Debauchery and Original Sin:  
The Currency Composition of Sovereign Debt

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Abstract

We present a model that accounts for the “mystery of original sin”, and the surge in local currency borrowing by emerging economies in the recent decade. We quantitatively investigate the currency composition of sovereign debt in the presence of two types of limited enforcement frictions arising from a government’s monetary and debt policy: strategic currency debasement and default on sovereign debt. Local currency debt obligations act as a better consumption hedge against income shocks than foreign currency debt because their real value can be affected by monetary policy. However, this provides a government with more temptation to deviate from disciplined monetary policy, thus restricting borrowing in local currency more than in foreign currency. Our model predicts that a country with less credible monetary policy borrows mainly in foreign currency as a substitute for monetary credibility. An important extension demonstrates that in the presence of an expectational Phillips curve, local currency debt improves the ability of monetary policymakers to commit.

JEL: E32, E44, F34

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1. Introduction

“Original sin” in the international finance literature refers to a situation in which emerging economy central governments are not able to borrow abroad in their own currency. This concept, first introduced by Eichengreen and Hausmann (1999), is still a prevailing phenomenon for a number of emerging economies, even though the recent studies by Du and Schreger (2016 a,b), and Arslanalp and Tsuda (2014) find that the ability of emerging markets to borrow abroad in their own currency has significantly improved in the last decade.3

A sovereign government faces a temptation to inflate away the real value of local currency debt obligations. This temptation to debase or “debauch” the currency may lead markets to restrict lending in local-currency debt for some sovereign borrowers. This temptation has been understood by economists for many years, though the literature lacks a full model of the dynamic contracting problem in a setting of debasement and default. Indeed, Keynes (1919) asserted that “Lenin is said to have declared that the best way to destroy the capitalist system is to debauch the currency.” Keynes made this point in the context of the debate over debt forgiveness after the First World War – countries could effectively renge on debt by debauching the currency.4

Building on this idea, a number of studies propose theoretical models that attribute the predominance of foreign currency external borrowing to emerging markets’ monetary and fiscal indiscipline, and study its implications for emerging markets’ economic policy and performance (e.g., Calvo (1978); Jeanne (2003); Cespedes, Chang, and Velasco (2004); Corsetti and Mackowiak (2005)). However, Eichengreen, Hausmann, and Panizza (2004), and Hausmann and Panizza (2003) find weak empirical support for the idea that the level of development, institutional quality, or monetary credibility is correlated with the share of external debt denominated in local currency.

Eichengreen, Hausmann, and Panizza (2004) coined the term “Original Sin” and call this empirical finding the “Mystery of Original Sin”, as emerging markets seem to suffer from an inherited burden from the past, regardless of the government’s policies, or their legal or political institutions. They claim that the original sin problem of emerging market economies is exogenous to a country’s economic fundamentals—it is rather related to the structure of the international financial system.

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3 For example, Du and Schreger find that the cross-country mean of the share of external government debt in local currency has increased to around 60% for a sample of 14 developing countries. The countries in the sample are Brazil, Colombia, Hungary, Indonesia, Israel, South Korea, Malaysia, Mexico, Peru, Poland, Russia, South Africa, Thailand and Turkey.

4 See White and Schule (2009) for a discussion of the context of Keynes’s famous statement.
In this paper, we build a full model of the dynamic contracting problem in a setting of debasement and default to account for emerging market economies’ original sin problem and the “Mystery of Original Sin”. We make the point that contrary to Eichengreen, Haussmann, and Panizza (2004), the original sin problem can be mainly attributed to a country’s monetary indiscipline, but that the relationship between endogenous variables, such as inflation performance, and the currency composition of debt is not straightforward.

For example, borrowers with a low cost of inflation (i.e., countries with less disciplined monetary policy) prefer a portfolio more weighted toward local-currency debt, because they can use inflation more easily to make debt repayment state-contingent. But the lender may be less likely to offer a portfolio with a large amount of local-currency debt in such a scenario because the temptation to excessive currency debasement may be too high for the borrowers with a low cost of inflation. That is, when there is lack of commitment to a sovereign government’s monetary policy, there is a tension between wishes of sovereign borrowers and lenders regarding how much to borrow and lend in local currency, thus leading to a possibly indirect relationship between inflation performance and the local currency share of sovereign debt.

Using the recent data set by Arslanalp and Tsuda (2014, 2018), we reconfirm the “mystery of original sin”: The ability to borrow in domestic currency is not directly related to observable macroeconomic performance. But we do find evidence that the share of local currency (LC) debt issued by sovereign governments is related to the decision to use inflation targeting as a monetary policy, to the political stability of the government, and to the depth of capital markets. These variables, in turn, have counterparts in structural parameters in our model.

We study the currency composition of sovereign debt in the presence of two types of limited enforcement frictions arising from a government’s monetary and fiscal discipline: strategic currency debasement and default on sovereign debt. We build a dynamic general equilibrium model of a small open economy to quantitatively investigate the implications of these two different enforcement frictions for a government’s debt portfolio choice.

Our setting is a standard small open economy model with stochastic endowment shocks, extended to allow a benevolent sovereign government to borrow in both local and foreign currency. Risk neutral foreign investors in international financial markets are willing to lend to the sovereign government any amount, whether in local or foreign currency, as long as they are guaranteed an expected return of the risk-free rate prevailing in the international financial markets. Since the real value of repayment for local currency debt can change depending on the ex-post inflation rate (currency depreciation rate), the foreign investors and the sovereign agree to a local currency debt contract that specifies an inflation rate at each state of the world.

To model inflation targeting – a time-consistent monetary (exchange rate) policy under commitment – we consider an optimal self-enforcing contract that maximizes utility of the representative household in the small open economy and that prevents the government from breaching the contract in any state of the world.
Our approach to modelling the local currency debt contract featuring a government’s state contingent monetary policy is thus in line with the optimal dynamic contracting approach to sovereign borrowing (e.g., Atkeson (1991); Kehoe and Levine (1993); Alvarez and Jermann (2000); Aguiar, Amador, and Gopinath (2009)). This model framework is more suitable for studying a committed time-consistent monetary policy than the Markov equilibrium approach which quantitative incomplete market sovereign default models adopt (e.g., Aguiar and Gopinath (2006); Arellano (2008); Ottonello and Perez (2016)). The latter is better suited for studying discretionary monetary policy.

Why do we connect the ability to borrow in local currency with the adoption of an inflation-targeting monetary policy? Inflation targeting is a form of monetary policy commitment, whose analog in our framework is the willingness of the sovereign borrower to adopt a local-currency contract with state contingent inflation rates. Svensson (1997) points out that a strong commitment to a systemic monetary policy through inflation targeting can mimic the optimal inflation contract offered to an independent central banker suggested by Walsh (1995). This optimal contract can also be thought of as a credible time-consistent optimal monetary policy in a similar vein to Lucas and Stokey (1983) and Chang (1998). Moreover, the structure of the local currency debt contract in the model mimics the inflation targeting framework in the real world: it features a target inflation rate with flexible inflation rate bands.

Our model predicts that the optimal contract for local currency debt allows the government to inflate away a certain fraction of local currency debt in times of bad income shocks but asks for currency appreciation in times of good shocks as a compensation for the bad times. However, due to the limited enforcement constraint arising from a government’s temptation to inflate away local currency debt, the borrowing limit for local currency is endogenously constrained, thus restricting the consumption hedging benefit of local currency debt. On the other hand, the enforcement constraint arising from the option to fully default on its debt mainly determines the endogenous borrowing limit for foreign currency debt. These two enforcement frictions combine to generate an endogenous debt frontier, determining the maximum amount of debt in each currency.

In our model, as well as in reality, a sovereign’s default on debt is generally more costly for its economy than excessive currency debasement. Costly default provides foreign currency debt with more credibility than local currency debt, thus allowing the sovereign to borrow more in foreign currency. This extra credibility from costly default makes foreign currency debt valuable, whereas the state-contingency inherent in local currency debt makes local currency debt valuable: a sovereign with less disciplined monetary policy borrows mainly in foreign currency as a substitute for monetary credibility. Thus, we see a mix of foreign and local currency debt in equilibrium.

We structurally estimate our benchmark model for three emerging markets: Peru, Mexico, and the Philippines, all of which escaped from the “original sin” in the recent decade after having adopted inflation
targeting. The quantitative results show that a country with more disciplined monetary policy - represented by a country with a high cost of inflation in our model - can borrow more in both foreign and local currency, and that the country borrows mainly in local currency as it provides a better consumption hedge. The country with less disciplined monetary policy wants to borrow more in local currency but is restricted to borrow mainly in foreign currency due to the enforcement constraint. Thus, our model can account for both the original sin phenomenon for the emerging economies with less disciplined monetary policy and a recent surge in local currency borrowing by those with more disciplined monetary policy after having adopted inflation targeting in the last decade.

The currency composition of debt and variables such as the volatility of inflation are all endogenous. They depend on the economy’s characteristics such as the degree of patience and risk aversion, and the cost of default and inflation as well as its income shock process. The model shows that there is no simple monotonic relationship among these variables, so it is perhaps not surprising that empirically there is no clear-cut link between the currency composition of the external portfolio and endogenous macroeconomic variables.

We also consider a version of the economy in which policymakers face an expectational Phillips curve, which allows the possibility of using monetary policy to smooth output fluctuations. However, monetary authorities are not endowed with the power to commit to a policy plan. If the economy can only borrow in foreign-currency denominated debt, or is in financial autarky, monetary policy is discretionary. But when a country is able to obtain a contract to borrow in local currency, the value of that contract acts as a commitment device that allows the policymaker to stick to a state-contingent pre-announced monetary policy.

In the remainder of section 1, we first revisit the mystery of original sin problem by Eichengreen, Hausmann, and Panizza (2004), and Hausmann and Panizza (2003) to empirically investigate the determinants of the original sin problem, and then we review the literature. In section 2, we present our formal model. In section 3 we structurally estimate the model for Peru and show the properties of a calibrated version, including an extensive examination of the sensitivity to parameters. That section also demonstrates how the model can account for the recent increasing trend in local-currency denominated sovereign debt among emerging market economies and the mystery of original sin; offers an explanation for why we have weak empirical support for the hypothesis that monetary credibility is correlated with original sin; and, structurally estimates the model for three countries to see whether the estimated deep parameters are in line with their empirical counterparts that are found to be statistically significant in accounting for each country’s LC share. Then section 4 presents a model with a Phillips curve and demonstrates the additional gains to an economy coming from the enhanced ability to commit to a monetary policy when it can settle on a contract to borrow in local currency.
1.1 Mystery of Original Sin Revisited

Eichengreen, Hausmann, and Panizza (2004), and Hausmann and Panizza (2003) find that empirically there seems to be very little link between the share of external debt denominated in local currency and variables such as the volatility of inflation, or the measures of economic development which perhaps should determine how much the country can borrow in local currency. These studies find that only the absolute size of the economy proxied by its GDP is robustly correlated with original sin. They call their finding the “mystery of original sin” and claim that the original sin problem of emerging market economies is exogenous to a country’s economic fundamentals.

Ogrokhina and Rodriguez (2018) reexamine the economic determinants of local-currency debt. They confirm the findings that typical measures of inflation performance have limited power in accounting for which countries are able to issue local-currency government debt. However, they introduce some new variables which do partially unlock the mystery of original sin, and which are consonant with the model we present. In particular, they find evidence that countries that adopt inflation targeting have been more successful at issuing sovereign debt denominated in local currency – and that effect is independent of actual inflation performance.

These studies have relied on a less-than-perfect measure of foreign-held local-currency sovereign debt, relying primarily on measures of local-currency debt issued in foreign markets. Two new studies have tried to carefully measure all sovereign debt held outside a country’s borders, including by currency denomination of the debt, irrespective of whether the debt was issued abroad or within the sovereign. The studies, by Du and Schreger (2016b) and Arslanalp and Tsuda (2014, 2018) have a narrower range of country coverage than the previous studies, but the data they produce more neatly lines up with the variable of interest in our study, which is the amount of sovereign debt held abroad that is denominated in local currency. The measures in the two studies are highly correlated. We will use the Arslanalp and Tsuda’s data set, which is publicly available and periodically updated.

The country coverage of the data set is spotty prior to 2010, so we cannot undertake an extended time series analysis. If we eliminate from the study countries such as China and India, for which only a small fraction of their sovereign debt is held by foreigners – whether in local currency or not – there are nineteen countries that we can investigate. Figure 1 displays the evolution of the share of their debt held externally that is denominated in local currency.

Many of the countries in the sample were undergoing a shift in the early years of the 2000s, from a regime in which little or none of their sovereign debt was local-currency, toward a regime in which a significantly larger fraction was. By the end of the sample, for example, nearly 100 percent of Indonesia’s foreign debt was in local currency, and the figure was around 80 percent for Brazil and South Africa. Other
countries, such as Mexico and Peru saw significant increases, though not approaching 100 percent. On the other hand, some countries saw very little increase in the share of debt in local currency.

One likely explanation for the increase is that most of the countries in the sample officially adopted inflation targeting as their monetary policy stance in the late 1990s or early 2000s. There were twelve countries in the sample in this category: Brazil (adopted in 1999), Colombia (1999), Hungary (2004), Indonesia (2005), Mexico (2001), Peru (2002), Philippines (2002), Poland (1998), Russia (2008), South Africa (2000), Turkey (2006), and Thailand (2000). In addition, Malaysia was understood to be an inflation targeter, but they did not adopt that position officially. Only six of the countries did not adopt inflation targeting: Argentina, Bulgaria, Latvia, Lithuania, Romania, and Ukraine. In all of these cases, the share of external debt denominated in local currency remained very low throughout the time period.

However, a complication to our empirical analysis is that several countries in the sample were committed to joining the euro area. In fact, Latvia (in January 2014) and Lithuania (in January 2015) did adopt the euro. The data includes euro-denominated debt as foreign-currency debt, but that is an ambiguous proposition for these countries. Romania, Bulgaria, Hungary and Poland also are in this group, though none has yet to adopt the euro. However, as noted, Hungary and Poland continued to devote their monetary policy toward inflation targeting. In our regression analysis, then, we will classify those two countries as pursuing inflation targeting; and, we will group the countries that do not target inflation separately into those looking to join the euro area, and the two remaining countries, Argentina and Ukraine. Although the fraction of local-currency sovereign debt held abroad is low for all of the countries that do not target inflation, the reason might be different for the European countries versus the other two.

Figure 2 presents scatterplots of the share of externally held debt in local currency against measures of inflation performance. The share of home currency debt is measured as the average over the 2010-2017 period. The first panel of the figure illustrates the relationship between average inflation rates (for the 2000-2017 period) and local-currency share, while the second panel graphs the monthly standard deviation of annual inflation (again for 2000-2017) against local currency shares. Figure 2 illustrates the mystery of original sin – there appears to be very little relationship between inflation performance and the share of debt held abroad that is denominated in local currency. We look at the share of debt over the 2010-2017 period because the currency composition of debt takes some time to adjust even after a country has adopted inflation targeting. There might be a lag between the implementation of the policy and when markets conclude that the policy commitment is credible, but also some foreign-currency debt is longer term so it takes time for its share in total externally held debt to decline.

Table 1 presents panel estimates of the determinants of the share of externally held foreign debt denominated in local currency for the nineteen countries, using annual data, 2010-2017. Inevitably, because of the paucity of data, it is not judicious to include a large number of explanatory variables in a single
regression. The reported regressions consider nine independent variables, in various combinations: A
dummy variable for the countries that did not adopt inflation targeting; a dummy variable for the countries
that were aiming to adopt the euro; annual inflation; the Chinn-Ito measure of capital account openness; the
World Bank’s World Development Indicator measure of financial development, domestic credit relative to
the non-government component of GDP; log of total GDP, and log of GDP per capita; and the indexes of
government effectiveness and political stability from the World Bank’s World Governance Indicator.

The countries that did not adopt inflation targeting had significantly lower shares of local-currency
debt. The apparent upswing in local-currency sovereign debt appears to be related to the adoption of
inflation-targeting monetary policy, as Ogrokhina and Rodriguez (2018) found in their dataset of foreign-
issued debt. Additionally, Bulgaria and Romania issued little domestic currency debt, and instead sold debt
to foreigners denominated in euros, consistent with their aim to join the euro area.

Inflation performance itself has little explanatory power, which is consistent with the mystery of
original sin documented by Eichengreen, et al. (2004), and Hausmann and Panizza (2003). We have also
included measures for the size of the country (log GDP) and the level of income per person (log of GDP
per capita.) The former measure had explanatory power in the earlier studies, but we generally find that it
does not, except in the first specification of Table 1. As in the earlier studies, income per person as a proxy
for economic development is not helpful in explaining currency denomination of sovereign debt.

We do find a few measures that have success in explaining the ability to sell sovereign debt abroad
that is denominated in local currency. We find that countries with greater financial development, and
countries with more political stability are better able to issue domestic-currency debt.

Overall, our findings are similar to the earlier studies of original sin. We have, in Table 1, reported
results for some of the variables that were successful in accounting for local-currency debt, but we looked
at many more. In panel regressions, we considered measures such as the total government debt relative to
GDP, trade openness and other measures of governance. We also did cross-sectional regressions and
considered more measures of inflation performance such as average inflation, the standard deviation of
We also considered as explanatory variables the classification of the exchange-rate regime from Ilzetski
et al. (2017) and the Fernandez et al. (2015) measure of capital control intensity. None were useful explanatory
variables.

We note now that the variables that do appear to predict that a country will be able to escape original
sin and issue significant amounts of local-currency debt – commitment to inflation targeting, financial
development, and political stability – have analogs in the form of deep parameters in our theoretical model.
In Section 3.5 we structurally estimate the model and examine whether the estimated parameters are
consistent with their empirical counterparts.
Figure 1:
Share of Debt in Local Currency

Figure 1 (continued):
Share of Debt in Local Currency
Figure 2: LC Share and Inflation

Note: Local currency share refers to the share of externally held sovereign debt denominated in local currency. For LC share, we use the period average from 2010-2017. For the inflation related variables, we use the sample period from 2000 to 2017.
Table 1 – Determinants of Local-Currency Foreign-Held Sovereign Debt

Dependent variable: Share of Externally Held Sovereign Debt Denominated in Local Currency
Panel Ordinary Least Squares, Annual, 2010-2017

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Table 1 (continued) – Determinants of Local-Currency Foreign-Held Sovereign Debt

Dependent variable: Share of Externally Held Sovereign Debt Denominated in Local Currency
Panel Ordinary Least Squares, Annual, 2010-2017

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<td>(0.0404)</td>
<td></td>
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<tr>
<td>In(GDP)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.0243</td>
<td>-0.0372</td>
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<td></td>
<td></td>
<td>(0.0499)</td>
<td>(0.0515)</td>
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<tr>
<td>ln(GDP) per capita</td>
<td></td>
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<td>-0.0243</td>
<td>-0.0372</td>
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<td></td>
<td>(0.0499)</td>
<td>(0.0515)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Govt. effectiveness</td>
<td>0.1242**</td>
<td>0.1560***</td>
<td>0.1384***</td>
<td>0.1399***</td>
<td></td>
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<tr>
<td></td>
<td>(0.0536)</td>
<td>(0.0472)</td>
<td>(0.0493)</td>
<td>(0.0513)</td>
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<tr>
<td>Political stability</td>
<td>0.0419*</td>
<td>0.0380*</td>
<td>0.0520**</td>
<td>0.0618***</td>
<td></td>
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<tr>
<td></td>
<td>(0.0238)</td>
<td>(0.0230)</td>
<td>(0.0231)</td>
<td>(0.0237)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>N</td>
<td>133</td>
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<td>143</td>
<td>152</td>
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<td>152</td>
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</tbody>
</table>

The table reports the OLS estimates of the coefficient of the panel regression listed. The data are annual, 2010-2017. There is an intercept term in each regression, not reported. The 19 countries in the sample include the inflation-targeting countries of Brazil, Columbia, Hungary, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Russia, South Africa, Turkey and Thailand. The countries dummied as aiming to join the euro area are Bulgaria and Romania. The two dummied as non-inflation targeters are Argentina and Ukraine. Inflation is CPI inflation. Capital account openness is the Chinn-Ito measure. Domestic credit to the private component of GDP is from World Development Indicators of the World Bank., The measures of government effectiveness and political stability are from the World Bank’s World Governance Indicators.

OLS standard errors in parentheses. *, **, and *** indicate that the alternative model significantly different from zero at 10%, 5%, and 1% significance level, respectively, based on standard normal critical values for the two-sided test.
1.2 Related Literature

Our work builds on the intuition from the classical argument that attributes the predominance of foreign currency debt in international financial markets to a lack of monetary credibility. A government’s strategic debasement to inflate away the real value of debt can pose a significant obstacle to issuing local currency debt (Calvo, 1978; Kydland and Prescott, 1977).

Bohn (1990) builds a model in which governments can only commit to repayment of nominal sums and have an incentive to inflate away debt. In Bohn’s set-up, some domestic-currency debt is sustainable because the government bears an exogenous cost to inflation. In more recent work, Ottonello and Perez (2016) study the currency composition of sovereign debt in a dynamic general equilibrium model of a small open economy with a government with limited commitment to monetary and debt policy. As in Bohn (1990), the government faces an exogenous cost of inflation. Ottonello and Perez provide a quantitative analysis of the optimal monetary policy with local-currency debt. In both models, the original-sin regime – in which governments can borrow only in foreign currency – arises only as the special case in which the cost of inflation is zero. In practice, there must be a fairly high cost of inflation internally to underpin realistic levels of domestic currency borrowing in these models. These models also do not incorporate any possibility of outright default, which plays an important role in limiting the size of sovereign debt.

Our model differs from Ottonello and Perez (2016) in that we study committed monetary and debt policy with enforcement frictions, whereas Ottonello and Perez study discretionary policy with the same frictions. Moreover, Ottonello and Perez (2016)’s main focus is to explain the dynamics and cyclical properties of the LC share of debt over the business cycle. Phan (2017) examines an Eaton-Gersovitz style model with local and foreign currency borrowing subject to strategic default and debasement risk. That paper posits a trigger strategy for the borrower that will support borrowing in local currency and shows that equilibrium local currency debt can be sustained even if the punishment for default or complete debasement of local-currency debt allows for the country to save in the foreign currency assets. It thus offers a possible resolution to the Bulow and Rogoff (1989) puzzle, but, in common with Bohn and Ottonello-Perez, it cannot account for original sin.

In our model, lenders recognize that the sovereign borrower has an incentive to inflate away the debt, and that this option to inflate is more valuable to the borrower when, for example, it is suffering from low output or has high debt obligations. The lender and the sovereign negotiate a contract that allows for more inflation in circumstances such as this. In that sense, inflation is akin to “excusable default” as in Grossman and van Huyck (1988). That paper presents a static model of debt (that is, debt is acquired a period in advance, but can be used only as working capital. It completely depreciates after one period so it cannot be
accumulated, nor can it be used to smooth consumption) in which the two parties agree to a contract that specifies debt repayment in each state of the world. If the borrowing country abrogates the contract, it falls into complete autarky.

Grossman and van Huyck (1993) present a version of that model in which the debt is contracted in nominal terms, but the real repayment is determined by the inflation rate of the government. That paper is a step in the direction of our model but differs in that the model is static and there is actually no debt. Instead, the sovereign makes an agreement with risk-neutral “lenders” to receive a state-contingent payoff one period hence, which could be negative, and which has a mean of zero. The contract is written in such a way that the actual payoff is determined by the rate of inflation chosen by the sovereign, and the penalty for violating the terms of the contract is complete autarky. Their model does not incorporate any possibility of outright default. Moreover, Grossman and van Huyck (1993) do not consider a portfolio choice problem between local and foreign currency debts as in our paper, only focusing on the implications of debasement risk on local currency debt.

Our work draws on, and is closely related to, models with optimal dynamic contracts in the presence of commitment problems. Atkeson (1991), Kehoe and Levine (1993), Zhang (1997), Alvarez and Jermann (2000), and Bai and Zhang (2010) are the closest analogs. These studies show that constrained borrowing limits arising from the limited enforcement problems can cause significant distortions to allocations of an economy.

Our model differs from Atkeson (1991), Kehoe and Levine (1993), and Alvarez and Jermann (2000) in that, in our setting, there is not a full set of state-contingent claims traded internationally. Instead, our starting point resembles Eaton and Gersovitz (1981), Zhang (1997), Aguiar and Gopinath (2006), Arellano (2008), and Bai and Zhang (2010) in that we assume that only bonds that are nominally non-state-contingent can be traded. As in those papers, we do not derive this limitation endogenously, and instead appeal to the real-world observation that sovereign debt typically is not explicitly state contingent. However, our paper is unique in that it recognizes the two ways in which the debt repayments may be state contingent – because of debasement and outright default. Thus, our model shares some of the features of both strands of literature – optimal contracts but with debt that has some, but not full, state contingency. Debt denominated in home currency can be supported because of the threat of falling into the original sin regime in which all debt is denominated in foreign currency. And, foreign-currency debt can be supported in the original sin regime because of the threat of autarky.

Finally, we note that our model does share the characteristic of papers mentioned previously that governments also bear an exogenous cost to inflation. However, in contrast to the earlier work, that cost is not needed to account for why some countries can borrow in domestic-currency debt. Just the threat of falling into the original sin regime is sufficient to allow for some domestic-currency borrowing. The
exogenous cost of inflation is necessary in our model to nail down the nominal interest rate. Borrowers and lenders primarily are concerned with the real return on loans. The nominal interest rate would not matter per se but is determined by the borrower’s desire to avoid the exogenous inflation cost.

2. The Model Economy

We consider a standard small open economy model, extended to allow a sovereign government to borrow in both local and foreign currency from foreign lenders in international financial markets. Time is discrete \((t = 0, 1, 2, 3\ldots)\) and runs forever. Before the income shock is realized at period 0, the sovereign attempts to arrange a local currency debt contract with the foreign lenders. If the sovereign and foreign lenders successfully agree on terms of a local currency debt contract, the small open economy can borrow in both currencies thereafter. On the other hand, if the sovereign and foreign lenders fail to agree, the economy may borrow only in foreign currency thereafter.

The representative household receives stochastic endowment shocks every period and has preferences given by

\[
E_0 \sum_{t=0}^{\infty} \beta^t \left[ u(c_t) - C(\pi_t - \bar{\pi}) \right]
\]

where \(\beta\) denotes the time discount factor, \(c_t\) consumption, \(\pi_t\) the gross inflation rate at period \(t\) (i.e., \(P_t / P_{t-1}\)), and \(\bar{\pi}\) the target inflation rate of the country. The period utility function \(u(.)\) is differentiable, strictly increasing, and strictly concave and satisfies the standard Inada conditions. Following Barro and Gordon (1983), we introduce a cost of inflation in the form of utility loss \(C(\pi_t - \bar{\pi})\), which is differentiable and is symmetric around the target inflation rate \(\bar{\pi} \); any deviation in inflation rates from the target inflation rate incurs utility loss. The sovereign government is benevolent and makes borrowing, default, and debasement decisions so as to maximize welfare of this economy.

There is one tradable consumption good in this economy. The random income shock \(y_t\) has a finite support \(Y = \{y_1^1, y_2^2, \ldots, y^n\}\) and follows a Markov process with a transition function \(\Pr(y_{t+1} | y_t)\). The history of the income shock is denoted by \(s^t\). Let \(P_t\) and \(P^*_t\) respectively be the prices of the consumption good in the Home (i.e., the small open economy) and Foreign countries. The budget constraint in nominal terms is given by

\[
P_t c_t + S_t P_t^i b^\text{for}_{t+1} + P_t b^\text{loc}_{t+1} = P_t y_t + R^t S_t P^*_t b^\text{for}_t + i_t^t P^*_t b^\text{loc}_t,
\]
where $S_t$ is the exchange rate, $b_{t,for} \leq 0$ foreign currency debt, $b_{t,loc} \leq 0$ local currency debt, $i_t$ the gross interest rate on local currency debt, $R^*$ the constant gross risk-free rate prevailing in international financial markets.\(^5\) We assume that $b_{0,for}$ and $b_{0,loc}$ are initially given, $P_{t,1} = 1$, and $y_{t,1}$ is given with $Pr(y_{t,1}) = 1$. We also assume that the law of one price holds and the foreign price $P_{t}^*$ is normalized to be one, so that $P_{t} = P_{t}^*S_{t} = S_{t}$. Then the budget constraint for the economy, conditional on the sovereign government rolling over its debt by following the terms of contract, is given in real terms by

$$c_t + b^f_{t+1} + b^l_{t+1} = y_t + R^*b^f_{t} + i_t b^l_{t} \pi_t.$$ (3)

When the government does not breach the contract, it solves a portfolio problem between local and foreign currency debt to maximize social welfare of the economy. Finally, we impose the natural debt limit following Aiyagari (1994) given by

$$\left(b^f_{t+1} + b^l_{t+1}\right) \geq -D,$$ (4)

where $D = y/(R^*-1)$ and $y$ is the lowest income shock.

The government can breach the debt contract in the following two ways: First, the government can fully default on its debt denominated in both local and foreign currency simultaneously: Selective default on a certain type of debt is not allowed in our model, consistent with practices in sovereign debt markets and the theory in the sovereign debt literature.\(^6\) Second, the government can debase its currency more than required in the local currency contract, the terms of which will be specified in detail later. Thus, our model features two types of enforcement (commitment) frictions arising from a government’s monetary and fiscal indiscipline: strategic default and debasement. This is a novel feature of our model and we quantitatively study how these two frictions affect the currency composition of sovereign debt.

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\(^5\) Since we investigate the currency composition of two types of sovereign debts, we don’t allow the government to accumulate assets. $b^loc > 0$ is ruled out, because it would not be plausible to assume that the foreign lenders issue debt in the currency of the small home country. The small open economy could not punish a large lender such as the U.S. either for default or debasement. We don’t allow $b^for > 0$, because we want to rule out an equilibrium in which the economy borrows only in local currency and save only in foreign currency at the same time. In any case, the no accumulation constraint is not binding in the simulations. This is because when $\beta(1 + r^*) < 1$, the economy wants to borrow to achieve a front-loaded consumption profile, but due to debasement risk, the economy cannot borrow in local currency as much as it wants. In this case, the economy needs to rely on foreign currency debt to satisfy its borrowing need.

\(^6\) See Broner et. al. (2010) for a theoretical study on this problem.
When the government fully defaults on its debts, the economy enters permanent financial autarky, during which it loses access to international financial markets. When the government breaches the contract through excessive currency debasement, the country is restricted to borrow only in foreign currency as a punishment, thus entering the original sin regime. When the government in this regime defaults on its foreign currency debt, the economy also enters financial autarky. Figure 3 summarizes the two different types of breaches of the debt contract and their consequences.

In the benchmark model, we assume permanent financial autarky as a punishment for outright default and permanent original sin regime as a punishment for excessive debasement. However, even if we assume temporary original sin regime and/or temporary financial autarky as punishments, our main results carry through. (See Appendix C)

**Figure 3: Two Types of Breaches of Contract**

**Local Currency Debt Contract**

Foreign lenders in competitive international financial markets are risk-neutral and have deep pockets. There are two types of lenders: lenders who lend in local currency and those in foreign currency. Both are willing to lend to the sovereign government any amount, whether in local or foreign currency, as long as they are guaranteed an expected return of the gross risk-free rate $R^*$. Even if local currency debt is non-contingent in nominal terms with a gross interest rate $i$, depending on the government’s ex-post choice of
the inflation rate \( \pi_t \) (or equivalently currency depreciation rate), the real rate of interest on local currency debt \( i_t / \pi_t \) can differ. We consider the following recursive contract for local currency debt, which consists of two components: a nominal gross interest rate \( i_t \) and state contingent inflation rates in the next period \( \pi_t \).

\[
i_t = I \left( b^\text{for}_t, b^\text{loc}_t, y_{t-1} \right)
\]

(5)

\[
\pi_t = \Pi \left( b^\text{for}_t, b^\text{loc}_t, y_{t-1}, y_t \right)
\]

(6)

When the sovereign government borrows \( b^\text{for}_t \) and \( b^\text{loc}_t \) in foreign and local currency in period \( t-1 \), the contract charges a nominal gross interest rate \( i_t \) on local currency debt \( b^\text{loc}_t \). Moreover, the contract asks for a certain inflation (currency depreciation) rate depending on the realization of \( y_t \) in period \( t \).

Since the foreign investors who lend in local currency must be guaranteed an expected return of a gross risk-free rate \( R^* \) for the local currency debt, we have the following zero-profit condition on the contract:

\[
R^* = \sum_{y_t} \Pr( y_t \mid y_{t-1} ) \frac{i_t \left( b^\text{for}_t, b^\text{loc}_t, y_{t-1} \right)}{\pi_t \left( b^\text{for}_t, b^\text{loc}_t, y_{t-1}, y_t \right)}
\]

(7)

Note that \( \Pi( \ ) \) contains \( y_{t-1} \) as well as \( y_t \) because of the persistent income shock process \( \Pr( y_t \mid y_{t-1} ) \) in eq (7). As will be defined in the section below, we consider an optimal self-enforcing local currency contract subject to the lenders’ zero-profit condition, so as to model inflation targeting as a state-contingent monetary policy under commitment. Due to the zero profit condition (eq (7)), a currency depreciation (or equivalently \( \pi_t \) above the target inflation rate \( \bar{\pi} \)) at a certain state in the contract must be accompanied with a currency appreciation (i.e., \( \pi_t \) below \( \bar{\pi} \)) at other states.

This local currency contract featuring the government’s state-contingent monetary policy mimics the inflation targeting framework in the real world: inflation targeting usually takes a form of a target inflation rate \( \bar{\pi} \) with flexible inflation rate bands. In this context, the breach of the local currency contract through excessive debasement can be interpreted as a sovereign’s breach of the self-announced inflation rate bands by conducting a reckless monetary policy, which leads to high or hyper inflation in the economy; once the sovereign decides to deviate from the contracted inflation rate, it will choose a very high inflation rate to maximize a reduction in the real value of the local currency debt.
On the other hand, the foreign lenders charge the gross risk-free rate $R^*$ on the foreign currency debt as typical of a standard small open economy model featuring non-contingent debt. From now on, $x_t$ denotes the vector of state variables at period $t$, which consists of $(b_t^f, b_t^{loc}, y_{t-1}, y_t)$.

**Discussion of Main Assumptions**

**Two Types of Punishment**

Our paper derives a reputational equilibrium as in Eaton and Gersovitz (1981), but a sovereign government in our model has two types of reputation: repayment and monetary reputation. We assume that even if a sovereign government is almost always rational, there is a positive, but infinitesimal probability that a sovereign government becomes irrationally opportunist in terms of repayment and monetary policy, and that lenders view such an irrationally opportunist behavior as an irreversible change in the sovereign government’s type with respect to its repayment and monetary policy (Grossman and Huyck (1993)). Given that our contract is set up to maximize the utility of the sovereign borrower under self-enforcing constraints, the lenders are justified in their belief about the irrationality of a sovereign who breaches the contract.

Under these assumptions, if the sovereign defaults on its debt, its repayment reputation would be permanently lost, so that lenders would not lend any amount thereafter, whether it is in foreign or local currency, to the sovereign. Likewise, if the sovereign breaches the contract through excessive currency debasement, its monetary reputation would be permanently lost, so that lenders would not lend any amount in local currency thereafter (i.e., the country enters original sin regime.). Note that lenders would lend in foreign currency to the sovereign who lost its monetary reputation but not the repayment reputation. This implies that the local currency lenders cannot impose financial autarky on the government who lost only its monetary reputation after the excessive debasement: The foreign currency lenders will not cooperate with the local currency lenders in a punishment of financial autarky.\(^7\)

Reinhart and Rogoff (2009) document the prevalence of high inflation periods for many countries throughout history, and that in the aftermath of high inflation or hyperinflation, these countries generally experienced a huge shift toward the use of foreign currency as a transaction and borrowing (i.e.,

\(^7\) It is common for courts in the lending country to enforce a policy of no new sovereign loans from that country when the sovereign breaches its commitment through default, until the sovereign reaches a settlement with the original lenders. But in the case of inflation, the nominal debt is repaid, and so there is generally no legal grounds for prohibiting further lending to a high inflation country.
“dollarization”), because the governments’ monetary credibility had been lost. Original sin is a specific case of dollarization (Yimaz (2006)). The punishment of original sin for excessive debasement is motivated by this historical fact, as the punishment of financial autarky for outright default is motivated by the historical facts regarding sovereign defaults (Eaton and Gersovitz (1981)).

Since 2007, when it became known that Argentina’s government was falsifying official inflation rates, thus impairing investors’ real returns on Argentina’s inflation-linked peso-denominated bonds, the local currency share in Argentina’s external government debt was drastically decreased. It reached zero in the fourth quarter of 2013 and has continued to be zero until the fourth quarter of 2017, the last period of Arslanalp and Tsuda’s (2018) data. Argentina was for some years able to borrow in local currency, but its recent reversion to the original sin regime also provides evidence supportive of the assumption that a sovereign that harms foreign lenders by conducting opportunistic monetary policy is punished by losing its ability to borrow in domestic currency.

The punishment for excessive debasement – forcing the sovereign into the original sin regime – is generally less costly to the economy than the punishment of financial autarky for outright default. Corollary 2 in the section 2, however, shows that if both outright default and excessive debasement are equally punished with financial autarky, local currency debt has no debasement risk, so the sovereign can always borrow in local currency. That is, we would not see any economy which suffers from original sin in equilibrium with equal punishment: this implication is not consistent with the fact that most emerging market economies still borrow only in foreign currency.

**LC Debt Contract with State Contingent Inflation Rates**

Unlike Atkeson (1991), Kehoe and Levin (1993), and Alvarez and Jermann (2000), which assume a full set of state-contingent claims traded internationally, we make a more realistic assumption that the asset markets are incomplete: the set of assets that the government can issue is restricted to non-contingent bonds in nominal terms, whether it is denominated in local or foreign currency.

Grossman and van Huyck (1988, 1993) point out that throughout history, international loans, while non-contingent in nominal terms, are state-contingent through frequent rescheduling of repayments, often via currency debasement. Grossman (1990), and Grossman and van Huyck (1993) suggest that the U.K.

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9 Cavallo, Cruces, and Perez-Truglia (2016) show the gap between Argentina’s official inflation rates from the national statistical office (INDEC) and those constructed by the authors. They show that the gap can be as high as 20% from the period 2008 to 2014. Cruces and Samples (2016) show that the loss incurred to investors who hold Argentina’s inflation-linked peso nominated bonds can be significant by comparing the real returns on Argentina’s peso-dominated and US dollar dominated bonds during the same period.
and the U.S.’s currency appreciation on returning to gold at the prewar parity after the Napoleon War (U.K.),
the Civil War, and the First World War (U.S.) were motivated to establish a trustworthy reputation with
foreign lenders to maintain access to future loans for the next war.

Even under the incomplete asset market structure, however, a sovereign government can work out
time-consistent optimal state contingent monetary and debt policy in a similar spirit to Lucas and Stokey
(1983) and Chang (1998). The government can then announce the monetary and fiscal policy to foreign
lenders and ask them to agree on the terms of contract featuring the policy. As long as foreign lenders get
an expected return of $R^*$, risk-neutral lenders would accept the contract. If the sovereign borrower breaches
the contract through default or debasement, lenders would not trust the sovereign to follow the announced
policy anymore, thus punishing it according to the belief about the sovereign mentioned above.

We interpret that the sovereign borrower’s adoption of a local currency contract with state
contingent inflation rates as a commitment to inflation targeting. Svensson (1997) points out that a stronger
commitment to a systemic monetary policy through inflation targeting, with increased transparency through
communication with the public and increased accountability of the central bank, can mimic the optimal
inflation contract offered to an independent central banker suggested by Walsh (1995).

Proposition 1 in Section 2 shows that with no cost of inflation and under a sovereign’s full
commitment, the local currency contract with state-contingent inflation rates can replicate the consumption
allocation under the complete asset markets. This result is one of our motivations to study local currency
debt with state-contingent inflation rates – such debt under full commitment would, in the real world, offer
an important channel of consumption insurance, which leads us to ask what forces lead to their absence in
some countries.

**Value of Debasement**

Due to the limited commitment (enforcement) of monetary policy, the sovereign government can
debase its currency excessively at any time by choosing a higher inflation rate than $\pi(x_i)$ called for in the
contract, in order to inflate away a certain fraction of local currency debt. When the government breaches
the contract through excessive debasement, the country is restricted to borrowing *only* in foreign currency
thereafter as a punishment. That is, the country enters the regime of original sin or foreign currency
borrowing.

The value of debasement is given by

$$V^{\text{debate}}(b_{t}^{\text{for}}, b_{t}^{\text{loc}}, y_{t-1}, y_t; \pi(x_i)) = \max_{\pi, \pi(x_i)} \left[ u(c_t) - C(\pi_t, -\pi) \right] + \beta E V^{\text{for}}(b_{t+1}^{\text{for}}, y_{t+1})$$

(8)
subject to the budget constraint:

\[ c_t + b_{t+1}^{for} = y_t + R^* b_t^{for} + \frac{i b_{t}^{loc}}{\pi_t} , \]  
\[ b_{t+1}^{for} \geq -D . \]  

\( V^{for} ( ) \) denotes the value of borrowing in foreign currency after the debasement.

**Value of Foreign Currency Borrowing (Original Sin Regime)**

If a sovereign and lenders fail to agree on terms of local currency debt at period 0 (i.e., there exists no sustainable local currency debt contract (see Definition 1 below)), or if the sovereign breaches the local currency contract through excessive debasement at a later period, the economy must borrow only in foreign currency thereafter.

The value of foreign currency borrowing is given by

\[ V^{for} \left( b_t^{for}, y_t \right) = \max_{b_{t+1}^{for}} E_t \beta^t V^{for} \left( b_{t+1}^{for}, y_{t+1} \right) \]  

subject to the following constraints:

\[ c_t + b_{t+1}^{for} = y_t + R^* b_t^{for} \]  
\[ V^{for} \left( b_{t+1}^{for}, y_{t+1} \right) \geq V^{def} \left( y_{t+1} \right) \text{ for all } y_{t+1} \]  
\[ b_{t+1}^{for} \geq -D . \]

Equation (13) is the enforcement constraint related to the government’s default decision and requires that the continuation value of foreign currency borrowing be equal to or higher than the value of default in any possible future contingencies. Note that this enforcement constraint determines an endogenous debt limit for foreign currency borrowing that can be supported in equilibrium for the original sin regime. \( V^{def} \left( y_{t+1} \right) \) denotes the value of default for the government which chooses to default on its debt, whether in local or foreign currency, or both.

Appendix C-1 shows that our main results are robust even when we allow the economy to default in equilibrium in the original sin regime. The chief takeaway from Appendix C-1 is that allowing equilibrium
default affects the value of debasement through a change in the value of foreign currency debt. The resulting change, in turn, affects the value of the local currency contract, but there is no qualitative change in the simulation results of our model.

**Value of Default**

Upon default, the economy enters permanent financial autarky during which the economy loses access to the international financial market, and the economy suffers a drop in income. The value of default is given by

\[ V^{\text{def}} (y_t) = u(c_t) + \beta E_t V^{\text{def}} (y_{t+1}) \]  

(15)

\[ c_t = h(y_t), \]  

(16)

where \( h(y_t) < y_t \). \( h(y_t) \) represents a decrease in income associated with financial autarky after default, which is consistent with empirical findings in the sovereign debt literature.

**Original Problem under the Optimal Self-Enforcing Contract**

We study an optimal self-enforcing contract in our model: The contract is optimal in the sense that it maximizes utility of the representative household in the small open economy. Moreover, the contract is self-enforcing in the sense that the government under this contract does not have any incentive to breach the contract in any state of the world. We take an optimal contracting approach to sovereign borrowing so as to model inflation targeting as a committed monetary policy. This approach is better suited for studying committed time-consistent monetary policy than the Markov equilibrium approach, which is suited for studying discretionary policy.

The original problem under the optimal self-enforcing contract is given by:

\[
\max_{\{c_t, b^\text{for}_{t+1}, b^\text{loc}_{t+1}, \pi_t, b_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \left[ u(c_t(s')) - C(\pi_t(s') - \bar{\pi}) \right]
\]  

(17)

subject to (1) the budget constraint, (2) the enforcement constraint, (3) the expected zero profit condition for the lenders. \((y_{-1}, b^\text{for}_0, b^\text{loc}_0)\) are initially given.

\[
c_t(s') + b^\text{for}_{t+1}(s') + b^\text{loc}_{t+1}(s') = y_t(s') + R b^\text{for}_t(s'^{-1}) + \frac{i_t(s'^{-1}) b^\text{loc}_t(s'^{-1})}{\pi_t(s')}
\]  

(18)
\[
E \sum_{n=0}^{\infty} \beta^n \left[ u(c(s^{n+1})) - C(\pi(s^{n+1}) - \bar{\pi}) \right] \geq \max \{ V_{\text{def}}(y_t), V_{\text{debase}}(b_t^\text{for}, b_t^\text{loc}, y_t, y_{t-1}) \}, \text{ for } \forall s', t \geq 0
\]  
(19)

\[
R^* = \sum_{y_t} \Pr(y_t | s^{t-1}) \frac{i_t(s^{t-1})}{\pi_t(s')} 
\]  
(20)

Then, an equilibrium in this model is an infinite sequence of inflation and interest rates on local currency debt \( \pi_t(s') \) and \( i_t(s^{t-1}) \) in the contract, and allocations \( \{ c_t(s'), b_t^\text{for}(s'), b_t^\text{loc}(s') \} \) such that the contract and the allocations solve the maximization problem subject to the budget constraint (equation (18)), the enforcement constraint (equation (19)), and the lender’s expected return condition (equation (20)).

Note that the enforcement constraint equation (19) has two value functions on the right hand side: the values of debasement and default. The enforcement constraint comes from two different types of limited commitment problems regarding the government’s monetary and debt policy. These two enforcement frictions combine to generate an endogenous debt frontier, determining the maximum amount of debt in each currency. The debt frontier, in turn, affects the currency composition of sovereign debt, which will be discussed in detail in section 3.

**Recursive Formulation of the Original Problem**

Since the enforcement constraint equation (19) has expected values of future variables, we cannot use the standard recursive Bellman equation, as pointed out first by Kydland and Prescott (1977). This is a common problem shared with many economic models dealing with time-inconsistent government policy. However, our original problem is recast and solved recursively following Atkeson (1991), which uses the solution techniques of Abreu et al (1990) and is extended by Bai and Zhang (2010) for incomplete asset markets models.

Before the income shock \( y_t \) is realized at period \( t \), the optimal contract chooses a nominal interest rate \( i_t \) on the local currency debt \( b_t^\text{loc} \) and an ex-post inflation rate \( \pi_t \) (currency depreciation rate) for each state \( y_t \) for the period \( t \), so as to maximize the expected sum of value functions \( V^{c+t} s \).

\[
W(b_t^\text{for}, b_t^\text{loc}, y_{t-1}) = \max_{i_t, \pi_t} \sum_{y_t, y_{t-1}} \Pr(y_t | y_{t-1}) \sum_{x_t} \pi(x_t, i_t) 
\]  
(21)

subject to the lender’s expected zero profit condition and the enforcement constraint:
\[ R^* = \sum_{y_{i-1}} Pr(y_i \mid y_{i-1}) \frac{i(h_{i,1}^\text{for}, b_{i,1}^\text{loc}, y_{i-1}, y_i)}{\pi_i(h_{i,1}^\text{for}, b_{i,1}^\text{loc}, y_{i-1}, y_i)} \]  

(22)

\[ V^C(h_{i,1}^\text{for}, b_{i,1}^\text{loc}, y_{i-1}, y_i; x_i, \pi) \geq \max \left\{ V^{\text{base}}(h_{i,1}^\text{for}, b_{i,1}^\text{loc}, y_{i-1}, y_i), V^\text{def}(y_i) \right\} \text{ for } \forall y_i \]  

(23)

After the income shock \( y_i \) is realized at period \( t \), taking \( \pi(x_i) \) and \( i_i \) as given, the government solves the following value function:

\[ V^C(h_{i,1}^\text{for}, b_{i,1}^\text{loc}, y_{i-1}, y_i; x_i, \pi) = \max_{b_{i,1}^\text{for}, b_{i,1}^\text{loc}} \left[ \pi(x_i) - C(x_i, \pi) \right] + \beta W(h_{i+1}^\text{for}, b_{i+1}^\text{loc}, y_i) \]  

(24)

\[ c_i + b_{i+1}^\text{for} + b_{i+1}^\text{loc} = y_i + R^* b_{i,1}^\text{for} + \frac{i b_{i,1}^\text{loc}}{\pi(x_i)} \]  

(25)

Following Atkeson (1991), Chang (1998), and Bai and Zhang (2010), we solve the above problem iteratively starting with sufficiently high initial values \( W_0 \) and \( V_0 \), where the subscript denotes the number of iterations. At each iteration \( n \), the domain \( D_n \) of \( W_n \) and \( V_n \) is updated such that it solves the maximization problems of equations (21) and (24) subject to equations (22), (23), and (25). The sequences of \( \{W_n\}, \{V_n\}, \) and \( \{D_n\} \) are decreasing, finally converging to \( W, V, \) and \( D \). Then, we obtain combinations of \( (b_{loc}, b_{for}) \) in \( D \) that satisfy the budget and enforcement constraints. Appendix D presents a detailed computation algorithm.

When the enforcement constraint (eq.(23)) is not binding at any \( x_i' \), we have the following first order conditions with respect to \( \pi(x_i') \)’s:

\[ -u'(c(x_i')) i b_{i,1}^\text{loc} - C'(\pi(x_i')) \pi(x_i')^2 = -u'(c(x_i')) i b_{i,1}^\text{loc} - C'(\pi(x_i')) \pi(x_i')^2, \]  

(26)

where \( x_i' \equiv (b_{i,1}^\text{for}, b_{i,1}^\text{loc}, y_{i-1}, y_i') \), and \( y' < y^j \) for \( i < j \).

The first term on the left hand side in eq. (26) is the marginal benefit of an increase in the inflation rate at the low income state \( (x_i') \); an increase in inflation rates leads to a decrease in the real value of local currency debt \( b_{i,1}^\text{loc} < 0 \), thus increasing consumption at \( (x_i') \). Note that the first term on the left hand side
in eq. (26) has $b_{t}^{loc}$: The more local currency debt the economy holds at period $t$, the higher marginal benefit of an increase in inflation rates is. The second term on the left-hand side is the marginal cost of the increase in the inflation rate at state $\left(x_{i}^{t}\right)$.

If there is an increase in the inflation rate (i.e., currency depreciation) at the state $\left(x_{i}^{t}\right)$, the zero profit condition for the foreign lenders (eq.(22)) requires a decrease in inflation rates (i.e., currency appreciation) at other high income states $\left(x_{j}^{t}\right)$ to compensate for the loss incurred to the lenders at the low income state $\left(x_{i}^{t}\right)$. At an optimum, the contract equates the marginal benefit of inflation net of the cost of inflation across states when the enforcement constraint is not binding at any $y_{j}$.

When the enforcement constraint (eq.(23)) is binding at the high income state $\left(x_{j}^{t}\right)$, we have the following inequality:

$$-u'\left(c\left(x_{i}^{t}\right)\right)i_{t}b_{t}^{loc} - C'\left(\pi\left(x_{i}^{t}\right)\right)\pi\left(x_{i}^{t}\right)^{2} \geq -u'\left(c\left(x_{j}^{t}\right)\right)i_{j}b_{j}^{loc} - C'\left(\pi\left(x_{j}^{t}\right)\right)\pi\left(x_{j}^{t}\right)^{2}$$

This inequality shows that when the enforcement constraint is binding at the high income state $\left(x_{j}^{t}\right)$, the monetary policy becomes restricted in providing sufficient consumption insurance at the low income state $\left(x_{i}^{t}\right)$. A further depreciation of the currency at the low income state $\left(x_{i}^{t}\right)$ requires an appreciation of the currency at the high income state $\left(x_{j}^{t}\right)$, which in turn, would violate the enforcement constraint at $\left(x_{j}^{t}\right)$.

The first order condition with respect to $i_{j}$ is given by

$$\sum_{y'_{j},y} \Pr\left(y'_{j} \mid y_{t-1}\right)C'\left(\pi_{t}\left(x_{j}^{t}\right)\right)\pi\left(x_{j}^{t}\right) = 0,$$  \hspace{1cm} (27)

The first order condition with respect to $i_{j}$ shows that at an optimum, the nominal interest rate $i_{j}$ on local currency debt is chosen to minimize the expected sum of costs of inflation across states. Note that with a symmetric cost of inflation around the target inflation rate \(\bar{\pi}\), the marginal cost at $\pi_{t} < \bar{\pi}$ is negative.

The following proposition and corollary characterize the state-contingent nature of local currency debt in our model.
**Proposition 1:** Suppose that there is no cost of inflation (i.e., \( C(\pi_t, -\pi) = 0 \) for all \( \pi_t \)). Then, the optimal local currency contract under full commitment (i.e., no enforcement constraint eq (19)) can replicate the consumption allocation under complete assets market.

**Proof:** See the Appendix.

With no cost of inflation and under the sovereign’s full commitment, the optimal local currency contract completely smooths consumption of the representative household across states, thus replicating the consumption allocation under complete assets market.

**Corollary to Proposition 1:** Suppose that \( y_i^j < y_i^j \). Then, under the same conditions as in Proposition 1, \( \pi_t \) in the optimal contract is such that

\[
\pi(x_i^j) > \pi(x_i^j)
\]

The corollary shows that without any frictions, the optimal local currency contract allows the government to depreciate its currency in times of bad income shocks but asks for currency appreciation in times of good income shocks as a compensation to the investors for bad times. Thus, compared to foreign currency debt, local currency debt under the optimal contract is a better instrument for consumption hedging against income shocks due to its state-contingency, especially when there is no cost of inflation.

**Debt Frontier**

\(B_{loc}^y\) is defined as follows:

\[
B_{loc}^y = \max_{y \in \mathcal{Y}} \left\{ b_{loc}^y(y) \right\},
\]

where \( b_{loc}^y(y) < 0 \) is the borrowing limit for local currency for a current shock \( y \) and is defined as:

\[
b_{loc}^y(y) = \max_{y \in \{y_1, y_2\} \cup \emptyset} \left[ V^y \left( 0, b_{loc}^y(y'), y, y' \right) = \max \left\{ V^{debase} \left( 0, b_{loc}^y(y'), y, y' \right), V^{def} \left( y' \right) \right\} \right]
\]

That is, \( b_{loc}^y(y) \) is the maximum amount of the local currency debt that does not violate the enforcement constraint under all future contingencies, given that a current income shock is \( y \), and that the sovereign does
not borrow in foreign currency (i.e., $b_{t+1}^{\text{for}} = 0$). For any more local currency borrowing than $b_{t+1}^{\text{loc}}(y)$ (i.e., $b_{t+1}^{\text{loc}} < b_{t+1}^{\text{loc}}(y)$), the sovereign would be tempted to default or to excessive debase for a certain income shock $y'$ in the next period, so that it would not be sustainable and not allowed in the contract. Then $\bar{B}_{t+1}^{\text{loc}} < 0$ is interpreted as the maximum amount of the local currency borrowing with $b_{t+1}^{\text{for}} = 0$ without violating the enforcement constraint at any date and any state.

**Debt frontier** $\underline{B}^{\text{for}}(b_{t+1}^{\text{loc}})$ is defined in the following:

$$\underline{B}^{\text{for}}(b_{t+1}^{\text{loc}}) \equiv \max_{y \in Y} \left\{ b_{t+1}^{\text{for}}(y) \right\}, \text{ for } \underline{B}^{\text{loc}} \leq b_{t+1}^{\text{loc}} \leq 0,$$

where $b_{t+1}^{\text{for}}(b_{t+1}^{\text{loc}}, y)$ is defined in the following:

$$b_{t+1}^{\text{for}}(b_{t+1}^{\text{loc}}, y) \equiv \max_{y \in Y} \left\{ b_{t+1}^{\text{for}}(y) : V_c \left( b_{t+1}^{\text{loc}}(y), b_{t+1}^{\text{loc}} + y, y' \right) = \max \left\{ V_{\text{debase}} \left( b_{t+1}^{\text{loc}}(y'), b_{t+1}^{\text{loc}}, y, y' \right), V_{\text{def}} \left( y' \right) \right\}, \right.$$

$$\text{ for } b_{t+1}^{\text{loc}}(y) \leq b_{t+1}^{\text{loc}} \leq 0. \quad (30)$$

That is, $b_{t+1}^{\text{for}}(b_{t+1}^{\text{loc}}, y)$ is the maximum amount of foreign currency borrowing which satisfies the enforcement constraint under all future contingencies, given that the economy chooses to borrow $b_{t+1}^{\text{loc}}$ in local currency for the current income shock $y$. Any more borrowing than $b_{t+1}^{\text{loc}}$ (i.e. $b_{t+1}^{\text{for}} < b_{t+1}^{\text{loc}}(b_{t+1}^{\text{loc}}, y)$) in foreign currency violates the enforcement constraint for some $y'$ in the next period, so is not sustainable in equilibrium.

For any combinations of $(b_{t+1}^{\text{loc}}, b_{t+1}^{\text{for}})$ inside the debt frontier $\underline{B}^{\text{for}}(b_{t+1}^{\text{loc}})$, a sovereign government honors its debt contract with the foreign investors at any date and any state. The debt frontier is in the same spirit as no default borrowing constraint in Zhang (1997) and solvency constraints in Alvarez and Jermann (2000).

**Definition 1:** If $b_{t+1}^{\text{loc}}(y) = 0$ for all $y \in Y$ in equilibrium, there exists no sustainable local currency debt contract in equilibrium.

When the economy is not able to borrow any amount in local currency for any date and any state, we have that $b_{t+1}^{\text{loc}}(y) = 0$ for all $y \in Y$. This refers to the situation that a sovereign and lenders fail to agree on terms of a local currency debt contract at period 0, so that a sovereign must borrow in foreign currency thereafter in equilibrium, given that foreign currency borrowing exists. It must be noted that this case is
Proposition 2: For sufficiently small values of \( \beta \), sufficiently low costs of inflation, and sufficiently high output costs of default, there exists no sustainable local currency debt contract in equilibrium, so that the economy must borrow in foreign currency from period 0 onward.

Proof: See the Appendix.

The extreme case in which \( \beta = 0 \) illustrates the proposition clearly. Fix a small amount of local currency debt \( b_{-1}^{loc} < 0 \), and let \( b_{-1}^{for} = 0 \). With \( \beta = 0 \), the contract attempts to solve the following maximization problem subject to the lender’s zero profit condition, before \( y_0 \) is realized:

\[
\text{Max}_{\bar{y}_0, \pi_0(y_0)} \sum_{y_0} \Pr(y_0 \mid y_{-1})[u(y_0 + \frac{i_0 b_{-1}^{loc}}{\pi_0(y_0)}) - C(\pi_0(y_0) - \bar{\pi})]
\]

\[
R^* = \sum_{y_0} \Pr(y_0 \mid y_{-1}) \frac{i_0}{\pi_0(y_0)}
\]

Let \( \lambda \) be the Lagrange multiplier associated with the zero-profit condition. Then the first order condition w.r.t \( \pi_0(y_0(s)) \) is given by

\[
[u'(c_o(y_0(s)))(-\frac{i_0 b_{-1}^{loc}}{\pi_0^2(s)}) - C'(\pi_0(s))] = \lambda \frac{i_0}{\pi_0^2(s)} \text{ for all } y_0(s) \in Y.
\]

After \( y_0 \) is realized, however, the government finds it optimal to breach the contract through excessive debasement at all states of the world if the cost of inflation is sufficiently low and the cost of default is sufficiently high.

The first order condition w.r.t. \( \pi_0(y_0(s)) \) for the value of debasement after \( y_0(s) \) is realized is given by

\[
[u'(c_o(y_0(s)))(-\frac{i_0 b_{-1}^{loc}}{\pi_0^2(s)}) - C'(\pi_0(s)))] = 0 \text{ for all } y_0(s) \in Y.
\]

Since \( \lambda \) and \( i_0 \) are positive, the contract cannot replicate the value of debasement at each state. When \( \beta = 0 \) and the cost of inflation is sufficiently low, no sustainable local currency debt can be constructed: Households do not put any value on the future continuation value following the contract, and the gain from a consumption increase through ex-post excessive debasement is high. As \( \beta \) gets sufficiently high, households put more value on the future continuation value following the contract than the consumption increase from the excessive debasement.
If a sustainable local currency contract cannot be constructed, the economy must borrow in foreign currency from period 0 onward.\textsuperscript{10} This proposition indicates why many emerging market economies still suffer from Original Sin, borrowing only in foreign currency.

\textbf{Corollary to Proposition 2 (No Existence of Original Sin)}: Suppose that foreign currency borrowing exists, and that the cost of inflation is greater than zero. If breach of contract through excessive debasement is punished by financial autarky as with outright default on debt, then there always exists a sustainable local currency debt contract, so that the economy can borrow in local currency from period 0 onward.

The proof is straightforward. If breach of contract by excessive debasement is punished by financial autarky, the value of debasement is strictly less than the value of default, when the cost of inflation is greater than zero. Then, local currency debt has no debasement risk. In this case, the sovereign and lenders can agree on a local currency debt contract in which inflation rates are set to the target inflation rate $\bar{\pi}$ for all states. As long as foreign currency borrowing exists, this local currency debt contract can be sustainable in equilibrium. That is, if both outright default and excessive debasement are equally punished by financial autarky, there will be no economy that borrows only in foreign currency in equilibrium.

We see a mix of foreign and local currency debt in equilibrium arising from the fact that default on debt is generally more costly for its economy than excessive debasement. This implies that because of the higher cost from default, foreign currency debt has more credibility than local currency debt, thus allowing the sovereign to borrow generally more in foreign currency as a substitute for monetary credibility. This implication of the model is consistent with the fact that only a small subset of emerging market economies can borrow mainly in local currency externally, whereas most emerging market economies still borrow mainly in foreign currency. All in all, foreign currency debt is valuable for its credibility, whereas local currency debt is valued for its state contingency.

\textsuperscript{10} Ottonello and Perez (2017) show that the local currency debt market shuts down only when the cost of inflation is zero. In our model, it is possible that the local currency debt is sustainable in equilibrium without a cost of inflation. When the economy is very risk-averse and/or patient, and/or its income shock process is very volatile, the economy would put more value on the continuation value from the local currency contract than on an increase in current consumption from excessive debasement. Our model has a different prediction because our model considers a committed monetary policy with commitment frictions, whereas Ottonello and Perez (2017) considers a discretionary monetary policy with the same frictions. Phan (2018) also shows that the local currency debt can be sustainable in equilibrium without any cost of inflation if certain conditions hold.
Assumption 1: The cost of inflation function $C(\pi_t - \bar{\pi}; \xi)$ is such that

(i) $C(\pi_t, -\bar{\pi}; \xi)$ is symmetric around the target inflation rate $\bar{\pi}$. $C(0; \xi) = 0$ and is strictly increasing in $\pi_t > \bar{\pi}$ for any given $\xi$.

(ii) $C(\pi_t, -\bar{\pi}; \xi)$ is differentiable w.r.t $\xi$ and is strictly increasing in $\xi$ for any given $\pi_t, \neq \bar{\pi}$.

(iii) $\frac{\partial^2 C(\pi_t, -\bar{\pi}; \xi)}{\partial \pi_t \partial \xi} > 0$. That is, the marginal cost of inflation is strictly increasing in $\xi$ for any given $\pi_t, \neq \bar{\pi}$.

Assumption 2: Assume that there exists a sustainable local currency debt contract. Let $B^{loc,L}$ be the maximum local currency borrowing limit of the contract with the cost of inflation parameter $\xi^L$. Suppose that the following conditions hold for this contract:

(i) The output cost of default is sufficiently high so that $V^{\text{debase}}(0, B^{loc,L}, y, y'; \xi^L)$ is strictly larger than $V^{\text{def}}(y')$ for any $y, y'$.

(ii) When the optimal contract asks for currency appreciation (i.e., $\pi^{\text{con}}(x) < \bar{\pi}$) at any state $x$, $|\pi^{\text{con}}(x) - \bar{\pi}| < |\pi^{\text{debase}}(x) - \bar{\pi}|$.

The first condition in Assumption 2 states that at the maximum borrowing limit $B^{loc,L}$, the incentive to debase is greater than the incentive to default. The second condition rules out a case in which the inflation deviation for $\pi^{\text{con}}(x)$ from the target inflation rate is greater than that in the case of debasement, when the optimal contract asks for currency appreciation (i.e., $\pi^{\text{con}}(x) < \bar{\pi}$). The second condition rules out a case in which the optimal contract asks for an appreciation ($\pi^{\text{con}}(x) < \bar{\pi}$), and the size of the deviation from the target, $|\pi^{\text{con}}(x) - \bar{\pi}|$, is greater than the deviation that would occur under a debasement that violates the contract, $|\pi^{\text{debase}}(x) - \bar{\pi}|$. An appreciation increases the real value of debt repayment and incurs inflation costs, so such a high rate of appreciation in the contract could only happen if there were an unrealistically high income variance, such that the contract called for a very high appreciation under an extremely good realization of the state. Note that for the case of currency depreciation ($\pi^{\text{con}}(x) > \bar{\pi}$), we always have that $\pi^{\text{con}}(x) < \pi^{\text{debase}}(x)$ in equilibrium.

Proposition 3: Under Assumptions 1 and 2, $B^{loc,H} < B^{loc,L}$ for $\xi^H > \xi^L$.

Proof: See the Appendix.
That is, when the temptation to excessive debasement is high, a country with a higher cost of inflation has a more relaxed borrowing limit for local currency debt. This result follows from the fact that the value of debasement decreases more than the value of the contract as $\xi$ increases.

We interpret the adoption of inflation targeting as an indication that the cost of inflation for policymakers has increased. There might be a number of reasons why inflation costs have risen: Perhaps the political cost of inflation has increased; perhaps central banks have gained more independence and the policy objective puts more weight on inflation; perhaps central bank policymakers have learned more about the welfare costs of inflation. We can rely on a revealed preference argument to infer that inflation costs must have increased, without having to resolve the underlying cause. If policymakers put weight on deviations of inflation from a designated target, the strength of inflation targeting increases as the weight on inflation variation in the loss function increases.

That is, if the loss function for the policymaker includes a term such as $C(\pi_t - \bar{\pi}; \xi)$, as in our model, then the “targeting rule” puts a higher weight on deviations of inflation from its target as $\xi$ increases. This is true whether or not the objective function is derived from underlying preferences, as in Woodford (2003). A targeting rule sets the monetary policy instrument to achieve a specific criterion for variables in the loss function.\(^\text{11}\) Several general treatments of optimal monetary policy demonstrate that a higher value of $\xi$ leads to a rule with stricter inflation targeting.\(^\text{12}\)

Whereas Proposition 2 characterizes which countries suffer from original sin, Proposition 3 shows that the degree of monetary credibility represented by the cost of inflation parameter $\xi$ determines how much each country is able to borrow in local currency. This result is consistent with our empirical findings in section 1.1: Emerging market economies, after having adopted inflation targeting as a monetary policy, have managed to borrow much more in local currency, thus departing from the prevalence of original sin in the 1980s and 1990s.

**Proposition 4:** Suppose that the cost of inflation is zero for all $\pi_t$. Then the equilibrium interest rate for local currency debt $i_t$ is indeterminate.

The proof is straightforward and is from the lender’s expected zero profit condition equation (22). With no cost of inflation, the real interest rate on local currency debt $i_t / \pi_t$ only matters for the equilibrium allocations.


Proposition 5: If $C(\pi_t - \bar{\pi}) = \infty$ for any $\pi_t \neq \bar{\pi}$, then $\pi_t(s^t) = \bar{\pi}$ for all $t$. Moreover, the currency composition between foreign and local currency debts is indeterminate.

Proof: See the Appendix.

When the cost of inflation is infinite, foreign currency debt becomes the same as local currency debt, so the currency composition between the two types of debts is indeterminate.

3. Quantitative Results

Figure 4: Peru’s Inflation Performance and LC share of External Debt

After having suffered hyperinflation in early 1990s, Peru adopted inflation targeting in January of 2002. Peru’s adoption of inflation targeting has been generally considered successful (Dancourt, 2015), and since adoption, its inflation has been stabilized. (Left panel of Figure 4). According to Arslanalp and Tsuda’s (2018) data, the local currency share of Peru’s external government debt was zero throughout 2004 (hence in the original sin regime), but its LC share started to take off in the first quarter of 2005 and has substantially increased. The LC share reached 50% in the last quarter of 2017 (Right panel of Figure 4). In this section, we estimate the model using Peru’s data and simulate it to explain the two empirical facts documented in the section 1.1: the mystery of original sin – the fact that standard measures of economic performance do not account for the ability of countries to borrow in domestic currency – and emerging market economies’ escape from original sin in the 2000s.
Table 2: Model Parameters

<table>
<thead>
<tr>
<th>Parameters from Literature</th>
<th>Value</th>
<th>Description</th>
<th>Source/ Target Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$</td>
<td>4</td>
<td>Risk aversion</td>
<td>Literature</td>
</tr>
<tr>
<td>$r_f$</td>
<td>4%</td>
<td>Risk free rate</td>
<td>Literature</td>
</tr>
<tr>
<td><strong>Parameters Directly Estimated from Data</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_i$</td>
<td>0.028</td>
<td>Std of income</td>
<td>Peru’s GDP Series (1990-2017)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.805</td>
<td>Persistence of income shock</td>
<td>Peru’s GDP Series (1990-2017)</td>
</tr>
<tr>
<td><strong>Estimated Parameters (SMM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.939</td>
<td>Time discount factor</td>
<td>LC Share</td>
</tr>
<tr>
<td>$\xi$</td>
<td>0.138</td>
<td>Cost of inflation</td>
<td>Volatility of inflation</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.93%</td>
<td>Output cost of default</td>
<td>Debt to GDP ratio</td>
</tr>
</tbody>
</table>

Table 3-1: Target Moments (Data Vs. Simulated Moments)

<table>
<thead>
<tr>
<th>Description</th>
<th>Empirical Moments</th>
<th>Simulated Moments</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC Share of External Government debt (%)</td>
<td>38.9 %</td>
<td>39.0%</td>
</tr>
<tr>
<td>Std of Inflation Rate (%)</td>
<td>1.47 %</td>
<td>1.47%</td>
</tr>
<tr>
<td>External Government Debt (% of GDP)</td>
<td>20.46%</td>
<td>20.12%</td>
</tr>
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</table>

Table 3-2: Non-Target Moments of Model and Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Model</th>
<th>Data (2000-2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corr (y, LC Share)</td>
<td>0.67</td>
<td>0.66</td>
</tr>
<tr>
<td>Corr (y, Inflation rate)</td>
<td>-0.45</td>
<td>-0.64</td>
</tr>
<tr>
<td>Corr (c, Inflation rate)</td>
<td>-0.30</td>
<td>-0.21</td>
</tr>
<tr>
<td>Corr (TB/Y, y)</td>
<td>0.42</td>
<td>-0.19</td>
</tr>
<tr>
<td>$\sigma(TB/Y)$</td>
<td>1.09%</td>
<td>2.40%</td>
</tr>
</tbody>
</table>

Note: y and c respectively denote the real GDP per capita and consumption per capita for Peru. TB/Y denotes the trade balance to GDP ratio. All the variables are detrended with the HP filter with a smoothing parameter of 100. For the correlation between y and LC share, the sample period is 2004-2017.
3.1 Parameters and Functional Forms

Table 2 reports parameter values employed or estimated for our main benchmark estimation. A period is a year. We use a CRRA utility function of the form \( (c^{\gamma-1} - 1) / (1 - \gamma) \) and set the risk aversion coefficient \( \gamma \) to be four, which is within the range of values used in the literature. The annual risk-free rate \( r_f \) is set to be 4%.

- The stochastic process for output is estimated from linearly detrended Peru’s GDP per capita series from 1990 to 2017. It is assumed to be a log-normal AR(1) process:
  \[ \log(y_t) = \rho \log(y_{t-1}) + \epsilon_t \]
  with \( E[\epsilon_t] = 0 \) and \( E[\epsilon_t^2] = \sigma^2 \). The estimated values are \( \rho = 0.805 \) and \( \sigma^2 = 0.028 \).

- We use a quadratic cost of inflation given by
  \[ C(\pi) = \xi (\pi - 1)^2 \]  
  which implies that the target inflation rate \( \bar{\pi} \) is normalized to be one.

- The cost of default during autarky is a fraction \( \lambda \) of income:
  \[ h(y_t) = (1 - \lambda) y_t \]

The remaining three parameters - the time discount factor \( \beta \), the cost of inflation parameter \( \xi \), and the output cost of default parameter \( \lambda \) - are estimated using simulated method of moments (SMM) to match three empirical moments from Peru’s data (Table 3-1): the mean local currency share of external government debt (2010-2017), the standard deviation of annual inflation rates (2000-2017), and the mean total external government debt to GDP ratio (2000-2017).
Table 4: Comparison of Simulated Moments across Different Parameter Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
<th>Benchmark</th>
<th>Low Inflation Cost ($\xi = 0.05$)</th>
<th>High Inflation Cost ($\xi = 0.2$)</th>
<th>Low Beta ($\beta = 0.93$)</th>
<th>High Beta ($\beta = 0.95$)</th>
<th>Low Default Cost ($\lambda = 0.5%$)</th>
<th>High Default Cost ($\lambda = 1.5%$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B^{loc}$ (% of GDP)</td>
<td>N.A</td>
<td>12.42%</td>
<td>7.36%</td>
<td>13.34%</td>
<td>11.50%</td>
<td>15.18%</td>
<td>7.82%</td>
<td>21.62%</td>
</tr>
<tr>
<td>Mean LC Debt (% of GDP)</td>
<td>7.96%</td>
<td>7.85%</td>
<td>2.20%</td>
<td>7.99%</td>
<td>2.93%</td>
<td>8.74%</td>
<td>5.67%</td>
<td>4.61%</td>
</tr>
<tr>
<td>Mean LC Share (%)</td>
<td>38.90%</td>
<td>39.00%</td>
<td>12.85%</td>
<td>43.66%</td>
<td>13.38%</td>
<td>57.98%</td>
<td>65.59%</td>
<td>15.63%</td>
</tr>
<tr>
<td>Mean Total Debt (% of GDP)</td>
<td>20.46%</td>
<td>20.12%</td>
<td>19.96%</td>
<td>20.22%</td>
<td>22.05%</td>
<td>16.25%</td>
<td>9.85%</td>
<td>33.70%</td>
</tr>
<tr>
<td>Corr (y,LC Share)</td>
<td>0.66</td>
<td>0.67</td>
<td>0.69</td>
<td>0.72</td>
<td>0.82</td>
<td>0.37</td>
<td>0.85</td>
<td>0.77</td>
</tr>
<tr>
<td>Corr (y,inflation rate)</td>
<td>-0.64</td>
<td>-0.45</td>
<td>-0.56</td>
<td>-0.44</td>
<td>-0.59</td>
<td>-0.40</td>
<td>-0.43</td>
<td>-0.44</td>
</tr>
<tr>
<td>Corr (c,inflation rate)</td>
<td>-0.21</td>
<td>-0.31</td>
<td>-0.45</td>
<td>-0.31</td>
<td>-0.53</td>
<td>-0.24</td>
<td>-0.32</td>
<td>-0.29</td>
</tr>
<tr>
<td>Corr (TB/Y,y)</td>
<td>-0.19</td>
<td>0.42</td>
<td>0.44</td>
<td>0.41</td>
<td>0.27</td>
<td>0.52</td>
<td>0.42</td>
<td>0.40</td>
</tr>
<tr>
<td>Std of inflation rate (%)</td>
<td>1.47%</td>
<td>1.47%</td>
<td>6.23%</td>
<td>1.20%</td>
<td>1.12%</td>
<td>1.65%</td>
<td>1.29%</td>
<td>1.40%</td>
</tr>
<tr>
<td>Std of TB/Y (%)</td>
<td>2.40%</td>
<td>1.09%</td>
<td>1.10%</td>
<td>1.04%</td>
<td>0.43%</td>
<td>1.79%</td>
<td>0.96%</td>
<td>1.10%</td>
</tr>
</tbody>
</table>

Note: This table compares the simulated moments of the benchmark model with those of the model with a different parameter value. We change only one parameter at a time with all the other parameter values fixed at the same as those from the benchmark model. Total debt refers to the external public debt.
Figure 5: Debt Frontiers with Different Parameter Values

Different Costs of Inflation

Different Values of Time Discount Factor

Different Output Costs of Default
3.2 Simulation Results

Table 3-2 compares the simulated moments to the empirical moments not targeted from SMM.\(^\text{13}\) Except for the correlation between the trade balance and GDP per capita, the simulated moments are strongly consistent with the empirical moments: inflation is highly negatively correlated with output and with consumption.\(^\text{14}\) Also, our model can capture the observed procyclicality of the local currency share of debt, which has been noted by Ottonello and Perez (2016) and addressed in that study with a different model.

Table 4 compares the simulated moments from the benchmark model with those from the model with different parameter values. We change only one parameter at a time, with all other parameters fixed at the benchmark values.

Different Costs of Inflation

The fourth and fifth column of the Table 4 respectively report the simulated moments for the cases of low and high costs of inflation (\(\xi = 0.05\) vs \(\xi = 0.2\)). The top panel of Figure 5 shows the debt frontiers for the respective cases. The debt frontier \(B_{\text{for}}^{\text{loc}}(b_{\text{loc}}^{\text{for}})\) displays the maximum debt limits for both types of debts supported in equilibrium without violating the enforcement constraints under all future contingencies. For any combination of \((b_{\text{loc}}, b_{\text{for}})\) inside the debt frontier, a sovereign honors its debt contract with foreign investors at any time and any state.

For the case of high inflation cost, the maximum local currency debt limit \(B_{\text{loc}}^{\text{loc}}\) is 13.34% of GDP, whereas for the case of the low inflation cost, \(B_{\text{loc}}^{\text{loc}}\) is 7.36%. That is, a high cost of inflation is associated with a more relaxed borrowing limit for the local currency debt. The average total debt – the sum of local and foreign currency debt in real terms – for both cases is quite similar at around 20%. The average LC share in total debt, however, shows a significant difference between the two cases: The LC share for the economy with a high cost of inflation is 43.66%, compared to 12.85% for the economy with a low cost of inflation.

Since the sovereign with a low cost of inflation can easily take advantage of the hedging benefit of local currency debt, it wants to borrow more in local currency. On the other hand, the sovereign with a low cost of inflation (thus less disciplined in terms of monetary policy) faces a high degree of temptation.

\(^{13}\) To get the simulated moments, we simulate the model 5000 times, and the first 1000 simulated data points are removed to rule out any effects of initial conditions.

\(^{14}\) Our model does not match the counter-cyclical trade balance for Peru. It must be, however, noted that our endowment economy model abstracts from investment, which is key to generating counter-cyclicality of the trade balance for small open economy models.
to excessive depreciation, so that foreign investors’ unwillingness to lend in local currency is reflected in the debt frontier. Since the sovereign cannot borrow as much as it wants in local currency, it needs to rely on foreign currency debt to satisfy its borrowing need. Thus, in equilibrium, we see a mix of local and foreign currency debt in the sovereign debt portfolio.

The sovereign with a high cost of inflation can borrow more in both foreign and local currency than the sovereign with a low cost of inflation. Figure 5 shows that its debt frontier is larger than, and covers that for the low cost of inflation borrower. But for the sovereign with a high cost of inflation, taking advantage of the hedging benefit of local currency debt is costly, so it uses inflation less actively than the sovereign with a low cost of inflation. The lower volatility of inflation for the sovereign with a high cost of inflation shows this point.

**Different Values of Time Discount Factor**

The sixth and seventh column of the Table 4 respectively report the simulated moments for the cases of low and high values of the time discount factor ($\beta = 0.93$ vs. $\beta = 0.95$). The middle panel of Figure 5 shows the debt frontiers for the respective cases. A sovereign with a high value of beta (more patient) can borrow more in both local and foreign currency, as it has a higher future continuation value than the sovereign with a low value of beta. It has less temptation to breach contract through either outright default or excessive debasement. Even if the patient sovereign can borrow more in both currency, the equilibrium amount of total debt is much less than that for the impatient sovereign (16.25% of GDP for the patient vs 22.05% for the impatient), because the patient sovereign prefers less front-loading of consumption. The patient sovereign faces a more relaxed debt frontier, and it borrows mainly in local currency. Unlike the case with a high cost of inflation, the patient sovereign will want to take advantage of the hedging benefit of local currency debt, thus actively using inflation to smooth its consumption. It follows that inflation is more volatile for the sovereign with a high value of beta than that with a low value of beta.

**Different Output Costs of Default**

The last two columns of Table 4 report the simulated moments for the cases of low and high output costs of default. The bottom panel of Figure 5 shows the debt frontiers for the respective cases. The change in the output cost of default directly affects the value of default, and it indirectly affects the value of debasement, because it affects the value of foreign currency borrowing through the enforcement constraint (equation (13)). An increase in output cost of default enlarges the debt frontier, thus increasing a sovereign’s overall borrowing capacity. Hence, the sovereign with a high default cost has a larger amount of total debt
in equilibrium (33.70% vs 9.85%). The increase in output cost of default, however, relaxes the borrowing limit substantially more for foreign currency than for local currency. That is, the output cost of default has more influence on the borrowing limit for foreign currency. This leads the sovereign with a high default cost to borrow more in foreign currency.

3.3 Who Suffers from Original Sin and Who Does Not?

Figure 6: Sensitivity Analysis w.r.t Cost of Inflation ($\xi$)

Figure 6 plots maximum local currency borrowing limits $B_{loc}^{\text{Max}}$, average local currency shares of sovereign debt, and inflation volatilities from the simulated models for different values of the cost of inflation parameter $\xi$ ranging from 0.005 through 0.245. As the cost of inflation increases, the economy can borrow more in local currency (the left panel of the figure 6). Accordingly the average LC share of the sovereign debt increases because the cost of inflation is the same regardless of the amount of local currency debt, but the benefit from consumption smoothing through inflation increases with the amount of local currency debt. Finally, as the cost of inflation increases, inflation volatility decreases.

The prediction of the model in Figure 6 is consistent with two empirical facts regarding the original sin phenomenon: First, emerging economies which suffered high inflation volatility during the 80s and 90s borrowed mostly in foreign currency. Second, the emerging economies which have gotten increasingly more disciplined in monetary policy after having adopted inflation targeting in early 2000s managed to borrow more in local currency during the last decade. At the same time, their inflation rates have been stabilized in tandem with increased local currency debt. Peru’s successful inflation targeting episode is also consistent with our model’s prediction.
3.4 Why Do We Still Have the Mystery of Original Sin?

In the previous section, we have shown that holding other parameters constant, an increase in the cost of inflation after having adopted inflation targeting is accompanied with a negative relationship between the volatility of inflation and the LC share. In this section, to provide a solution to the “Mystery of Original Sin”, we conduct a sensitivity analysis with respect to several key parameters to investigate the effects of changes in the key parameters on the optimal composition of sovereign debt. Appendix B presents a full sensitivity analysis.

The main finding of the sensitivity analysis is that even if the cost of inflation is the most important determinant for emerging economies’ ability to borrow in local currency debt, there is no clear-cut link between the currency composition of external sovereign debt and inflation related variables. Both the currency composition of debt and inflation related variables are endogenous and, depending on changes in exogenous variables or different parameters, we can have either a positive or negative relationship between these variables. This finding suggests why we still observe the mystery of original sin – a weak empirical support for the relationship between a country’s inflation performance and the local currency share of its sovereign debt in the data.

Table 5: Correlation between Average LC share and Inflation Volatility

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Correlation (LC share, Inflation Volatility)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Inflation</td>
<td>negative</td>
</tr>
<tr>
<td>Discount Factor</td>
<td>positive</td>
</tr>
<tr>
<td>Risk Aversion</td>
<td>positive</td>
</tr>
<tr>
<td>Output Cost of Default</td>
<td>non-monotonic</td>
</tr>
<tr>
<td>Persistence of Income Shock</td>
<td>positive</td>
</tr>
<tr>
<td>Volatility of Income Shock</td>
<td>positive</td>
</tr>
</tbody>
</table>

Table 5 summarizes the correlations between the average LC share and inflation volatility in simulations with respect to changes in key parameters in our model. With respect to the change in parameters for cost of inflation, the average LC share and inflation volatility move in the opposite direction. On the other hand, with respect to the change in parameters for the time discount factor, the degree of risk-aversion, persistence and volatility of income shock, the LC share and inflation volatility move in the same direction. With respect to the change in the parameter for the output cost of default, we do not see any monotonic relationship between the two variables.
Figure 7 shows scatterplots of the average LC share and volatility of inflation and illustrates this point more clearly. The black square in the center of the figure denotes the inflation volatility and the average LC share pair in the simulation from the benchmark estimation. The black dashed line tracks the movements in (LC share, inflation volatility) as we increase the cost of inflation parameter $\xi$, holding other parameters constant. As $\xi$ increases, the inflation volatility decreases, whereas the LC share increases. The red dashed line tracks the movements in (LC share, inflation volatility) as we increase the income variance. As the income variance increases, both LC share and inflation volatility increases in the simulation. Finally, the blue dashed line tracks the movements as we increase the output cost of default $\lambda$. As $\lambda$ increases, LC share decreases, whereas the inflation volatility does not change much.

Figure 7 illustrates why we still have a weak empirical relationship between a country’s inflation performance and local currency borrowing, even though emerging economies have been able to borrow more in local currency after having adopted inflation targeting in the last decade. Different countries have different characteristics such as different degree of patience, output cost of default, and income volatilities, etc., which determine their borrowing needs and the degree of temptation to breach the contract, as well as the extent to which their governments use inflation to smooth consumption. Different combinations of these characteristics can lead to different pairs of LC share and inflation volatility in equilibrium.

**Figure 7 : Scatterplots of Volatility of Inflation and Average LC Share**

![Figure 7: Scatterplots of Volatility of Inflation and Average LC Share](image_url)
3.5 Three Country Comparison Using Simulated Method of Moments

In this section, we structurally estimate the model for three of the countries included in our empirical study in section 1.1 – Mexico, Peru, and the Philippines. Specifically, we investigate what characteristics of each country account for the differences in LC share and inflation volatility across the three countries, and how these characteristics are reflected in deep parameters. Finally, we examine whether the estimated deep parameters are in line with their empirical counterparts.

Table 6 presents summary statistics for the three countries. These countries are at comparable levels of development and all three adopted inflation targeting in the early 2000s. We see, however, that Mexico’s local currency share of external public debt is larger than Peru (71.04% vs 38.94%), but its overall inflation performance is worse than Peru’s (Std. of Inflation: 1.62% vs 1.46%). On the other hand, Peru’s LC share is larger than that of the Philippines (38.94% vs 29.29%) and its overall inflation performance is better than the Philippines’ (Std of Inflation: 1.46% vs 2.0%). The latter fact is consistent with Calvo (1978) and Kydland and Prescott (1977), but the former fact has so far puzzled many economists, because this fact seems to suggest that debasement risk has little to do with a country’s borrowing ability in local currency.

Table 6: Summary Statistics for Mexico, Peru, and the Philippines

<table>
<thead>
<tr>
<th></th>
<th>Mexico</th>
<th>Peru</th>
<th>Philippines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Currency Share (2010-2017)</td>
<td>71.04%</td>
<td>38.94%</td>
<td>29.29%</td>
</tr>
<tr>
<td>GDP per Capita (2010 US dollars)</td>
<td>$ 9235</td>
<td>$ 4692</td>
<td>$2098</td>
</tr>
<tr>
<td>GDP (Current US Dollars)</td>
<td>$1 trillion</td>
<td>$132 billion</td>
<td>$181 billion</td>
</tr>
<tr>
<td>Average Inflation (2000-2017)</td>
<td>4.63%</td>
<td>2.81%</td>
<td>3.84%</td>
</tr>
<tr>
<td>Std inflation (2000-2017)</td>
<td>1.62%</td>
<td>1.46%</td>
<td>2.00%</td>
</tr>
<tr>
<td>Max inflation (2000-2017)</td>
<td>11.02%</td>
<td>6.78%</td>
<td>10.54%</td>
</tr>
</tbody>
</table>

We have three types of parameters – some taken as common standard values from the literature, some estimated from country output data, and the rest estimated by SMM estimation of our model. As common parameters for all three countries, the annual risk-free rate $r$ is set to be 4%, which is the standard value in the literature. The coefficient of risk-aversion $γ$ is set to be four, which is within the range of values used
in the literature. The target inflation $\bar{\pi}$ is normalized to be one. The two parameters related to the income process for each country- the variance and persistence of output – are estimated for each of these three countries directly from the data. That leaves us with three deep parameters – the cost of inflation $\xi$, the output cost of default $\lambda$, and the time discount factor $\beta$ – that we estimate from the model to match the following three target moments as we did in the benchmark estimation: the standard deviation of inflation, the average LC share of external public debt, and the average external public debt to GDP ratio.

**Table 7: Parameters**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_f$</td>
<td>4%</td>
<td>Risk Free Rate</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>4</td>
<td>Risk-aversion Coefficient</td>
</tr>
<tr>
<td>$\bar{\pi}$</td>
<td>1</td>
<td>Target Inflation (Normalization)</td>
</tr>
</tbody>
</table>

**Table 7-1 Common Parameter**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$</td>
<td>Mexico</td>
<td>Peru</td>
</tr>
<tr>
<td>$\sigma_e$</td>
<td>0.025</td>
<td>0.028</td>
</tr>
</tbody>
</table>

**Table 7-2 Parameters Estimated Directly from the Data**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimates</th>
<th>Target Moments</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\xi$ (Cost of Inflation)</td>
<td>Mexico</td>
<td>Peru</td>
<td>Philippines</td>
</tr>
<tr>
<td>$\lambda$ (Output Cost of Default)</td>
<td>0.89%</td>
<td>0.93%</td>
<td>1.22%</td>
</tr>
<tr>
<td>$\beta$ (Time Discount Factor)</td>
<td>0.959</td>
<td>0.939</td>
<td>0.948</td>
</tr>
</tbody>
</table>

15 We estimate using annual real GDP per capita data for the period 1990-2017 from the World Bank. We linearly detrend the series and estimate the AR(1) process using the cyclical components of each series.
Table 8 Empirical Counterparts for Parameters

<table>
<thead>
<tr>
<th>Empirical Counterparts</th>
<th>Mexico</th>
<th>Peru</th>
<th>Philippines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Credit to GDP (( \lambda ))</td>
<td>21.52%</td>
<td>22.83%</td>
<td>34.64%</td>
</tr>
<tr>
<td>Government’ Effectiveness (( \beta ))</td>
<td>0.185</td>
<td>-0.332</td>
<td>-0.003</td>
</tr>
</tbody>
</table>

Note: These statistics are the average values over the period 2000-2017. Domestic Credit to GDP refers to the amount of domestic credit to the private component of GDP.

Table 9: Simulated and Data Moments

Table 9-1 Target and Simulated Moments

<table>
<thead>
<tr>
<th>Description</th>
<th>Target Moments (Data)</th>
<th>Simulated Moments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mexico</td>
<td>Peru</td>
</tr>
<tr>
<td>LC Share</td>
<td>0.71</td>
<td>0.39</td>
</tr>
<tr>
<td>Std of Inflation (%)</td>
<td>1.62</td>
<td>1.46</td>
</tr>
<tr>
<td>External Public Debt to GDP (%)</td>
<td>15.50</td>
<td>20.46</td>
</tr>
</tbody>
</table>

Table 9-2 Non-Target Moments between Data and Model

<table>
<thead>
<tr>
<th>Description</th>
<th>Data Moments</th>
<th>Simulated Moments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mexico</td>
<td>Peru</td>
</tr>
<tr>
<td>Corr (LC Share, y)</td>
<td>-0.08</td>
<td>0.66</td>
</tr>
<tr>
<td>Corr (( \pi ), y)</td>
<td>-0.26</td>
<td>-0.64</td>
</tr>
<tr>
<td>Corr (( \pi ), c)</td>
<td>-0.60</td>
<td>-0.21</td>
</tr>
<tr>
<td>Corr (TB/Y, y)</td>
<td>-0.33</td>
<td>-0.19</td>
</tr>
<tr>
<td>( \sigma (\text{TB/Y}) )</td>
<td>0.32%</td>
<td>2.40%</td>
</tr>
</tbody>
</table>

Note: \( \pi \), \( \sigma \) respectively denote GDP per capita, gross GDP, final consumption expenditure per capita, and an annual inflation rate. \( \text{TB/Y} \) denotes the ratio of external balance to GDP. \( \sigma \) denotes the standard deviation. All statistics for Mexico and Peru are computed for the period from 2000 through 2017, except for the correlation between LC share and \( y \), for which the sample period is 2004-2017. The correlations between LC share and \( y \), \( \pi \) and \( y \), and \( \pi \) and \( c \) for the Philippines are computed over the period from 2009 through 2017, because the Philippines’s LC share has been zero until 2008. All the variables are detrended with the HP filter with a smoothing parameter of 100.

Table 7-3 shows that in the estimated model, Peru has a greater cost of inflation than Mexico, so its inflation volatility is lower than that of Mexico. However, Mexico’s time discount factor \( \beta \) is greater than...
that of Peru, so its LC share is larger than that of Peru. On the other hand, Peru has also a greater cost of inflation than the Philippines, so that its inflation volatility is lower than that of the Philippines. Even though Peru has a lower time discount factor than the Philippines, its LC share is larger because the Philippines has a significantly larger output cost of default, so that it has a much more relaxed borrowing limit for foreign currency than for local currency.

These estimated parameters are consistent with their empirical counterparts. We relate the three deep parameters to empirical counterparts that were found to be statistically significant in accounting for a country’s LC share in the regression in the section 1.1. First, an increase in a country’s cost of inflation \( \xi \) is associated with adoption of inflation targeting. Second, as an empirical counterpart for the output cost of default \( \lambda \), we use the ratio of the amount of domestic credit to the private component of GDP, which measures the degree of financial development of a country. The sovereign default literature points out that sovereign default negatively affects aggregate output mainly through its effect on the financial sector – the more developed or complex a country’s financial market is, the more damage sovereign default would likely cause to aggregate output. Finally, as an empirical counterpart for \( \beta \), we use the index of government effectiveness. Hatchondo et al. (2009) show how the stability of the government in power mimics the effects of a more patient borrower.\(^\text{16}\)

Table 8 reports the average values over 2000-2017 period for each of these three variables. Domestic credit to GDP, the proxy for the output cost of default, \( \lambda \), is the highest for the Philippines and the lowest for Mexico. This matches our estimates, which found that the Philippines had the highest value of \( \lambda \), and Mexico the lowest. The index of government effectiveness, the proxy for the time discount factor \( \beta \), is the highest for Mexico at 0.185 and the lowest for Peru at -0.332. Again, this ordering for the three countries matches our SMM estimates for \( \beta \).

Table 9 reports the targeted and non-targeted moments for all three of our countries. The findings for Mexico and the Philippines are similar to those for Peru discussed previously.

\(^{16}\) See also D’Erasmo (2011).
4. Model with Phillips Curve

In this section, we consider a simple but important extension of the basic model. In the model we have examined heretofore, the stabilizing properties of monetary policy work only through their effects on required payments on local-currency denominated debt. As we have shown, countries that are able to escape original sin can smooth consumption to some extent by using inflation/currency depreciation during periods of low output in order to reduce the real value of their debt service.

There is, of course, another channel through which monetary policy might smooth fluctuations that has a long tradition in macroeconomics – in Keynesian models when nominal prices do not adjust instantaneously, policy can induce higher real output at the cost of higher inflation. We introduce a simple “expectational Phillips curve” in which actual output can deviate from “potential” output if realized inflation turns out to be different than expected inflation. In this simple set-up, potential output is exogenously given and follows a stochastic process like the one assumed previously in this study for actual output. Now, actual output can rise above (fall below) potential output when actual inflation is greater than (less than) the rationally-expected rate of inflation.

Even with the introduction of the Phillips curve, we still assume that monetary policymakers have no inherent ability to commit to an inflation plan. There is an extensive literature that has emphasized the relative ineffectiveness of monetary policy in stabilizing output or consumption when policymakers can act only under discretion. Much of the New Keynesian optimal monetary policy literature either assumes policymakers have the ability to act under commitment, or else contrasts the effects of policy under commitment versus discretion. Usually those studies take the ability or inability to commit to a monetary policy plan as exogenously given in the model.

It is well known that there is an inflationary bias when monetary policy is set without commitment. Rogoff (1985) proposes solving this problem by appointing a central banker that puts relatively more weight on inflation stabilization than the social objective function calls for. Walsh (1995) suggests that central bankers are able to commit to monetary policy rules if they can sign contracts in which the central bankers’ rewards are tied to the rate of inflation. We find here a different motivation for at least partial commitment. A country that is able to borrow in local currency engages in a contract with international lenders that specifies state-dependent inflation rates. This contract, then, commits the policymaker to a “rule” for inflation, with a punishment that the country falls into the original sin regime if the rule is violated. The ability to borrow in local currency not only allows the country to smooth consumption by making the real value of debt repayment state dependent, but it also allows the policymaker

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17 See Woodford (2003), chapter 7, for an extensive discussion.
to exploit the Phillips curve to a greater extent. Countries that can only borrow in foreign currency or are in autarky can only set monetary policy without any ability to commit. We will show here that the ability to use the Phillips curve as another tool to smooth consumption confers additional welfare gains for countries that receive a contract to borrow in their own currency.

4.1. Setup of the Extended Model

**Phillips Curve**

We use the following Phillips curve:

\[ z_t(\pi_t, \pi_e) = \left(1 + \delta(\pi_t - \pi_e)\right) y_t, \]  

where \( z_t \) is actual output at period \( t \), \( \pi_t \) is the inflation rate at period \( t \), and \( \pi_e \) is the rational expectation of \( \pi_t \) formed at the end of period \( t-1 \) by agents in this economy, before \( \pi_t \) is determined at period \( t \). Finally, \( \delta \) is assumed to be nonnegative, and \( y_t \) is potential output at period \( t \), which follows the same Markov process as in the benchmark model in the section 2. The government in this economy can achieve higher output than potential output \( y_t \) if it chooses \( \pi_t \) above \( \pi_e \), but this will incur the inflation cost. Other than this Phillips curve, all other assumptions in this model are identical to those in the benchmark model in section 2.

**Value of Default**

The value of default is given by

\[ V^{\text{def}}(y_{t-1}, y_t; \pi_e) = \max_{z_t} \left[ u(c_t) - C(\pi_t - \bar{\pi}) \right] + \beta E_t \left[ V^{\text{def}}(y_t, y_{t+1}; \pi_e) \right], \]

subject to

\[ c_t = h(z_t(\pi_e, \pi_t)). \]

Unlike the benchmark model, the government in the economy in default conducts monetary policy to maximize the welfare of the economy by choosing \( \pi_t \) taking \( \pi_e \) as given. But, as with the benchmark model, the government does not have any inherent ability to commit to a monetary policy. In this case the government must conduct a discretionary monetary rather than the committed monetary policy. Finally, the rational expectations of \( \pi_t \) formed before \( y_t \) is realized implies:

\[ \pi_e = E_{t-1}[\pi_t] \]
Note that because of the above equation determining the rationally expected inflation $\pi^e$, the value of default contains $y_{t-1}$ as a state variable.

**Value of Foreign Currency Borrowing (Original Sin Regime)**

The value of foreign currency borrowing is given by

$$V^\text{for}(b^\text{for}_{t}, y_{t-1}, y_{t}; \pi^e) = \max_{\pi, b^\text{for}_{t}} \left[ u(c_{t}) - C(\pi_{t} - \pi) \right] + \beta E_{t} \left[ V^\text{for}(b^\text{for}_{t+1}, y_{t}, y_{t+1}; \pi^e) \right] \quad (37)$$

subject to

$$c_{t} + b^\text{for}_{t+1} = z_{t}(\pi_{t}, \pi^e) + R^{e} b^\text{for}_{t} \quad (38)$$

$$V^\text{for}(b^\text{for}_{t+1}, y_{t}, y_{t+1}) \geq V^\text{def}(y_{t}, y_{t+1}) \quad \text{for all } y_{t+1} \quad (39)$$

$$b^\text{for}_{t+1} \geq -D \quad (40)$$

Finally, when solving the above problem, the government takes $\pi^e$ as given, and $\pi^e$ is determined by the following equation:

$$\pi^e = E_{t-1}[\pi^e] \quad (41)$$

As with the case of default, the government cannot commit to any monetary policy so that it must use a discretionary monetary policy. Unlike our baseline model, the government now chooses $\pi^e$ in addition to $b^\text{for}_{t+1}$ so as to maximize the social welfare of the economy under the original sin regime.

**Values of Debasement and Contract**

For the values of debasement and the contract, we have the same setup as in our basic model except that $y_{t}$ is replaced with $z_{t}(\pi_{t}, \pi^e)$ in the budget constraint, and we have the rational expectations condition for $\pi^e$. For the case of strategic debasement, when the government deviates from the contracted inflation rate, it also takes into account the Phillips curve effect as well as the reduction of real value of local currency debt.
As for the value of the contract, however, the government has now an additional consumption smoothing tool besides the one working through change in the real value of local currency debt. Moreover, the government now can conduct a committed monetary policy by following the optimal contract agreed upon with the foreign lenders, even though it is constrained to a certain extent. Hence, foreign lenders in this case double as a commitment device which can punish the government for the deviation from the monetary policy specified in the contract. That is, by agreeing to a local currency contract, the government not only escapes from the original sin regime, but also obtains the commitment device which enables it to conduct a committed monetary policy. Later in this section, we isolate this value of this commitment device for different values of $\delta$.

4.2. Model Moments

As baseline parameters, we use a set of estimated parameters for Peru, but then use different values of $\delta$ to see how the slope of the Phillips curve influences economic outcomes. Table 10 compares several model moments for different values of $\delta$. $\delta = 0$ refers to our basic model without the Phillips curve.

As $\delta$ increases, the Phillips curve gets steeper, so that the government can more easily increase actual output $z$ above potential output $y$ by choosing $\pi$, higher than $\pi$. When the government cannot commit to any monetary policy, the steeper Philips curve provides the government with more temptation to re-optimize or reset its monetary policy. This, in turn, leads to an increase in average inflation rates in equilibrium as agents rationally expect the government’s temptation to re-optimize its monetary policy. The first row in the table 10 shows that the average inflation rate for the original sin regime increases as $\delta$ increases. At the same time, the value of the original sin regime decreases due to the high cost of inflation associated with the high inflation rate. That is, as $\delta$ increases, social welfare for the original sin regime, for which the government cannot commit, decreases. This result is consistent with Kydland and Prescott (1977) and Barro and Gordon (1983). This represents the well-known inflation bias when policy is set under discretion. As $\delta$ increases, the policymakers are more tempted to resort to inflation, for which the economy bears a cost.

Even if an increase in $\delta$ leads to a higher output gain at the time of strategic debasement, the value of debasement, on net, decreases, as the decrease in the value of original sin regime (i.e., the continuation value for the value of debasement) outweighs the output gain at the time of debasement. Hence, as $\delta$ increases, the value of the contract increases relative to the value of debasement and default, so that the debt frontier is enlarged. We can see this in Table 10 from the increase in the maximum local currency
borrowing $B^{\text{loc}}$, the LC share of the external debt, and the debt to GDP ratio, as $\delta$ increases. Moreover, consumption of the model economy gets smoother with an increase in $\delta$.

Table 10: Simulated Moments for the Model with Phillips Curve

<table>
<thead>
<tr>
<th></th>
<th>$\delta = 0$ (Benchmark)</th>
<th>$\delta = 0.02$</th>
<th>$\delta = 0.04$</th>
<th>$\delta = 0.06$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Inflation Rate for the Original Sin Regime</td>
<td>0%</td>
<td>5.2%</td>
<td>12.2%</td>
<td>17.9%</td>
</tr>
<tr>
<td>$B^{\text{loc}}$ (% of GDP)</td>
<td>12.4%</td>
<td>14.4%</td>
<td>27.2%</td>
<td>41.6%</td>
</tr>
<tr>
<td>Average LC Share (%)</td>
<td>39.0%</td>
<td>42.7%</td>
<td>87.3%</td>
<td>96.3%</td>
</tr>
<tr>
<td>$\sigma(\pi_t)$</td>
<td>1.47%</td>
<td>1.99%</td>
<td>4.07%</td>
<td>3.91%</td>
</tr>
<tr>
<td>$\sigma(c_t) / \sigma(y_t)$</td>
<td>0.92</td>
<td>0.91</td>
<td>0.88</td>
<td>0.85</td>
</tr>
<tr>
<td>External Debt to GDP ratio</td>
<td>20.1%</td>
<td>22.6%</td>
<td>30.7%</td>
<td>41.7%</td>
</tr>
</tbody>
</table>

4.3. Value of Commitment Device

Figure 8 plots the value of contract $W(b^{\text{loc}}_0, b^{\text{for}}_0, y_0)$ and the value of foreign currency borrowing, $W^{\text{for}}(b^{\text{for}}_0, y_0)$, where $b^{\text{loc}}_0 = b^{\text{for}}_0 = 0, y_0 = 1$ for the range of $\delta$ from 0 to 0.1. Let $U$ be the difference between $W(b^{\text{loc}}_0, b^{\text{for}}_0, y_0)$ and $W^{\text{for}}(b^{\text{for}}_0, y_0)$ for the case of $\delta$ being zero. Then $U$ represents the economy’s welfare gain for obtaining the ability to borrow in local currency as the economy escapes from the original sin regime. For positive values of $\delta$, the gap between the two value functions is the sum of two welfare gains; the first is the welfare gain for the ability to borrow in local currency represented by $U$, and the second is that for obtaining the commitment device which enables the government to conduct a committed monetary policy. The figure shows that the value of the commitment device increases as $\delta$ increases for the range of $\delta$ from zero to 0.1.

\[ W^{\text{for}}(b^{\text{for}}_0, y_0) = E_0 \left[ v^{\text{for}}(b^{\text{for}}_0, y_0, 1) \right] \]
This diagram illustrates how local-currency debt contract can work in a vein similar to the commitment devices introduced by Rogoff (1985) and Walsh (1995). Countries that can successfully obtain contracts—either, as we have noted in the baseline model, because they face high internal costs of excessive inflation, or because they greatly value the ability to smooth consumption—get a bonus, because the contract also confers a greater ability to utilize the Phillips curve to smooth output fluctuations.

Figure 8: Value of Contract Vs. Value of Foreign Currency Borrowing

5. Conclusions

This paper quantitatively investigates the currency composition of sovereign debt in the presence of two types of limited enforcement problems arising from a government’s monetary and debt policy: strategic currency debasement and default on sovereign debt. Local currency debt has better state contingency than foreign currency debt in the sense that its real value can be changed by a government’s monetary policy, thus acting as a better consumption hedge against income shocks. However, this higher degree of state contingency for local currency debt provides a government with more temptation to deviate from disciplined monetary policy, thus restricting borrowing in local currency more than in foreign currency. The two financial frictions related to the two limited enforcement problems combine to generate an endogenous debt frontier for local and foreign currency debt. Our model predicts that a less disciplined country in terms of monetary policy borrows mainly in foreign currency, as the country faces a much tighter
borrowing limit for the local currency debt than for the foreign currency debt. The prediction of our model is consistent with the original sin phenomenon and can also account for a surge in local currency borrowing by emerging economies in the recent decades. The extensive examination of the estimated model by conducting the sensitivity analysis with respect to the key parameters shows why we still have the mystery of original sin. Additionally, the extension of our model to include a Phillips curve shows that the threat of losing the ability to borrow in local currency can foster monetary policy credibility.

References


Aguiar, Mark; Manuel Amador; Emmanuel Farhi; and, Gita Gopinath. 2013. “Crisis and Commitment: Inflation Credibility and the Vulnerability to Sovereign Debt Crises.” Working paper, Department of Economics, Harvard University.


Appendix A: Proof of the Propositions

**Proposition 1:** Suppose that there is no cost of inflation (i.e., \( C(\pi_t - \bar{\pi}) = 0 \) for all \( \pi_t \)). Then, the optimal local currency contract under full commitment (i.e., no enforcement constraint eq (19)) can replicate the consumption allocation under the complete assets market.

**Proof.** Suppose that the sovereign in the small open economy can trade a full set of Arrow securities with foreign lenders in the international financial markets. Since foreign lenders in the international financial markets are risk-neutral and the risk-free rate \( r^* \) is constant across states and time, the pricing kernel for the Arrow securities is \( 1/ (1 + r^*) \) across states and time. Under complete assets market, consumption for the small open economy is equalized across states (i.e., \( C_i(s') = C_i(s') \)) at any date \( t \), and the following Euler equation characterizes the optimal consumption path over time.

\[
\frac{u'(c_t)}{u'(c_{t+1})} = \beta (1 + r^*)
\]

(Note that the natural borrowing limit is never binding in equilibrium, because the household’s utility function satisfies the Inada condition \( \lim_{c \to 0} u'(c) = \infty \).)

We first show that the local currency contract under full commitment without any cost of inflation completely smooths consumption across states in equilibrium.

The envelope condition for \( V^c \) with respect to \( \pi_t(x'_i) \) is given by

\[
V^c_{\pi_t} = -u'(c_t(x'_i)) \frac{i_{loc}}{\pi_t(x'_i)} \text{ for all } i.
\]

The Lagrangean for the maximization problem with respect to state-contingent inflation rates is given by

\[
L = \max_{\pi_t(x'_i)} \sum_{y'_{t} \in \mathcal{Y}} \Pr(y'_{t} \mid y_{t-1}) V^c(x'_i; \pi_t(x'_i)) + \lambda \left\{ \sum_{y'_{t} \in \mathcal{Y}} \Pr(y'_{t} \mid y_{t-1}) \frac{i_t}{\pi_t(x'_i)} - R^* \right\}
\]

The first order condition w.r.t \( \pi_t(x'_i) \) is given by

\[
\Pr\left(y'_{t} \mid y_{t-1}\right) V^c_{\pi_t}(x'_i) - \lambda \Pr\left(y'_{t} \mid y_{t-1}\right) \frac{i_t}{\pi_t(x'_i)^2} = 0
\]
It follows that

\[ V_{x_i}^c \left( x_i' \right) \pi_i \left( x_i' \right)^2 = V_{x_i}^c \left( x_i' \right) \pi_i \left( x_i' \right)^2 \]

Combining the first order conditions and the envelope condition, we have:

\[ u' \left( c \left( x_i' \right) \right) b_{i,loc} = u' \left( c \left( x_i' \right) \right) b_{i,loc} \]

Then, we have that \( C_j (s') = C_j (s^j) \).

The first order condition w.r.t \( b_{i+1}^{loc} \) for the maximization problem (eq. (17)) is given by

\[ u'(c_i) = \beta (1 + r^*) E_t [u'(c_{i+1})] \]

Since consumption across states is equalized, the Euler equation becomes the following:

\[ \frac{u'(c_i)}{u'(c_{i+1})} = \beta (1 + r^*) \cdot \]

**Proposition 2**: For sufficiently small values of \( \beta \), sufficiently low costs of inflation, and sufficiently high output costs of default, there exists no sustainable local currency debt contract in equilibrium, so that the economy must borrow in foreign currency from period 0 onward.

**Proof**: We will show that for any small amount of local currency debt \( b^{loc} < 0 \), if the discount factor \( \beta \) is sufficiently small and the cost of inflation is sufficiently low, then the value of contract is less than the value of debasement for certain states of the world, so that there exists no sustainable local currency contract supported in equilibrium.

We consider a case in which the output cost of default is sufficiently high so that there exists \( b^{for} < 0 \) such that \( V^{for} \left( b^{for}, y \right) \geq V^{def} \left( y \right) \) for all \( y \in Y \) even for \( \beta = 0 \). That is, for any values of \( 0 \leq \beta < 1 \), the value of foreign currency borrowing exists. Moreover, the value of default is not binding in the enforcement constraint (eq. 19) for a small amount of local currency debt \( b^{loc} < 0 \). \( h(y) = 0 \) for all \( y \in Y \) (that is, the entire income is lost when the economy defaults) is one example.
Fix a small amount of \( b_{loc} < 0 \), and \( y, y' \in Y \). Let \( V^{c, no}(0, b_{loc}, y, y') \) be the value of the optimal contract under full commitment (i.e., no enforcement constraint eq (19)) with \( b_{for} = 0, b_{loc}, y, \) and \( y' \).

Note that if there exists no sustainable local currency contract with \( b_{for} = 0, \) there exists no sustainable local currency contract with \( b_{loc} < 0 \). This is because the incentive for excessive debasement is higher for the case with a positive amount of foreign currency debt.

Let \( f(\beta; b_{loc}, y, y') = \left\{ V^{c, no}(0, b_{loc}, y, y'; \beta) - V^{debase}(0, b_{loc}, y, y'; \beta) \right\} \). If \( f(\beta; b_{loc}, y, y') < 0 \), there exists no sustainable local currency contract that can support \( b_{loc} < 0 \) with \( y, y' \) and \( \beta \). The discussion immediately following the statement of Proposition 2 showed that \( f(\beta = 0; b_{loc}, y, y') < 0 \) for a sufficiently low cost of inflation.

Let \( \beta^H \) be the time discount factor very close to but less than one. Then we have either of the following two cases at \( \beta^H \).

**Case (1):** \( f(\beta^H; b_{loc}, y, y') > 0 \). Since \( f(\cdot) \) is continuous in \( \beta \), it follows from the intermediate value theorem that there exists \( 0 < \beta' < \beta^H \) such that \( f(\beta'; b_{loc}, y, y') = 0 \). At this point, \( (\beta', b_{loc}, y, y') \), we have:

\[
u(c^t_{loc}) - C(\pi^t_{loc}) + \beta W^{c, no}(b_{loc}, z_{loc}, y') = u(c^t_{debase}) - C(\pi^t_{debase}) + \beta E_{f} V^{for}(b_{loc}, y') \]

where the left hand side is \( V^{c, no}(0, b_{loc}, y, y'; \beta) \), and the right hand side \( V^{debase}(0, b_{loc}, y, y'; \beta) \).

It follows from the Envelope conditions for the values of contract and debasement w.r.t \( \beta \) that

\[
\begin{align*}
f_{\beta}(\beta'; b_{loc}, y, y') &= V^{c, no}_{\beta} - V^{debase}_{\beta} = W^{c, no} - E_{f} V^{for}.
\end{align*}
\]

Since \( u(c^t_{debase}) - C(\pi^t_{debase}) - u(c^t_{loc}) - C(\pi^t_{loc}) > 0 \), we have that \( W^{c, no} - E_{f} V^{for} > 0 \) from eq ((1)) , thus \( f_{\beta}(\beta'; b_{loc}, y, y') > 0 \) at this point. That is, at \( \beta' \) for which the values of contract and debasement are equalized, an increase in \( \beta \) at \( \beta' \) increases \( V^{c, no} \) more than \( V^{debase} \). This implies that \( f(\beta; b_{loc}, y, y') \) crosses the \( \beta \) axis only once. Hence, there exists \( \beta' \) such that for any \( 0 < \beta < \beta' \), \( f(\beta; b_{loc}, y, y') < 0 \). Since the value of contract with the enforcement constraint \( V^c \) is less than or equal to the value of contract without the enforcement constraint \( V^{c, no} \), there exists a small value of \( \beta \).
for which there exists no sustainable local currency contract, so that the economy must borrow only in foreign currency from period 0 onward.

**Case (2):** \( f\left(\beta^{\mu}; b_{\text{loc}}, y, y'\right) \leq 0 \). In this case, we cannot use the intermediate value theorem. However, suppose that there exists \( 0 < \beta^* < \beta^{\mu} \) such that \( f\left(\beta^*; b_{\text{loc}}, y, y'\right) = 0 \). As shown in the case (1), at the point for which \( f\left(\beta^*; b_{\text{loc}}, y, y'\right) = 0 \), we have that \( f_\beta \left(\beta^*; b_{\text{loc}}, y, y'\right) > 0 \). This single crossing property implies that if \( f\left(\beta = 0; b_{\text{loc}}, y, y'\right) < 0 \) and \( f\left(\beta^{\mu}; b_{\text{loc}}, y, y'\right) \leq 0 \), there exists no \( 0 < \beta^* < \beta^{\mu} \) such that \( f\left(\beta^*; b_{\text{loc}}, y, y'\right) = 0 \). In this case, the value of debasement is strictly larger than the value of contract all over \( \beta^*'s \), thus no local currency borrowing all over the range.
Figure P3: The Values of Contract and Debasement with $\xi^L$ in $b^{loc}$ axis. $B_{loc,L}$ denotes the maximum local currency borrowing with $\xi^L$.

**Proposition 3:** Under Assumptions 1 and 2, $B^{loc,H} < B^{loc,L}$ for $\xi^H > \xi^L$.

**Proof:**

Fix $y \in Y$. For any $y'$, we have that

$$V^c(0, b^L, y, y', \xi^L) \geq V^{debase}(0, b^L, y, y'; \xi^L) \text{ for } B_{loc,L} \leq b^L < 0$$

(2)

For some $y'$, this holds with equality at $B^{loc,L}$. Figure P3 depicts eq (2).

Recall that the values of contract and debasement are respectively given by

$$V^c(0, b^L, y, y'; \xi^L) = \max_{b^L, b^L} \left[ u(c_i) - C(\pi_i - \pi; \xi^L) \right] + \beta W(b^L, b^L, y), \text{ subject to }$$

$$c_i + b^L = y' + \frac{i b^L}{\pi_i(x_i)}$$

$$V^{debase}(0, b^L, y, y'; \xi^L) = \max_{c_i, \pi_i(x_i)} \left[ u(c_i) - C(\pi_i - \pi; \xi^L) \right] + \beta E_{i} V^f(b^L, y'), \text{ subject to }$$

$$c_i + b^L = y' + \frac{i b^L}{\pi_i}$$
The Envelope conditions for the values of contract and debasement w.r.t \( b_{\text{loc}} \) are respectively
\[
V^c_{b_{\text{loc}}} = u'\left(c^\text{con}\right) \frac{i_{\text{con}}}{\pi_i^\text{con}} \quad \text{and} \quad V^\text{debase}_{b_{\text{loc}}} = u'\left(c^\text{debase}\right) \frac{i_{\text{debase}}}{\pi_i^\text{debase}}.
\]
Since \( \pi_i^\text{debase} > \pi_i^\text{con} \) and \( c_i^\text{con} < c_i^\text{debase} \), we have that \( V^c_{b_{\text{loc}}} > V^\text{debase}_{b_{\text{loc}}} \) for any \( b_{\text{loc}} \in [B_{\text{loc},L},0) \). That is, both \( V^c \) and \( V^\text{debase} \) are increasing in \( b_{\text{loc}} \), but \( V^c \) increases more than \( V^\text{debase} \) as \( b_{\text{loc}} \) increases, holding \( y, y', \xi \) constant. (Figure P3)

The Envelope conditions for the values of debasement \( V^\text{debase} \) and contract \( V^c \) w.r.t the cost of inflation parameter \( \xi \) are respectively \( V^\text{debase}_\xi = -C_\xi \left(\pi_i^\text{debase} - \bar{\pi}\right) \) and \( V^c_\xi = -C_\xi \left(\pi_i^\text{con} - \bar{\pi}\right) \), where \( C_\xi(.) \) denotes a partial derivative w.r.t \( \xi \). Since \( |\pi_i^\text{debase} - \bar{\pi}| > |\pi_i^\text{con} - \bar{\pi}| \), \( C(.) \) is symmetric, \( C_\xi(.) > 0 \), \( C^{\text{ss}}(.) > 0 \), we have the following inequality for any \( y' \):
\[
V^\text{debase}_\xi \left(0,b_{\text{loc}}^\xi,y,y'\right) = -C_\xi \left(\pi_i^\text{debase} \right) < -C_\xi \left(\pi_i^\text{con} \right) = V^c_\xi \left(0,b_{\text{loc}}^\xi,y,y'\right) \quad \text{for} \quad b_{\text{loc}}^\xi \in [B_{\text{loc},L},0). \]

Thus, an increase in \( \xi \) reduces \( V^\text{debase} \) more than \( V^c \) for any given \( y' \) at any \( b_{\text{loc}}^\xi \in [B_{\text{loc},L},0) \). That is, both value functions in the Figure P3 shift down but \( V^\text{debase} \) shifts down more.

If we increase \( \xi \) at \( \xi^L \), it follows from the Envelope condition w.r.t \( \xi \) that the gap between the values of contract and debasement \( V^\xi \left(0,B_{\text{loc},L}^L, y, y', \xi^H \right) - V^\text{debase}_\xi \left(0,B_{\text{loc},L}^L, y, y', \xi^H \right) \) in the inequality (2) get larger for any \( y' \) at \( B_{\text{loc},L}^L \). Then it follows from the Envelope conditions w.r.t \( b_{\text{loc}} \) that there exists \( b_{\text{loc}}^\xi < B_{\text{loc},L}^L \) such that \( V^\xi \left(0,b_{\text{loc}}^\xi, y, y', \xi^H \right) - V^\text{debase}_\xi \left(0,b_{\text{loc}}^\xi, y, y', \xi^H \right) \geq 0 \) for any \( y' \). Then we have that \( B_{\text{loc},H}^L < B_{\text{loc},L}^L \) for \( \xi^H > \xi^L \).
**Proposition 5**: If $C(\pi_t - \bar{\pi}) = \infty$ for any $\pi_t \neq \bar{\pi}$, then $\pi_t(s') = \bar{\pi}$ for all $t$. Moreover, the currency composition between foreign and local currency debts is indeterminate.

**Proof**: The proof is straightforward. If any deviation of inflation $\pi_t$ from the target inflation rate $\bar{\pi}$ incurs an infinitely high cost of inflation, we have that $\pi_t(s') = \bar{\pi}$ in equilibrium. With the equilibrium inflation being $\bar{\pi}$ at any state of the world, the nominal interest rate on local currency debt $i_{t,s}$ becomes $\bar{\pi}R^*$ at any state of the world from the lender’s expected zero profit condition. Moreover, the real interest rate on the local currency debt is $R^*$ at any state of the world. Then, the local and foreign currency debt become identical, so we have an indeterminate currency composition of the sovereign debt in equilibrium.
Appendix B: Sensitivity Analysis

In this section we conduct sensitivity analysis with respect to several key parameters to investigate the effects of changes in these key parameters on the optimal composition of sovereign debt.

**Discount Factor**

Figure B-1: Sensitivity Analysis w.r.t Time Discount Factor

As a sovereign becomes more patient, it becomes less tempted to excessive debasement or default on debt. Accordingly, the economy can and does borrow more in local currency. As the economy borrows more in local currency, the sovereign more actively conducts monetary policy to take advantage of the hedging benefit of local currency debt.

**Degree of Risk Aversion**

Figure B-2: Sensitivity Analysis w.r.t Degree of Risk Aversion
Figure B-2 displays sensitivity analysis with respect to different values of $\gamma$. As households become more risk averse, they value consumption smoothing more, and thus prefer to borrow in local currency. Hence, the maximum borrowing limit for the local currency debt $B_{loc}$ increases with the degree of risk aversion. Even though the local currency share of debt increases, inflation volatility increases. As households get more risk-averse, the economy borrows more in local currency and more actively conducts monetary policy to smooth consumption, taking advantage of the hedging benefit of local currency debt.

**Output Cost of Default**

*Figure B-3: Sensitivity Analysis w.r.t Output Cost of Default*

Figure B-3 shows sensitivity analysis with respect to different output cost parameters $\lambda$. As the output cost of default increases, the borrowing limit for local currency increases, so the economy can borrow more in local currency. However, the average local currency share decreases with $\lambda$. The debt frontier enlarges as the output cost of default increases; however as shown in the main quantitative analysis in section 3, compared to the local currency debt, the borrowing limit for foreign currency debt gets more relaxed with the increase in output cost of default. The economy then tends to borrow relatively more in foreign currency than in local currency.
Persistence of Income Shock

Figure B-4: Sensitivity Analysis w.r.t Persistence of Income Shock

Figure B-4 presents sensitivity analysis with respect to different degrees of persistence of the income shock process. As the income shock becomes more persistent, the value of debasement/default increases; when a good income shock hits the economy, the good income shock is expected to persist for a long period of time, thus making breaching the contract more attractive. This is reflected in a decrease in the borrowing limit for the local currency debt with an increase in the degree of persistence. Along the way, both the average LC share and inflation volatility decrease.

Income Variance

Figure B-5: Sensitivity Analysis w.r.t Income Variance
Figure B-5 presents sensitivity analysis with respect to different levels of income variance. As the variance of income increases, the value of breaching the contract decreases; the values of debasement and default decrease, because the economy has a less efficient consumption smoothing vehicle in the original sin regime and permanent financial autarky in the face of higher income volatility. As the variance of income increases, the borrowing limit for local currency debt increases. Along the way, both the LC share and inflation volatility increase.
Appendix C: Robustness Checks

In the section, we use three different specifications of the model to see whether our main quantitative results are robust. In the Appendix C-1, we allow the model economy to default in equilibrium in the Original Sin regime. In the Appendix C-2, rather than staying in the Original Sin regime permanently after strategic debasement, in each period the model economy has a recurring chance to escape from the Original Sin regime with an exogenous probability. Finally, in the Appendix C-3 the model economy has a recurring chance to escape from the Original Sin regime and financial autarky with exogenous probabilities. The chief takeaway from this exercise is that the different specifications of the model mainly affect the enforcement constraint (eq. (19)) through changes in the values of default and/or debasement, but this change does not lead to any qualitative change to our main theoretical and quantitative results.

C-1 Model with Equilibrium Default in the Original Sin Regime

Figure C-1

In this section we allow the model economy in the original sin regime (i.e., value of foreign currency borrowing in Section 2) to default on its debt in equilibrium, in order to see whether our quantitative results are robust to this specification. When we allow equilibrium default, the Bellman equation for the value of foreign currency borrowing reduces to that in Aguiar and Gopinath (2006), and Arellano (2008). We set the probability of getting out of financial autarky to be zero (permanent financial autarky) as consistent with the benchmark model. However, the main result in this section is also robust to different values of the probability.
Figure C-1 compares debt frontiers for our benchmark estimation and the model with equilibrium default. The debt frontier for the model with equilibrium default is larger than that for our benchmark model. This implies that the value of debasement in the enforcement constraint (eq. (19)) is lower for the model with equilibrium default. Equilibrium default allows the economy to borrow more than our benchmark economy, but too much borrowing leads to the economy defaulting in equilibrium, thus falling in to permanent financial autarky and hurting social welfare of the economy.

Table C-1 compares the simulated moments for the benchmark estimation and the model that allows equilibrium default. Since the debt frontier is larger for the model with equilibrium default, it can borrow more in local currency and its LC share is larger. In terms of other simulated moments, there are some quantitative differences, but there is no qualitative difference. In sum, allowing the economy to default in equilibrium affects the value of contract through the enforcement constraint but our main results basically remain the same. Finally, all the propositions carry through with this specification.

Table C-1: Comparison of Simulated Moments

<table>
<thead>
<tr>
<th>Description</th>
<th>Benchmark</th>
<th>Equilibrium Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_{loc}$ (% of GDP)</td>
<td>12.42%</td>
<td>16.10%</td>
</tr>
<tr>
<td>Mean LC Debt (% of GDP)</td>
<td>7.85%</td>
<td>9.55%</td>
</tr>
<tr>
<td>Mean LC Share (%)</td>
<td>39.00%</td>
<td>51.11%</td>
</tr>
<tr>
<td>Mean Total Debt (% of GDP)</td>
<td>20.12%</td>
<td>20.79%</td>
</tr>
<tr>
<td>Corr (y,LC Share)</td>
<td>0.67</td>
<td>0.82</td>
</tr>
<tr>
<td>Corr (y,inflation rate)</td>
<td>-0.45</td>
<td>-0.45</td>
</tr>
<tr>
<td>Corr (c,inflation rate)</td>
<td>-0.31</td>
<td>-0.31</td>
</tr>
<tr>
<td>Corr (TB/Y,y)</td>
<td>0.42</td>
<td>0.44</td>
</tr>
<tr>
<td>Std of inflation rate (%)</td>
<td>1.47%</td>
<td>2.20%</td>
</tr>
<tr>
<td>Std of TB/Y (%)</td>
<td>1.09%</td>
<td>1.06%</td>
</tr>
</tbody>
</table>
C-2 Model with Temporary Original Sin Regime

In this section, we allow the model economy to have a recurring chance in each period to arrange a local currency contract with foreign lenders with an exogenous probability even if the economy is in the Original Sin regime after strategic debasement, or the economy fails to have the contract in the period zero. We set the probability of having a chance to arrange a local currency contract to be one percent.

**Figure C-2**

![Figure C-2](image)

**Table C-2: Comparison of Simulated Moments**

<table>
<thead>
<tr>
<th>Description</th>
<th>Benchmark</th>
<th>Temporary Original Sin Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{B}^{loc} ) (% of GDP)</td>
<td>12.42%</td>
<td>11.15%</td>
</tr>
<tr>
<td>Mean LC Debt (% of GDP)</td>
<td>7.85%</td>
<td>3.38%</td>
</tr>
<tr>
<td>Mean LC Share (%)</td>
<td>39.00%</td>
<td>22.21%</td>
</tr>
<tr>
<td>Mean Total Debt (% of GDP)</td>
<td>20.12%</td>
<td>19.87%</td>
</tr>
<tr>
<td>Corr (( y,LC ) Share)</td>
<td>0.67%</td>
<td>0.72%</td>
</tr>
<tr>
<td>Corr (( y,\text{inflation rate} ))</td>
<td>-0.45%</td>
<td>-0.43%</td>
</tr>
<tr>
<td>Corr (( c,\text{inflation rate} ))</td>
<td>-0.31%</td>
<td>-0.30%</td>
</tr>
<tr>
<td>Corr (( TB/Y,y ))</td>
<td>0.42%</td>
<td>0.41%</td>
</tr>
<tr>
<td>Std of inflation rate (%)</td>
<td>1.47%</td>
<td>1.11%</td>
</tr>
<tr>
<td>Std of TB/Y (%)</td>
<td>1.09%</td>
<td>1.10%</td>
</tr>
</tbody>
</table>
Figure C-2 compares the debt frontiers for the benchmark model and the model with the temporary Original Sin regime. The recurring chance of escaping from the Original Sin regime increases the value of foreign currency, thus increasing the value of debasement. The tighter debt frontier along the local currency borrowing for the model with temporary Original Sin regime shows this point. Table C-2 compares the simulated moments for the benchmark estimation and the model with temporary Original Sin regime. Since the debt frontier for the model with temporary Original Sin regime is tighter along the local currency borrowing, the model economy cannot borrow in local currency as much as in the benchmark model. Hence, its mean LC debt and LC share are smaller than those for the benchmark model. There are, however, no qualitative differences in other simulated moments between the two cases. Finally, all the propositions are robust to this specification.

**C-3 Model with Temporary Original Sin Regime and Financial Autarky**

In this section, the model economy has a recurring chance in each period to escape from the Original Sin regime and financial autarky with exogenous probabilities. We set the two probabilities equal to one percent.

![Figure C-3](image-url)
If we assume temporary autarky rather than permanent autarky as a punishment for outright default, it directly increases the value of default and indirectly changes the value of debasement through the change in the value of foreign currency borrowing. This has the similar effect as the decrease in output cost of default. At the same time, if we assume temporary Original Sin regime as a punishment for strategic debasement, this increases the value of debasement as shown in the Appendix C-2. All in all, these two effects combine to make the debt frontier in overall smaller than that for the benchmark model. The mean LC amount, LC share, and the average total amount of debt are smaller than those for the benchmark case, but there are no qualitative differences in the simulated moments between the two cases. Finally, all the propositions are robust to this specification.

Table C-3: Comparison of Simulated Moments

<table>
<thead>
<tr>
<th>Description</th>
<th>Benchmark</th>
<th>Temporary Original Sin and Autarky</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B^{loc}$ (% of GDP)</td>
<td>12.42%</td>
<td>9.20%</td>
</tr>
<tr>
<td>Mean LC Debt (% of GDP)</td>
<td>7.85%</td>
<td>2.62%</td>
</tr>
<tr>
<td>Mean LC Share (%)</td>
<td>39.00%</td>
<td>24.37%</td>
</tr>
<tr>
<td>Mean Total Debt (% of GDP)</td>
<td>20.12%</td>
<td>15.71%</td>
</tr>
<tr>
<td>Corr (y,LC Share)</td>
<td>0.67</td>
<td>0.69</td>
</tr>
<tr>
<td>Corr (y,inflation rate)</td>
<td>-0.45</td>
<td>-0.81</td>
</tr>
<tr>
<td>Corr (c,inflation rate)</td>
<td>-0.31</td>
<td>-0.39</td>
</tr>
<tr>
<td>Corr (TB/Y,y)</td>
<td>0.42</td>
<td>0.41</td>
</tr>
<tr>
<td>Std of inflation rate (%)</td>
<td>1.47%</td>
<td>0.91%</td>
</tr>
<tr>
<td>Std of TB/Y (%)</td>
<td>1.09%</td>
<td>1.00%</td>
</tr>
</tbody>
</table>
Appendix D: Computation Algorithm

In this section we describe the computation algorithm to solve the recursive problem (eq.(21) - eq.(24)). As pointed out by Chang (1998), and Bai and Zhang (2010), the unique feature of this algorithm is that we need to find a set of states \( S = (b_{for}, b_{loc}, y) \) that permit a non-empty set of feasible allocation on the value function \( W(b_{for}, b_{loc}, y) \), which is used to construct the debt frontier of our model. We need to start with a sufficiently high \( W^0 \), where superscript denotes the number of iterations. We first solve the recursive problem without the enforcement constraints to obtain the value \( W^0 \), which is used for our initial guess for \( W \). For each iteration \( i \), we solve the recursive problem to update \( S^i \) to include all the states \((b_{for}, b_{loc}, y)\) which satisfy the budget and the enforcement constraints. As shown by Bai and Zhang (2010), both sequence of \( \{W^i, S^i\} \) are decreasing and finally converging to the limit \( W, S \).

We solve for equilibrium using the global solution method featuring the value function iteration. We first generate a discrete grid for \((b_{for}, b_{loc}, y)\) and interpolate the value functions \((W, V)\) with a cubic spline. Given \( \{W^i, S^i\} \) at the \( i \)th iteration, we solve for the optimal inflation rate, the optimal \( i^i \), and the optimal amount of local and foreign currency debts \((\pi^i, b_{for}^{i+1}, b_{loc}^{i+1})\) subject to the enforcement constraint.

When computing the optimal \((b_{for}, b_{loc})\), we first find an optimal grid point by using the global search method, and then search for the optimum value around the point using the Nelder-Mead algorithm. When computing the optimal \((\pi, (y(s)), i)\), we use the lender’s zero profit condition and the optimality condition for the interest rate (eq (27)). We keep iterating the value functions and \( S^i \) until achieving convergence with a convergence criterion of \(10^{-6}\) sup norm.

Finally, the income shock process \( y \) is approximated with the two state Markov Chain using the method by Kopecky and Suen (2010).