eds.), *Handbook of International Economics: International Macroeconomics, Volume 6*, Volume 6 of *Handbook of International Economics*, pp. 237–289. Elsevier.

Bianchi, J. and J. Mondragon (2022). Monetary independence and rollover crises. *The Quarterly Journal of Economics 137*(1), 435–491.

Bianchi, J., P. Ottonello, and I. Presno (2023). Fiscal stimulus under sovereign risk. *Journal of Political Economy 131*, 2328–2369.

Bianchi, J. and C. Sosa-Padilla (2023, 07). Reserve accumulation, macroeconomic stabilization, and sovereign risk. *The Review of Economic Studies 91*(4), 2053–2103.

Blanchard, O., J. D. Ostry, A. R. Ghosh, and M. Chamon (2017). Are capital inflows expansionary or contractionary? theory, policy implications, and some evidence. *IMF Economic Review 65*, 563–585.

Bocola, L. (2016). The pass-through of sovereign risk. *Journal of Political Economy 124*(4), 879–926.

Calvo, G. A. (1988). Servicing the public debt: The role of expectations. *The American Economic Review 78*, 647–661.

Chatterjee, S. and B. Eyigungor (2012). Maturity, indebtedness, and default risk. *American Economic Review 102*(6), 2674–2699.

Corsetti, G. and L. Dedola (2016). The mystery of the printing press: Monetary policy and self-fulfilling debt crises. *Journal of the European Economic Association 14*(6), 1329–1371.

Corsetti, G., L. Dedola, and S. Leduc (2008). International risk sharing and the transmission of productivity shocks. *Review of Economic Studies 75*(2), 443–473.

Cruces, J. J. and C. Trebesch (2013). Sovereign defaults: The price of haircuts. *American economic Journal: macroeconomics 5*(3), 85–117.

Cuadra, G. and H. Sapriza (2008). Sovereign default, interest rates and political uncertainty in emerging markets. *Journal of international Economics 76*(1), 78–88.

De Ferra, S. and F. Romei (2023). Sovereign default in a monetary union. Working Paper.

Devereux, M. B., E. R. Young, and C. Yu (2019). Capital controls and monetary policy in sudden-stop economies. *Journal of Monetary Economics 103*, 52–74.

Díez, F. J., J. Fan, and C. Villegas-Sánchez (2021). Global declining competition? *Journal of International Economics 132*, 103492.

Du, W., C. E. Pflueger, and J. Schreger (2020). Sovereign debt portfolios, bond risks, and the credibility of monetary policy. *The Journal of Finance 75*(6), 3097–3138.

Dvorkin, M., J. M. Sánchez, H. Sapriza, and E. Yurdagul (2021). Sovereign debt restructurings. *American Economic Journal: Macroeconomics 13*(2), 26–77.

Eaton, J. and M. Gersovitz (1981). Debt with potential repudiation: Theoretical and empirical analysis. *Review of Economic Studies 48*(2), 289–309.

Edmond, C., V. Midrigan, and D. Y. Xu (2023). How costly are markups? *Journal of Political Economy 131*(7), 000–000.

Engel, C. and J. Park (2022). Debauchery and original sin: The currency composition of sovereign debt. *Journal of the European Economic Association 20*(3), 1095–1144.

Espino, E., J. Kozlowski, F. M. Martin, and J. M. Sanchez (2024). Domestic policies and sovereign default. *American Economic Journal: Macroeconomics 0*(0), 0–0. forthcoming.

Fanelli, S. (2017). Monetary policy, capital controls, and international portfolios. Working Paper.

Farhi, E. and I. Werning (2016). A theory of macroprudential policies in the presence of nominal rigidities. *Econometrica 84*(5), 1645–1704.

Galí, J. and T. Monacelli (2005). Monetary policy and exchange rate volatility in a small open economy. *Review of Economic Studies 72*(3), 707–734.

Galli, C. (2020). Inflation, default risk and nominal debt. Working Paper.

Gertler, M. and P. Karadi (2015). Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics 7*(1), 44–76.

Ha, J., M. A. Kose, and F. Ohnsorge (2019). *Inflation in emerging and developing economies: Evolution, drivers, and policies*. World Bank Publications.

Hatchondo, J. C. and L. Martinez (2009). Long-duration bonds and sovereign defaults. *Journal of international Economics 79*(1), 117–125.

Hatchondo, J. C., L. Martinez, and H. Sapriza (2009). Heterogeneous borrowers in quantitative models of sovereign default. *International Economic Review 50*(4), 1129–1151.

Hatchondo, J. C., L. Martinez, and C. Sosa-Padilla (2016). Debt dilution and sovereign default risk. *Journal of Political Economy 124*(5), 1383–1422.

Hébert, B. and J. Schreger (2017). The costs of sovereign default: Evidence from argentina. *American Economic Review 107*(10), 3119–3145.

Hur, S., I. O. Kondo, and F. Perri (2018). Real interest rates, inflation, and default. Working Paper.

Hurtado, S., G. Nuño, and C. Thomas (2023). Monetary policy and sovereign debt sustainability. *Journal of the European Economic Association 21*(1), 293–325.

Itskhoki, O. and D. Mukhin (2021). Exchange rate disconnect in general equilibrium. *Journal of Political Economy 129*(8), 2183–2232.

Itskhoki, O. and D. Mukhin (2022). Optimal exchange rate policy. Working Paper.

Kalemli-Özcan, S. (2019). Us monetary policy and international risk spillovers. Technical report, National Bureau of Economic Research.

Koop, G., M. H. Pesaran, and S. M. Potter (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics 74*(1), 119–147.

Lorenzoni, G. and I. Werning (2019). Slow moving debt crises. *American Economic Review 109*(9), 3229–3263.

Mendoza, E. G. (2010). Sudden stops, financial crises, and leverage. *American Economic Review 100*(5), 1941–1966.

Mendoza, E. G. and V. Z. Yue (2012). A general equilibrium model of sovereign default and business cycles. *The Quarterly Journal of Economics 127*(2), 889–946.

Miao, J. and P. V. Ngo (2021). Does calvo meet rotemberg at the zero lower bound? *Macroeconomic Dynamics 25*(4), 1090–1111.

Mihalache, G. (2020, 7). Sovereign default resolution through maturity extension. *Journal of International Economics 125c*, 103326.

Na, S., S. Schmitt-Grohé, M. Uribe, and V. Yue (2018). The twin ds: Optimal default and devaluation. *American Economic Review 108*(7), 1773–1819.

Ottonello, P. (2021). Optimal exchange-rate policy under collateral constraints and wage rigidity. *Journal of International Economics 131*, 103478.

Rey, H. (2015). Dilemma not trilemma: the global financial cycle and monetary policy independence. Technical report, National Bureau of Economic Research.

Roger, S. (2009). Inflation targeting at 20 - achievements and challenges.

Rotemberg, J. J. (1982). Sticky prices in the united states. *Journal of Political Economy 90*(6), 1187–1211.

Schmitt-Grohé, S. and M. Uribe (2003). Closing small open economy models. *Journal of international Economics 61*(1), 163–185.

Sunder-Plassmann, L. (2020). Inflation, default and sovereign debt: The role of denomination and ownership. *Journal of International Economics 127*, 103393.

Appendix to "Monetary Policy and Sovereign Risk in Emerging Economies (NK-Default)"

by Cristina Arellano, Yan Bai, and Gabriel Mihalache

A Characterization of the Equilibrium

In this appendix, we summarize the conditions of the private and monetary equilibrium and derive the optimal borrowing condition for the government.

A.1 Conditions for Private and Monetary Equilibrium

Given $S = (s, B, \Theta, B')$, the private and monetary equilibrium can be summarized with six variables: domestic and foreign goods consumption $\{C, C^f\}$, labor N, inflation π, the nominal domestic rate i, and the terms of trade e, that satisfy the following system of six equations:

$$C + e^{\rho}\xi = \left[1 - \frac{\varphi}{2}(\pi - \overline{\pi})^2\right] z(\tilde{z}, \Theta)N \tag{30}$$

$$e^{\rho}\xi = e[C^f + (1-\Theta)((r+\delta)B - q(s,B')(B' - (1-\delta)B))] \tag{31}$$

$$\frac{u_{C^f}}{u_C} = \frac{\rho}{\rho - 1}e \tag{32}$$

$$(\pi - \overline{\pi})\pi = \frac{\eta - 1}{\varphi}\left(-\frac{u_N}{z(\tilde{z},\Theta)u_C} - 1\right) + \frac{\beta}{u_C z(\tilde{z},\Theta)N}F(s, B', \Theta) \tag{33}$$

$$u_C = i\beta\, M(s, B', \Theta) \tag{34}$$

$$i = \bar{i}\left(\frac{\pi}{\overline{\pi}}\right)^{\alpha_p} m, \tag{35}$$

for given functions z, F, M, and q. Condition (30) is the resource constraint, condition (31) is the balance of payments condition, condition (32) is the intratemporal optimality of domestic and foreign goods consumption, condition (33) is the NKPC, condition (34) is the domestic Euler equation, and condition (35) is the monetary policy rule. The solution of this system of equations results in the policy functions $C(S), C^f(S), N(S), \pi(S), e(S), i(S)$.

The functions F and M are the expectations in the firms' pricing condition (NKPC) and the households' Euler condition given by

$$F(s, B', \Theta) = \mathbb{E}\left[z(\tilde{z}', \Theta')N(S')u_C(S')\left(\pi(S') - \overline{\pi}\right)\pi(S')\right], \tag{36}$$

$$M(s, B', \Theta) = \mathbb{E}\frac{u_C(S')}{\pi(S')}, \tag{37}$$

where the future private state $S' = (s', B', H_{\Theta}(s', \nu', B', \Theta), H_B(s', B'))$ depends on the future government borrowing policy $H_B(\cdot)$ and the evolution of credit standing $H_{\Theta}(\cdot)$ given by (11).

The function for the bond price q compensates lenders for losses in default and depends on the government's policy functions for default and borrowing

$$q(s, B') = \frac{1}{1+r}\mathbb{E}\left[(1 - H_D(s', \nu', B'))(r + \delta + (1-\delta)q(s', H_B(s', B'))\right]. \tag{38}$$

where $H_D(\cdot)$ is the government's default policy.

The equilibrium conditions (30) to (35) are analogous to those arising in the standard New Keynesian small open economy of Galí and Monacelli (2005). The difference in our model is that the government understands that its choice of default D and borrowing B' affect the state S and the equilibrium. Moreover, the government's choices determine the next period's state variables, which means that future allocations and prices also depend on the government's current choices. These future effects are encoded in the functions $F(s, B', \Theta)$, $M(s, B', \Theta)$, and $q(s, B')$.

A.2 Derivation of Optimal Government Borrowing

We derive the government's optimal borrowing condition, equation (17) from Section 2.8. To illustrate the government's borrowing incentives, we assume that all the policy functions are differentiable with respect to state B and that the first-order conditions are sufficient for the government's optimization problem. Conditional on not defaulting, $\Theta = 0$, the government chooses $\{C, C^f, N, \pi, B'\}$ to solve the following problem:

$$W(s,B) = \max_{\{C,C^f,N,\pi,B'\}} u(C,C^f,N) + \beta_g \mathbb{E}\left\{ \int_{\hat{v}(s',B')} W(s',B')dF_v(v') + \int^{\hat{v}(s',B')} [W^d(s') - v']dF_v(v') \right\} \tag{39}$$

subject to the constraints imposed by the Private and Monetary Equilibrium, which can be characterized by the following four conditions:

$$[\lambda] \;\; C + [C^f + (\delta + r)B - q(s,B')\left(B' - (1-\delta)B\right)]^{\frac{\rho}{\rho-1}} = \left[1 - \frac{\varphi}{2}\left(\pi - \overline{\pi}\right)^2\right] \tilde{z}N, \tag{40}$$

$$[\lambda_e] \;\; \frac{u_{C^f}}{u_C} = \frac{\rho}{\rho-1}[C^f + (\delta + r)B - q(s,B')\left(B' - (1-\delta)B\right)]^{\frac{1}{\rho-1}}, \tag{41}$$

$$[\gamma] \;\; \frac{\eta-1}{\varphi}\left(-\frac{u_N}{\tilde{z}u_C} - 1\right) + \beta\frac{1}{u_C\tilde{z}N}F(s,B',\Theta) = \left(\pi - \overline{\pi}\right)\pi, \tag{42}$$

$$[\kappa] \;\; \bar{i}\left(\frac{\pi}{\overline{\pi}}\right)^{\alpha_P} m\,\beta M(s,B',\Theta) = u_C, \tag{43}$$

where the default cutoff $\hat{v}(s',B') = W^d(s') - W(s',B')$ and we used $z(\tilde{z}, \Theta = 0) = \tilde{z}$. We have also normalized $\xi = 1$. The government takes as given the functions $F(s,B',\Theta)$ $M(s,B',\Theta)$, and $q(s,B')$. Let λ, λ_e, κ, and γ be the Lagrange multipliers associated with the resource constraint (40), the relative demand condition (41), the domestic Euler condition (43), and the NKPC condition (42), respectively. Note that the multiplier κ reflects the marginal value of the nominal interest rate. To see this, we use the envelop theorem and take the derivative of value W over $\bar{i}$:

$$\frac{\partial W}{\partial \bar{i}} = -\kappa\frac{u_c}{\bar{i}} \quad \Rightarrow \quad \kappa = -\frac{\partial W}{\partial \bar{i}}\frac{\bar{i}}{u_c}.$$

Given that $\bar{i} > 0$ and $u_c > 0$, the multiplier κ is positive when the value decreases with the nominal rate $\bar{i}$, , $\partial W/\partial \bar{i} < 0$.

The first-order conditions over C, C^f, N, π, and B' are

$$u_C - \lambda - \lambda_e\frac{u_{CC^f}u_C - u_{CC}u_{C^f}}{(u_C)^2} + \kappa u_{CC} + \gamma\frac{u_{CC}}{u_C}\left[-\frac{\eta-1}{\varphi}\frac{u_N}{\tilde{z}u_C} + \beta\frac{F(s,B',0)}{\tilde{z}Nu_C}\right] = 0,$$

$$u_{C^f} - \lambda\frac{\rho}{\rho-1}e + \lambda_e\left(\frac{\rho e^{2-\rho}}{(\rho-1)^2} - \frac{u_{C^fC^f}u_C - u_{CC^f}u_{C^f}}{(u_C)^2}\right)$$
$$+ \kappa u_{CC^f} + \gamma\frac{u_{CC^f}}{u_C}\left[-\frac{\eta-1}{\varphi}\frac{u_N}{\tilde{z}u_C} + \beta\frac{F(s,B',0)}{\tilde{z}Nu_C}\right] = 0,$$

$$u_N + \lambda\left[1 - \frac{\varphi}{2}\left(\pi - \overline{\pi}\right)^2\right]\tilde{z} - \gamma\left(\frac{\eta-1}{\varphi}\frac{u_{NN}}{\tilde{z}u_C} + \beta\frac{F(s,B',0)}{N^2\tilde{z}u_C}\right) = 0,$$

$$-\lambda\varphi(\pi - \overline{\pi})\tilde{z}N - \kappa\alpha_P\frac{u_C}{\pi} + \gamma(2\pi - \overline{\pi}) = 0,$$

$$\left[q + \frac{dq}{dB'}\left(B' - (1-\delta)B\right)\right]\left\{\lambda\frac{\rho}{\rho-1}e - \lambda_e\frac{1}{\rho-1}\frac{\rho}{\rho-1}e^{2-\rho}\right\} - \beta i\frac{\partial M}{\partial B'}\kappa - \beta\frac{1}{u_C\tilde{z}N}\frac{\partial F}{\partial B'}\gamma$$
$$= \beta_g\mathbb{E}(1-D')(r + \delta + (1-\delta)q(s',B''))\left\{\lambda'\frac{\rho}{\rho-1}e' - \lambda'_e\frac{1}{\rho-1}\frac{\rho}{\rho-1}(e')^{2-\rho}\right\}. \tag{44}$$

Let borrowing wedges τ_m^X and τ_m^C be defined by

$$\tau_m^X = 1 - \frac{1}{u_{C^f}}\left[\lambda\frac{\rho}{\rho-1}e - \lambda_e\frac{1}{\rho-1}\frac{\rho}{\rho-1}e^{2-\rho}\right], \qquad \tau_m^C = \beta i\frac{\partial M}{\partial B'}\kappa + \beta\frac{1}{u_CzN}\frac{\partial F}{\partial B'}\gamma.$$

By plugging the two borrowing wedges, τ_m^X and τ_m^C, into equation (44), we obtain the Euler equation (17) in Section 2.8.

B Proofs

B.1 Proof of Proposition 1

The proof consists of two parts. In the first part, we prove that higher borrowing B' increases the risk of default in the future. In the second part, we show that under Assumption 1, current inflation, the nominal domestic rate, and the monetary wedge increase with B'.

It is useful to collect Private and Monetary Equilibrium under the quasi-linear preferences in (21). In state $S = (s, B, \Theta, B')$, the equilibrium satisfies the following conditions

$$C + (C(\rho-1)/\rho))^{\rho} = z(\tilde{z}, \Theta) N \left[1 - \frac{\varphi}{2}(\pi - \overline{\pi})^2\right], \tag{45}$$

$$C^f = (C(\rho-1)/\rho))^{\rho-1} + (1-\Theta)\left[q(s,B')(B' - (1-\delta)B) - (r+\delta)B\right], \tag{46}$$

$$(\pi - \overline{\pi})\pi = \frac{\eta - 1}{\varphi}\left(\frac{CN^{1/\zeta}}{z(\tilde{z},\Theta)} - 1\right) + \beta \frac{C}{z(\tilde{z},\Theta)N} F(s, B', \Theta), \tag{47}$$

$$\bar{i}\left(\frac{\pi}{\overline{\pi}}\right)^{\alpha_P} m\beta M(s, B', \Theta) = \frac{1}{C} \tag{48}$$

where we have used the relations $u_{C^f}/u_C = \rho e/(\rho-1)$, $u_{C^f} = 1$, $u_C = 1/C$, and $-u_N = N^{1/\zeta}$. It will also be useful to define μ as the monetary wedge which is

$$1 + \mu = \frac{z(\tilde{z}, \Theta)}{N^{1/\xi} C} \tag{49}$$

Note that under quasi-linear preferences, it is immediate that given a borrowing choice B', the state for debt B does not affect $\{C, N, \pi, i\}$ and is simply absorbed by C^f. This means that $\{C, N, \pi, i\}$ are functions of (s, Θ, B'), but C^f is a function of the entire state (s, B, Θ, B'). In what follows, we consider how B' affects default risk and the Private and Monetary Equilibrium when the economy is in good credit standing, $\Theta = 0$, and for simplicity suppress the dependence of the functions on Θ.

Higher B' increases default risk $\Phi(s, B')$. We first show that the government's value under repayment, $W(s, B)$ is decreasing in B, that is $W(s, B_0) > W(s, B_1)$ for any given s for $0 < B_0 < B_1$.

Since (C, N, π, i) does not depend on B and C^f can take any real value, every B' that is feasible for the government with debt B_1 is also feasible with debt B_0. Moreover, $(1-\delta)q(s,B')B_0 + (r+\delta)B_0 < (1-\delta)q(s,B')B_1 + (r+\delta)B_1$ since $q(s, B') \geq 0$ and $r + \delta > 0$. This implies $C^f(s, B_0, B') > C^f(s, B_1, B')$ for any given (s, B'). Let B_1' and B_0' be the optimal borrowing levels associated with B_1 and B_0, respectively. The following inequalities hold

$$\begin{aligned}
W(s, B_1) &= u\left(C(s, B_1'), C^f(s, B_1, B_1'), N(s, B_1')\right) + \beta_g \mathbb{E} V(s', B_1') \\
&< u\left(C(s, B_1'), C^f(s, B_0, B_1'), N(s, B_1')\right) + \beta_g \mathbb{E} V(s', B_1') \\
&\leq u\left(C(s, B_0'), C^f(s, B_0, B_0'), N(s, B_0')\right) + \beta_g \mathbb{E} V(s', B_0') \\
&= W(s, B_0).
\end{aligned}$$

Note that the first inequality holds because $C^f(s, B_0, B') > C^f(s, B_1, B')$, and the second inequality holds because, under B_0, B_1' is feasible yet B_0' is the optimal choice. Hence for $B_0 < B_1$, $W(s, B_0) > W(s, B_1)$ for any given s.

The default cutoff given by $\hat{v}(s, B) = W^d(s) - W(s, B)$ increases with B as the repaying value $W(s, B)$ decreases with B for any given s and the defaulting value $W^d(s)$ is independent of B. This makes the default risk $\Phi(s, B') = E_{s'|s} F_v(\hat{v}(s', B'))$ increase with B for any given s.

Higher B' increases inflation, the nominal rate, and the monetary wedge. B' impacts $\{C, N, \pi, i\}$ exclusively through its effect on the F and M functions. We approximate the system of equations (45) and (47–49) with a first-order Taylor expansion around the equilibrium given state S, namely $(\overline{C}, \overline{N}, \overline{\pi}, \bar{i}, \overline{\mu})$, and when inflation is close to the target. We solve for deviations of these equilibrium variables. In the solution, holding shocks constant $d\tilde{z} = dm = 0$, the deviation of inflation $d\pi$, nominal domestic rates di, and the monetary wedge $d\mu$ are

$$d\pi = a_1\left[-\frac{1}{a_0} dM + dF\right], \quad di = \alpha_P \frac{\bar{i}}{\overline{\pi}} d\pi, \quad d\mu = a_2\left[\frac{\beta \bar{i}}{\theta} dM + \alpha_P dF\right], \tag{50}$$

where the positive constants a_1 and a_2 are a convolution of parameters,

$a_1 = \dfrac{\alpha_C}{\overline{\pi}^2 + \alpha_p \dfrac{\eta-1}{\varphi}(1 + \dfrac{1}{\zeta}(\alpha_C + \rho(1-\alpha_C)))} > 0$, $a_2 = \dfrac{(1 + \dfrac{1}{\zeta}(\alpha_C + \rho(1-\alpha_C)))\alpha_C}{1 + \alpha_p \dfrac{\eta-1}{\varphi}(1 + \dfrac{1}{\zeta}(\alpha_C + \rho(1-\alpha_C)))} > 0$, and $\alpha_C = \overline{C}/\overline{N} > 0$. The deviations of inflation, nominal rates, and the monetary wedge derived in the system (50) together with Assumption 1 prove the result.

B.2 Characterization of Constrained Efficient Allocations

We start by characterizing the reference model, which has no pricing frictions and constrained-efficient borrowings. After default, the country is permanently excluded from international financial markets. Hence, the defaulting value is given by

$$W^d = \max_{C,C^f,N} u(C, C^f, N)/(1-\beta)$$

subject to the resource constraint and the balanced trade conditions,

$$C + e^\rho = z(\bar{z}, \Theta)N, \quad e^\rho = eC^f.$$

The optimal allocations in default $\{C_d, N_d, e_d\}$ satisfy the following resource constraint and the two first-order conditions,

$$C + e^\rho = z(\bar{z}, \Theta)N, \quad C = \rho/(\rho-1)e, \quad N^{1/\zeta}C = z(\bar{z}, \Theta), \tag{51}$$

with $z(\bar{z}, \Theta = 1) = z_d$, and where we substituted the derivatives $u_C = 1/C$, $u_{C^f} = 1$, and $u_N = N^{1/\zeta}$. Once we know e_d, the balanced trade condition determines imported consumption $C^f_d = e_d^{\rho-1}$.

The problem for the government conditional on not defaulting, $\Theta = 0$, consists on choosing (C, C^f, N, B') to solve the following problem

$$W(B) = \max_{\{C,C^f,N,B'\}} u(C, C^f, N) + \beta \left\{ \left[1 - F_\nu(\hat{v}(B'))\right] W(B') + \int^{\hat{v}(B')} (W^d - \nu) dF_\nu(\nu) \right\}, \tag{52}$$

subject to the following resource constraint, the balanced trade condition, and the bond price function

$$C + e^\rho = \bar{z}N, \quad e^\rho = e\left[C^f + (1+r)B - q(B')B'\right], \quad q(B') = \left[1 - F_\nu(\hat{v}(B'))\right], \tag{53}$$

where we have substituted that $z(\bar{z}, \Theta = 0) = \bar{z}$. The default cutoff $\hat{v}(B')$ satisfies $\hat{v}(B) = W^d - W(B)$. The constrained efficient optimal allocations for $\{C^\star, N^\star, e^\star\}$ also satisfy the system of equations (51) but with $z(\bar{z}, \Theta = 0) = \bar{z}$. Define the constant $u^\star = \log C^\star - \dfrac{(N^\star)^{1+1/\zeta}}{1+1/\zeta} + (e^\star)^{\rho-1}$, which summarizes the constant utility from the allocations $\{C^\star, N^\star, e^\star\}$. We can then simplify the government's problem by

$$W(B) = \max_{B'} u^\star - (1+r)B + q(B')B' + \beta \left\{ \left[1 - F_\nu(\hat{v}(B'))\right] W(B') + \int^{\hat{v}(B')} (W^d - \nu) dF_\nu(\nu) \right\}. \tag{54}$$

The optimal borrowing $B^\star$ satisfies the following Euler equation

$$1 - h(\hat{v}(B'))B' = \beta(1+r), \tag{55}$$

where h is the hazard function of enforcement shock ν. Using this optimal borrowing B^*, we can evaluate the value $W^\star$ as,

$$W^\star = u^\star - (1+r)B^\star + [1 - \Phi(\hat{v}^\star)]B^\star + \beta \left\{ [1 - F_\nu(\hat{v}^\star)] W^\star + \int^{\hat{v}^\star} (W^d - \nu) dF_\nu(\nu) \right\},$$

where the optimal default cutoff satisfies $\hat{v}^\star = W^d - W^\star$. Furthermore, for arbitrary initial debt B, the government's repaying value and default cutoff become

$$W(B) = W^\star + (1+r)B^\star - (1+r)B, \quad \hat{v}(B) = W^d - W^\star - (1+r)B^\star + (1+r)B.$$

Hence, $W(B)$ is linear and decreasing in B, and the default cutoff function $\hat{v}^\star(B)$ increases with B.

B.3 Proof of Lemma 1

We show that the monetary authority can deliver $\overline{\pi}$ with $i = i^{ST}$ in period 0 by constructing this equilibrium in the one-time deviation economy. Suppose that the monetary authority can deliver strict inflation targeting (ST) with a choice of $i = i^{ST}$. The government here solves a similar problem as the constrained efficient one, namely it does not face pricing frictions, but now it discounts the future with β_g in period 0: (C, C^f, N, B') to solve the following problem

$$\max_{\{C,C^f,N,B'\}} u(C, C^f, N) + \beta_g \left\{ \left[1 - F_\nu(\hat{v}(B'))\right] W(B') + \int^{\hat{v}(B')} (W^d - \nu) dF_\nu(\nu) \right\}, \tag{56}$$

subject to the conditions in (53). The cutoff function $\hat{v}(B)$ and the future value function W and W^d are the same as those in the constrained efficient case (52). Optimal borrowing B^{ST} satisfies the government's Euler equation

$$1 - h(\hat{v}(B^{ST}))B^{ST} = \beta_g(1+r). \tag{57}$$

Delivering strict inflation targeting, namely $\pi = \overline{\pi}$, requires that i^{ST} satisfies the domestic Euler equation under the optimal government's borrowing B^{ST} such that domestic consumption is equal to the efficient level $C^\star$,

$$\frac{1}{C^\star} = \beta i^{ST}/\overline{\pi}\left[\frac{1-F_v(\hat{v}(B^{ST}))}{C^\star} + \frac{F_v(\hat{v}(B^{ST}))}{C_d}\right].$$

Note that since inflation is at the target, (C, N, e) solve (51) with $z = \overline{z}$ under no default. This construction shows that the monetary authority can deliver strict inflation targeting by setting the appropriate level of the nominal interest rate.

We now prove that the default risk is higher under strict inflation targeting. Using the implicit function theorem, we can find the derivative of B' with respect to β_g using the Euler (57),

$$\frac{\partial B'}{\partial \beta_g} = -\frac{1+r}{\frac{\partial h}{\partial v}\frac{\partial v}{\partial B'}B' + h} < 0.$$

The derivative is negative due to the assumption of an increasing hazard $\partial h/\partial \hat{v} > 0$ and that the default cutoff increases in B', $\partial v/\partial B' > 0$. The optimal borrowing for the constrained efficient economy depends on the discount factor β, as shown in (55), while the optimal borrowing for strict inflation targeting depends on β_g. Given that $\beta_g < \beta$ and $\partial B'/\partial \beta_g < 0$ gives that $B^{ST} > B^\star$ and $\Phi^{ST} = F_v(\hat{v}(B^{ST})) > \Phi^\star = F_v(\hat{v}(B^\star))$.

Furthermore, the welfare under strict inflation targeting is lower than that in the constrained efficient economy. Here is the reason. Both programs, the constrained efficient program and the strict inflation targeting program, face the same future value, default cutoff function, and bond price schedule. B^{ST} is available for the constrained efficient economy. However, the optimal choice is $B^\star$. It must be the case that for households, $W^{ST} \leq W^\star$.

B.4 Proof of Lemma 2

Here, we prove that default risk increases the monetary wedge for a given monetary policy i, when the monetary wedge is positive. We consider the response of the private economy to the government's borrowing B' when the economy is in credit standing, $\Theta = 0$. Higher B' pushes up the default risk, which affects the consumption and production of domestic goods through the domestic Euler equation. Specifically, for any given B', domestic consumption C, labor N, monetary wedge μ, and inflation π satisfies the following four equations,

$$C + \left(\frac{\rho-1}{\rho}C\right)^\rho = \left[1 - \frac{\varphi}{2}(\pi-\overline{\pi})^2\right]\overline{z}N \tag{58}$$

$$\frac{1}{1+\mu} = 1 + \frac{1}{\eta-1}\varphi(\pi-\overline{\pi})\pi \tag{59}$$

$$1+\mu = \frac{\overline{z}}{N^{1/\xi}C} \tag{60}$$

$$\frac{1}{C} = \frac{\beta i}{\overline{\pi}}\left[\frac{1-F_v(\hat{v}(B'))}{C^\star} + \frac{F_v(\hat{v}(B'))}{C_d}\right] \tag{61}$$

where we replaced the terms of trade e using $C = \dfrac{\rho}{\rho-1}e$. From the domestic Euler equation (61), we can solve for C as a function of default risk $F_v(\hat{v}(B'))$ and the given monetary policy i:

$$C = \frac{\overline{\pi}}{\beta i}\frac{1}{\left[\frac{1-F_v(\hat{v}(B'))}{C^\star} + \frac{F_v(\hat{v}(B'))}{C_d}\right]}.$$

Given that $C^\star > C^d$, it is easy to see that higher default risk $F_v(\hat{v}(B'))$ lowers C. Hence, the domestic Euler equation determines domestic consumption C for any given B'.

We now prove that monetary wedge μ increases with default risk. From NKPC, we can solve π as a function of monetary wedge μ[30]

$$\pi(\mu) = \frac{\overline{\pi} + \sqrt{\overline{\pi}^2 - 4\frac{\eta-1}{\varphi}\frac{\mu}{1+\mu}}}{2}. \tag{62}$$

Here, we abuse the notation and write the equilibrium π as a function of the monetary wedge μ. Note that $\frac{d\pi}{d\mu} \le 0$, and when $\mu > 0$, inflation is lower than target $\pi(\mu) < \overline{\pi}$. We can then replace N in the resource constraint (58) with (49) to get a mapping between the monetary wedge and domestic consumption,

$$C^{1+\xi} + \left(\frac{\rho-1}{\rho}\right)^{\rho} C^{\rho+\xi} = \left\{1 - \frac{\varphi}{2}[\pi(\mu) - \overline{\pi}]^2\right\}(1+\mu)^{-\xi}(\overline{z})^{1+\xi}. \tag{63}$$

Given that C is pinned down by the domestic Euler equation, the condition (63) solves for the monetary wedge μ for any C.

Given that high default risk decreases C, we need to show that when C is low, the monetary wedge is high, namely $\partial\mu/\partial C \le 0$. Using the implicit function theorem, we have

$$\frac{\partial\mu}{\partial C} = -\frac{(\overline{z})^{-(1+\xi)}(1+\mu)^{1+\xi}\left[(1+\xi)C^{\xi} + (\rho+\xi)\left(\frac{\rho-1}{\rho}\right)^{\rho} C^{\rho+\xi-1}\right]}{\xi\left\{1 - \frac{\varphi}{2}[\pi(\mu)-\overline{\pi}]^2\right\} + \varphi(1+\mu)\left[\pi(\mu)-\overline{\pi}\right]\frac{d\pi}{d\mu}}. \tag{64}$$

Let's consider the fraction in the derivative (64). The numerator is non-negative. The denominator has two terms. The first term is positive since the economy will not use all its output on inflation cost, i.e., $\left\{1 - \frac{\varphi}{2}[\pi(\mu)-\overline{\pi}]^2\right\} \ge 0$. The second term $\varphi(1+\mu)\left[\pi(\mu)-\overline{\pi}\right]\frac{d\pi}{d\mu}$ is also positive because $d\pi/d\mu \le 0$ and $\pi(\mu) \le \bar{\pi}$ when $\mu \ge 0$, according to our previous discussion. Therefore, both the numerator and denominator are positive. With a minus sign in the front of the fraction, this implies $d\mu/dC < 0$.

Hence, higher default risk decreases C and leads to a higher monetary wedge μ, when $\mu \ge 0$. □

B.5 Proof of Proposition 2: (Discipline)

Using the utility function (21) and conditions (intra $C - C^f$) and (balance payments), we can simplify the government problem (24) as

$$\max_{B',C,N,\pi} \log C + \left(\frac{\rho-1}{\rho}C\right)^{\rho-1} - (1+r)B + q(B')B' - \frac{N^{1+1/\zeta}}{1+1/\zeta}$$
$$+ \beta_g\left\{\left[1 - F_v(\hat{v}(B'))\right]W(B') + \int^{\hat{v}(B')}(W^d - v)dF_v(v)\right\} \tag{65}$$

subject to (bond price) and the private equilibrium conditions

$$C + \left(\frac{\rho-1}{\rho}C\right)^{\rho} = \left[1 - \frac{\varphi}{2}(\pi-\overline{\pi})^2\right]zN \tag{66}$$

$$\frac{N^{1/\zeta}C}{z} = 1 + \frac{1}{\eta-1}\varphi(\pi-\overline{\pi})\pi \tag{67}$$

$$\frac{\beta i}{\overline{\pi}}\mathbb{E}u_{C'}(B') \equiv \frac{\beta i}{\overline{\pi}}\left[\frac{1-F_v(\hat{v}(B'))}{C^{\star}} + \frac{F_v(\hat{v}(B'))}{C_d}\right] = \frac{1}{C}. \tag{68}$$

Let $(\lambda, \gamma, \kappa)$ be multipliers for conditions (66), (67), and (68) respectively. We can derive the following first-order conditions:
over C

$$\frac{1}{C}\left[1 + (\rho-1)e^{\rho-1}\right] - \lambda\left[1 + (\rho-1)e^{\rho-1}\right] - \gamma\frac{N^{1/\zeta}}{z} - \kappa\frac{1}{C^2} = 0$$

over N

$$-N^{1/\zeta} + \lambda\left[1 - \frac{\varphi}{2}(\pi-\overline{\pi})^2\right]z - \gamma\frac{1}{\zeta}\frac{N^{1/\zeta-1}C}{z} = 0$$

over π

$$-\lambda\varphi(\pi-\overline{\pi})zN + \gamma\frac{1}{\eta-1}\varphi(2\pi-\overline{\pi}) = 0$$

[30] Note that there are two solutions for inflation from NKPC, $\pi_1 = \frac{\overline{\pi} + \sqrt{\overline{\pi}^2 - 4\frac{\eta-1}{\varphi}\frac{\mu}{1+\mu}}}{2}$, $\pi_2 = \frac{\overline{\pi} - \sqrt{\overline{\pi}^2 - 4\frac{\eta-1}{\varphi}\frac{\mu}{1+\mu}}}{2}$. However the inflation cost $\varphi(\pi-\overline{\pi})^2/2$ under π_2 is higher than π_1. Hence, the optimal solution should be $\pi = \pi_1$.

over borrowing

$$1-h(\hat{v}(B'))B'-\frac{\kappa}{1-F_v(\hat{v}(B'))}\left[\frac{\partial \mathbb{E}u_C(B')}{\partial B'}\frac{1}{C\ \mathbb{E}u_C(B')}\right]=\beta_g(1+r). \tag{69}$$

where we have used condition (bond price). We can solve for the multipliers λ, γ, and κ from FOC's on π, N, and C:

$$\lambda=\frac{N^{1/\zeta}}{z}\frac{1}{\left[1-\frac{\varphi}{2}(\pi-\overline{\pi})^2\right]-(\eta-1)\frac{\pi-\overline{\pi}}{2\pi-\overline{\pi}}\frac{1}{\zeta}\frac{N^{1/\zeta}C}{z}}$$

$$\gamma=\lambda(\eta-1)\frac{\pi-\overline{\pi}}{2\pi-\overline{\pi}}zN$$

$$\kappa=\frac{C\left[1+(\rho-1)e^{\rho-1}\right]}{1+\mu}\left\{1+\mu-\frac{1+\frac{1}{\left[1+(\rho-1)e^{\rho-1}\right]}(\eta-1)\frac{\pi-\overline{\pi}}{2\pi-\overline{\pi}}N^{1/\zeta+1}}{\left[1-\frac{\varphi}{2}(\pi-\overline{\pi})^2\right]-(\eta-1)\frac{\pi-\overline{\pi}}{2\pi-\overline{\pi}}\frac{1}{\zeta}\frac{1}{1+\mu}}\right\}. \tag{70}$$

with the monetary wedge μ defined as (49).

We now prove by contradiction that when $i>i^{ST}$ monetary wedge is positive, $\mu>0$.

Suppose that when $i>i^{ST}$, $\mu\leq 0$. With this configuration, $\pi\geq\overline{\pi}$ according to (59). Furthermore, $\kappa\leq 0$ from (70) since $1+\mu<1$, $2\pi\geq\overline{\pi}$, the numerator of the second term in the brackets is larger than 1, and the denominator of this term is less than 1.

Optimal borrowing under strict inflation targeting (57) differs from that under the one-time deviation (69) economy given monetary policy i, by the additional term $-\kappa\left[\frac{\partial \mathbb{E}u_C(B')}{\partial B'}\frac{1}{C\ \mathbb{E}u_C(B')}\right]$. The sign of this term depends on the sign of the domestic Euler multiplier κ given that expected marginal consumption increases with B'. With $\kappa<0$, $B'\geq B^{ST}$.

Domestic consumption depends on the nominal rate i and default risk through the domestic Euler, condition (69). With $B'\geq B^{ST}$ and $i>i^{ST}$, $C<C^{ST}$. The proof of Lemma 2, indicates that the monetary wedge decreases with C; hence, from that result if $C<C^{ST}$, $\mu>0$. We now have a contradiction. Hence when $i>i^{ST}$, the monetary wedge is positive, $\mu>0$. A positive monetary wedge $\mu>0$ implies that $\pi<\overline{\pi}$ and $\kappa>0$ from (59) and (70). A positive multiplier, $\kappa>0$, lowers the government's incentive to borrow from (69). Hence $B'<B^{ST}$ and default risk is lower under the one-time deviation when $i>i^{ST}$.

B.6 Proof of Proposition 3: (Default Risk Monetary Rule)

Given fiscal policy, the allocations for C, N, and π in an economy with the default risk monetary rule satisfy three conditions: (66) and (67) and the following domestic Euler equation

$$\frac{1}{C}=\beta\bar{i}(\Phi(B')/\Phi^\star)^{\alpha_D}\mathbb{E}u_C(B').$$

The government's optimal borrowing condition in turn is

$$1-h(\hat{v}(B'))B'-\frac{\kappa}{1-\Phi(\hat{v}(B'))}\left[\frac{\partial \mathbb{E}u_C(B')}{\partial B'}\frac{1}{C\mathbb{E}u_C(B')}+\alpha_D\frac{f_v(\hat{v}(B'))}{CF_v(\hat{v}(B'))}\right]=\beta_g(1+r).$$

This condition contains an additional term relative to the condition (69), derived for the case of monetary policy determined by i, that depends on the sensitivity of nominal rates with respect to default risk, namely $\alpha_D u_C\frac{f_v(\hat{v}(B'))}{F_v(\hat{v}(B'))}$.

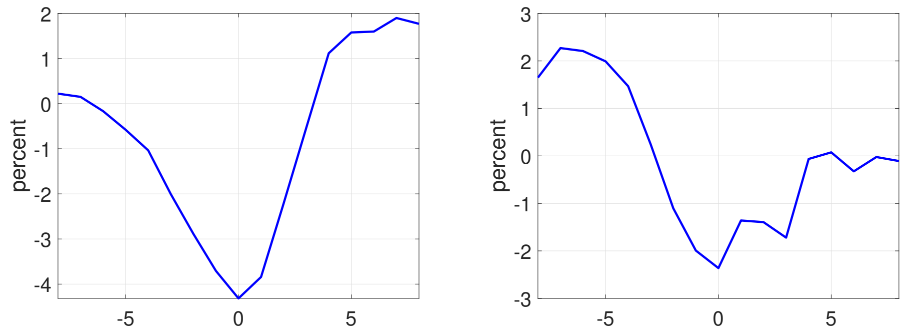
We first express allocations C, N, and π as functions of μ using conditions (66), (67), and the fact that the monetary wedge μ maps into the marginal rate of substitution between labor and consumption, condition (49). Note that for an arbitrary μ, these allocations do not depend on B'. In addition, given these allocations, the terms of trade e and the multiplier κ can be expressed as a function of μ through conditions (intra $C-C^f$) and (70).

We now consider the case when $\mu=\varepsilon$, an arbitrary positive small number. Let C_ε and κ_ε be the consumption and multiplier associated with such monetary wedge.

The monetary authority can implement those allocations and the efficient level of borrowing $B^\star$, and therefore default risk $\Phi(B')=\Phi^\star$, by setting a monetary rule $\bar{i}(\Phi(B')/\Phi^*)^{\alpha_D}$ with parameters $\bar{i}$ and α_D that satisfy

$$\frac{1}{C_\varepsilon}=\beta\bar{i}\mathbb{E}u_C(B^\star)$$

$$\kappa_\varepsilon\frac{1}{1-\Phi(\hat{v}(B^\star))}\left[\frac{\partial \mathbb{E}u_C(B^\star)}{\partial B'}\frac{1}{C_\varepsilon\mathbb{E}u_C(B^\star)}+\alpha_D\frac{f_v(\hat{v}(B^\star))}{C_\varepsilon F_v(\hat{v}(B^\star))}\right]=(\beta-\beta_g)(1+r).$$



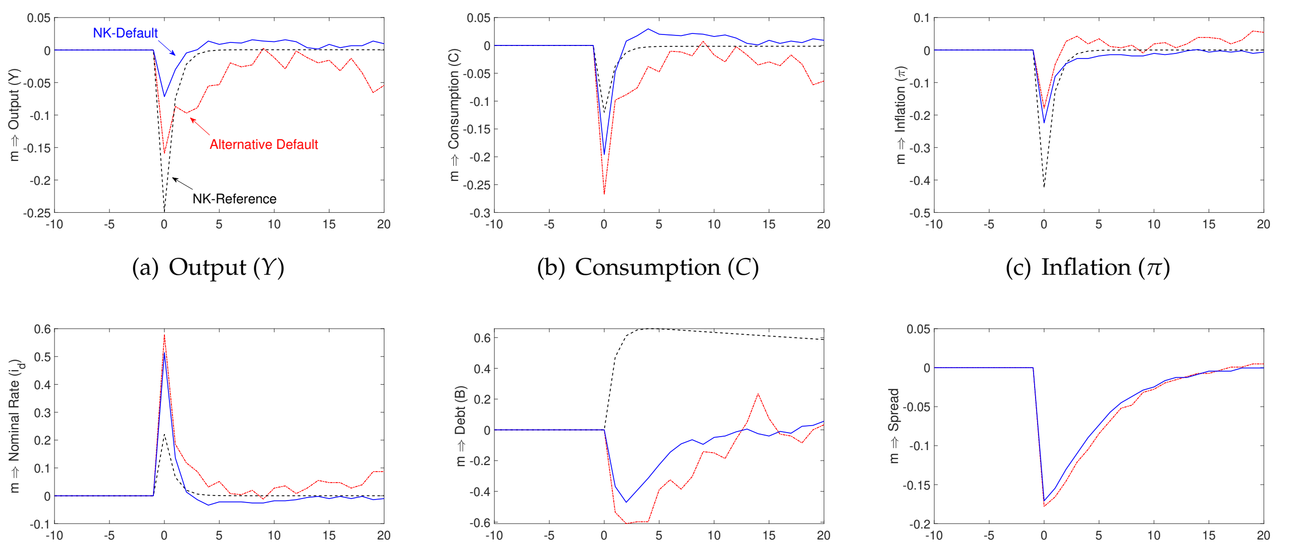
(a) Productivity Shock (b) Monetary Shock

Figure 9: Inflation Event Analysis: Shocks

These conditions induce the government to borrow efficiently. Given that $\varepsilon > 0$, $\kappa_\varepsilon > 0$ and therefore $\alpha_D > 0$, for $\beta > \beta_g$. Note that in this equilibrium $i \approx i^\star$ and $\pi \approx \bar{\pi}$.

C Additional Plots

This appendix collects additional plots not included in the main text. Figure 9 plots the time paths of the productivity and monetary shocks used to fit jointly the event paths for inflation and the nominal rate in Figure 7. Figures 10 and 11 are the impulse response functions for monetary and productivity shocks, respectively, across three models: NK-Default (as plotted in Figures 5 and 6 in the main text), the reference model without default risk NK-Reference, and the model with an alternative mechanism for high inflation during default, from Section 4.6.

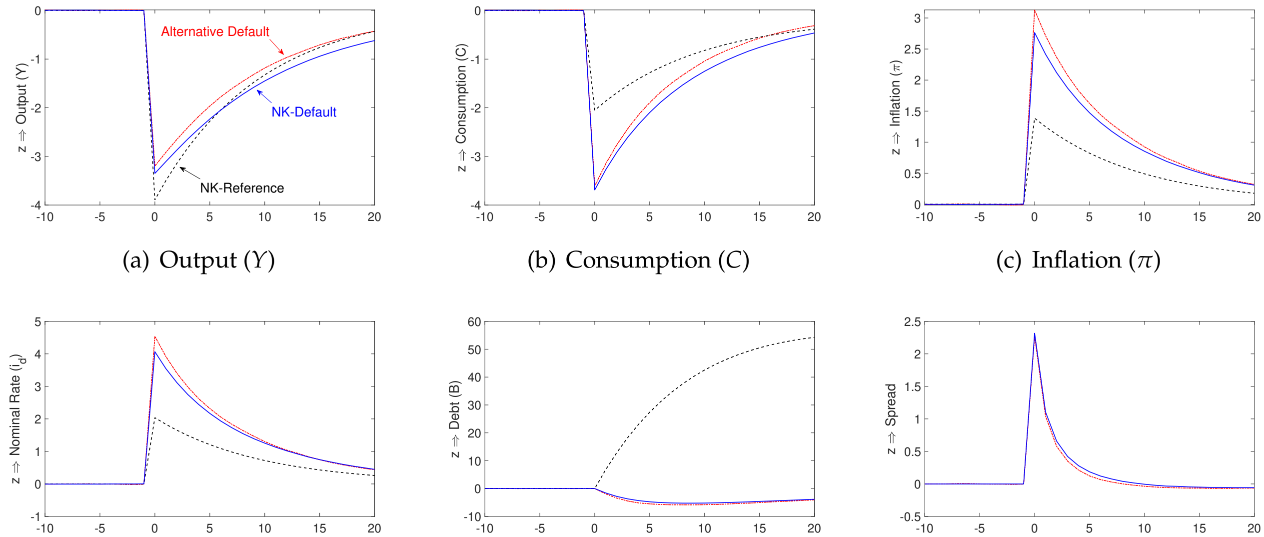


(a) Output (Y) (b) Consumption (C) (c) Inflation (π)

(d) Nominal Domestic Rate (i) (e) Debt (B) (f) Spread

Figure 10: Impulse Response Functions to Monetary Shocks

Note: Impulse response functions to monetary shocks across three models: our baseline NK-Default model (blue), the reference model without default risk,i.e., NK-Reference (dashed black), and the model with an alternative mechanism for high inflation during default (red).



(a) Output (Y)

(b) Consumption (C)

(c) Inflation (π)

(d) Nominal Domestic Rate (i)

(e) Debt (B)

(f) Spread

Figure 11: Impulse Response Functions to Productivity Shocks

Note: Impulse response functions to productivity shocks across three models: our baseline NK-Default model (blue), the reference model without default risk NK-Reference (dashed black), and the model with an alternative mechanism for high inflation during default (red).

D Data Sources

Considering data availability, our analysis focuses on eight countries that have adopted inflation targeting. These countries include Brazil, Chile, Colombia, Mexico, Peru, the Philippines, Poland, and South Africa (refer to Roger (2009) for more details).

To ensure consistency in our analysis and account for the transition period of implementing the policy, we examine the data from 2004Q1 to 2019Q4 for all the countries and relevant data series.

Our data series include the emerging markets bond index (EMBI), consumer price index (CPI), central banks' policy rates, nominal exchange rate, and national accounts.

Spreads. We use the commercial GFDatabase of Global Financial Data (2022) for monthly Emerging Markets Bond Index (EMBI) spreads. The primary source for EMBI is JPMorgan Chase. To align with our quarterly model, we aggregated the data to a quarterly frequency by calculating the quarterly averages from the raw series.

Consumer price index and inflation. All consumer price indices are sourced from the International Financial Statistics (IFS) compiled by the International Monetary Fund (IMF). These series are provided at a quarterly frequency. We then use consumer price indices to construct the quarterly inflation by using the current CPI divided by CPI four quarters ago.

Policy rates and nominal exchange rates. The policy rates and nominal exchange rates utilized in our analysis have been sourced from the Bank for International Settlements (BIS).

In particular, for the period spanning from 2004Q1 to 2019Q4, the monthly policy rates were derived from the following sources:

Brazilian central bank target for money market (SELIC) overnight rate; Chile official monetary policy rate; Colombia 1 day repo rate; Mexico bank funding rate from Nov 3, 1998, to Jan 20, 2008, and money-market overnight rate from Jan 21 2008 onwards; Peru official monetary policy rate; Philippines Official market intervention representative rate; Poland official 7-day central bank bill yield; South Africa official repo rate.

For each country, we took the broad indices of the nominal effective exchange rate from BIS, which is the nominal exchange rate against a broad basket (64 economies) of currencies.

In our analysis, we constructed quarterly policy rates and nominal effective exchange rates by calculating the quarterly averages of their respective monthly series.

National accounts. We used the commercial CEIC (https://www.ceicdata.com, 2022) for National Accounts data except for Colombia, whose data is from the OECD.

CEIC obtains its real national account data primarily from the OECD and its nominal national account data primarily from the International Monetary Fund's International Financial Statistics (IFS). For our sample countries, these include Brazil, Chile, Mexico, Poland, and South Africa. For Peru, the national account data is sourced from the Central Reserve Bank of Peru, while the data for the Philippines comes from the Philippine Statistics Authority.

Construction of inflation events. The inflation events are defined as the time periods that a country experiences inflation higher than two standard deviations above its mean (across 2004q1-2019q4). The nine events peak at Brazil 2015Q4, Chile 2008Q3, Colombia 2008Q4 and 2015Q2, Mexico 2008Q4 and 2017Q4, Peru 2008Q4, Philippines 2008Q4, South Africa 2008Q3. All nine events can be further classified into two groups:

- 2016-2018 events: Brazil 2015Q4, Colombia 2015Q2, Mexico 2017Q4;
- 2008 events: Chile 2008Q3, Colombia 2008Q4, Mexico 2008Q4, Peru 2008Q4, Philippines 2008Q4, South Africa 2008Q3.

The event window is defined as a 2-year window around the peak of each event.

Inflation targeting monetary policy in emerging market economies. The countries in our sample have adopted inflation targeting as their monetary policy regime. In Table 5 we compile references to the web pages where each Central Bank describes its mandate, operating procedures, and their inflation targets. For these countries, using interest rate policies to stabilize prices, under flexible exchange rates, is the norm.

Brazil	https://www.bcb.gov.br/en/monetarypolicy/Inflationtargeting
Chile	https://www.bcentral.cl/en/web/banco-central/areas/monetary-politics
Colombia	https://www.banrep.gov.co/en/monetary-policy
Mexico	https://www.banxico.org.mx/monetary-policy/interest-rate-operational-tar.html
Peru	https://www.bcrp.gob.pe/en/monetary-policy/informative-notes-on-the-monetary-program.html
Philippines	https://www.bsp.gov.ph/Pages/PriceStability/InflationTargetting.aspx
Poland	https://nbp.pl/en/monetary-policy/
South Africa	https://www.resbank.co.za/en/home/what-we-do/monetary-policy

Table 5: Web Pages Describing Inflation Targeting Monetary Policy

E Disciplining Effect Details and Robustness

This appendix provides robustness on the empirical result that illustrates our monetary disciplining mechanism. These results are based on monthly data for the 8 countries in our sample: Brazil, Chile, Colombia, Mexico, Peru, Philippines, Poland, and South Africa. The data consists of CPI inflation, industrial production growth, policy rates, and sovereign spreads. The data run from 2004 through 2022, and inflation and growth are constructed as yearly changes. As described in Section 4.1, we first recover monetary policy shocks by estimating standard interest rate rules country by country. We then standardize all series at the country level and estimate the projections in (27) with the panel data.

Table 6 contains the values of the regression coefficients for monetary policy shocks β_h. The first column contains the results for our baseline specification, also illustrated in Figure 3. Positive monetary shocks, which indicate tighter monetary shocks, tend to reduce spreads in the short run. The median short-run effect across the first 3 months of -0.07 says that a 1 standard deviation increase in monetary shocks tends to decrease spreads by 0.07 standard deviations. The effect is short lived with a negative coefficient for 3 months. The baseline specification contains as controls contemporaneous and six lags for industrial production growth and inflation, as well as country fixed effects. Errors in all our specifications are clustered in two ways: across country and time.

In column 2, we consider a specification with 9 lags for monetary shocks, industrial production and inflation. The results are very comparable to the baseline specification. In column 3, we redo our baseline specification but do not standardize the variables and instead run the specification in levels. The effects from this specification are very comparable to the baseline, although the median point estimate elasticity during the first quarter of -0.4, and the effects are significant for longer.

F Evidence from Inflation Expectations

The *default amplification* mechanism, which we have characterized theoretically in Section 3.1 and quantitatively in Section 4.3, implies that increases in default risk are associated with expectations of elevated future inflation. This Appendix compiles

Dependent variable: Spreads	(1) Baseline	(2) More Lags	(3)) Levels
Monetary shock	-0.09^{**}	-0.09^{**}	-0.45^{***}
Monetary shock (-1)	-0.07^{**}	-0.07^{***}	-0.40^{**}
Monetary shock (-2)	-0.05	-0.04	-0.28^{**}
Monetary shock (-3)	0.01	0.00	0.01
Monetary shock (-4)	0.05	0.04	0.15
Monetary shock (-5)	0.06	0.06	0.24
Monetary shock (-6)	0.05	0.06	0.18
Industrial production lags	Y	Y	Y
Inflation lags	Y	Y	Y
More lags	N	Y	N
Country Fixed Effects	Y	Y	Y
No. Observations	1483	1459	1483
R^2	0.38	0.38	0.50

Table 6: Robustness on Disciplining Mechanism

Note: The table contains the regression coefficients of sovereign spreads on monetary policy shocks from estimating equation (27) using monthly data for Brazil, Chile, Colombia, Mexico, Peru, Philippines, Poland, and South Africa. In columns (1) and (2) series are standardized at the country level. Standard errors in all specifications are clustered across time and country.

direct evidence of this implication, based on available inflation expectations data from emerging markets. Several of the inflation targeting countries in our sample conduct consumer expectations surveys, which include questions about households' beliefs about inflation over the subsequent 12 months. We compile this data for Brazil (FGV Consumer Survey), Chile (Chile Economic Expectation Survey), Colombia (Consumer Opinion Survey), the Philippines (Consumer Expectations Survey), and South Africa (BER Household Inflation Expectation Survey) and relate it with the EMBI sovereign spreads measure, at a quarterly frequency.

Inflation Expectations	(1)	(2)	(3)	(4)	(5)
EMBI	1.452^{***}	0.922^{***}	0.934^{***}	0.883^{***}	0.965^{***}
	(0.136)	(0.181)	(0.147)	(0.112)	(0.121)
GDP Growth			0.054^{*}		0.051^{***}
			(0.035)		(0.023)
Nominal Depreciation				-0.010	-0.006
				(0.007)	(0.007)
Fixed Effects	N	Y	Y	Y	Y
N	244	244	234	230	226
R^2	0.32	0.32	0.36	0.31	0.36

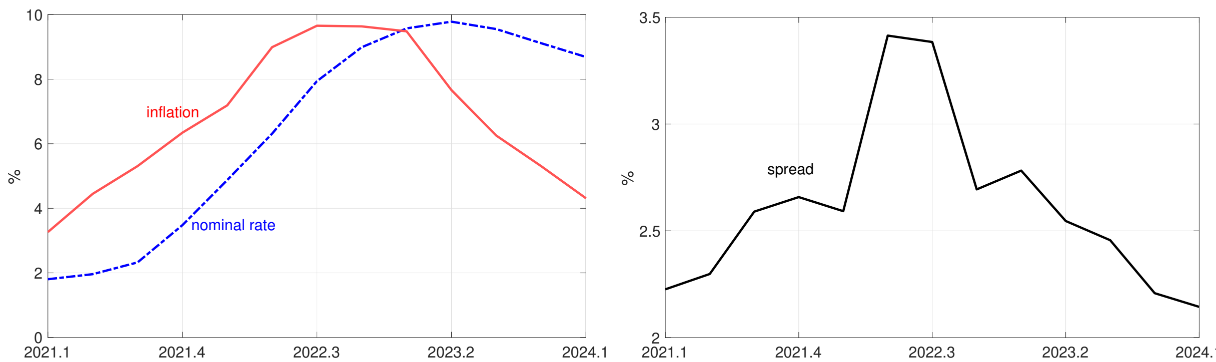
Table 7: Inflation Expectations and EMBI Spreads

Table 7 explores the relation between inflation expectations and EMBI spreads, using pooled and fixed effects estimates, with optional controls for the output growth rate and/or the nominal depreciation. We find that, on average, a 1% increase in spreads is robustly associated with a 0.9–1.0% increase in expected inflation over the following year, with some variation across countries.

We construct a measure of expected CPI inflation over the upcoming year in our baseline quantitative model and estimate the same specification as in the data. We find a coefficient of 1.14, within the 95% confidence interval of our empirical specifications, e.g., [0.727, 1.202] for the specification with both controls, column (5). This finding confirms that the association between spreads and inflation expectations is quantitatively similar between model and data, supporting our amplification mechanism.

G The 2021 Inflation Episode

As much of the world, emerging markets have also experienced an uptick in inflation starting in 2021. Figure 12 plots the evolution of inflation and the nominal rate (Panel (a)), and spreads (Panel (b)), averaged across our sample countries.[31] Inflation increased in all of the 8 countries, on average about 6.4%, with a range of 4.3% to 13.6% across countries. Central banks responded aggressively, with increases of nominal rates between 4.5% and 11.5%, by 8% on average. In the same time, spreads spiked by 0.9% to 2.4%, with an cross-country average of 1.3%. Importantly, by early 2024, inflation is well on its way towards target and the increase in spreads is fully reverted.



(a) Inflation and the Nominal Rate

(b) Spread

Figure 12: Inflation and Spreads During the 2021 Episode

H Numerical Algorithm

The model is subject to uncorrelated AR(1) productivity shocks z and monetary shocks m, which we discretize over a grids with $\#z = 25$ and $\#m = 31$ points spanning ± 3 and ± 4 standard deviations of their unconditional distribution. The B grid consists of $\#B = 520$ points equally spaced over $[0, 0.45]$.

The algorithm proceeds as follows:

1. We start with initial guesses for the value functions V_0, W_0^d and the bond price schedule q_0, together with guesses for the F_0 and M_0 functions and the default and borrowing policies. We assume the probability of default is 1 and $B' = B$ with probability one, everywhere in the state space.
2. We solve for for the private and monetary equilibrium (PME) everywhere in the state space, for arbitrary B'. We restrict attention to B' values that do not induce capital inflows or outflows that are "too large," for which a private and monetary equilibrium might not exist and confirm that this restriction does not bind in equilibrium:

$$|-(r+\delta)B + q(s,B')\left[B' - (1-\delta)B\right]| \leq 0.125 \qquad \text{(Capital Inflow Bounds)}$$

We solve the private and monetary equilibrium via root-finding using Powell's hybrid method, on a system of two equations in two unknowns, C^f and N:

(a) Using the current guess of $\left\langle C^f, N \right\rangle$ and the capital inflow, we compute the terms of trade e from the balance of payments condition.

(b) We compute the implied level of exports X associated with the terms of trade e.

(c) Given C^f and e, we can recover domestic consumption C from the relative consumption condition.

(d) Given C and the government's borrowing choice B', we compute the domestic nominal rate i from the domestic Euler equation.

(e) Given i, we use the interest rate rule to compute the level of PPI inflation π.

(f) We use these quantities to compute equation residuals for the New Keynesian Phillips curve and the domestic resource constraint.

The solution to the PME yields policy functions $C(s,B,B')$, $C^f(s,B,B')$, $N(s,B,B')$, $\pi(s,B,B')$, $i(s,B,B')$, $e(s,B,B')$.

[31] The EMBI spread data is only available for 5 countries during this period.

3. We solve the PME in default similarly. In particular, in default trade is balanced and the capital inflow term is zero, and productivity is penalized. The solution constitutes policy functions in default: $C_d(s)$, $C_d^f(s)$, $N_d(s)$, $\pi_d(s)$, $i_d(s)$, $e_d(s)$.
4. Using PME results, we compute the value of the government in each state (V) and in default (W^d) and derive choice probabilities for the B' policy and default probabilities.
5. Given borrowing and default policies (probabilities), we update the bond price schedule q and the expectation functions M and F.
6. We check for the convergence of the bond price schedule, value functions, and expectation functions. We stop if values are closer than $1e^{-7}$ and prices are closer than $1e^{-5}$ in the sup norm. Otherwise, we fully update and iterate.

Simulation. Model statistics are computed over a simulation of 150,000 periods in length, excluding periods in default and the 20 periods (5 years) following the return to market. Without recovery, the sovereign returns to the market without obligations and accumulates debt quickly over the following few periods. If we include these transitional debt dynamics in the sample used to compute model moments, we find the results are largely unaltered, with the exception of the cyclical patterns of the trade balance. By including all periods outside of default, the trade balance becomes acyclical, while with our selection criterion, the trade balance is countercyclical, as in the data.