Indexation of Public Debt: Analytical Considerations and an Application to the Case of Brazil

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Since the implementation of the Real Plan of 1994, the Brazilian economy has been in the process of reducing its degree of indexation. For more than three decades, Brazilian wages, rents, financial securities, and other contracts were indexed to the price level. The frequency of adjustment sometimes reached monthly or even daily intervals, as in the case of some financial securities.

Brazilian indexation was inseparably associated with high rates of inflation, which averaged 20 percent per month over the last three decades. Inflation peaked at 82 percent per month during the hyperinflation (or megainflation) episode that occurred just before the Collor Plan went into effect. The association between inflation and indexation has always provoked the debate about whether high and variable inflation induces the indexation of the economy through the breakdown of nominal contracts or whether indexation perpetuates the inflationary process as argued by the inertial theory of inflation.[1]

Brazilian indexation has relied mainly on price-level indexation as opposed to exchange rate indexation, which is common in several

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1. For this debate and the inertial inflation theory, see Arida and Resende (1985); Simonsen (1983). See also Fischer and Summers (1989), who show how better protection may end up causing more inflation.

Indexation, Inflation, and Monetary Policy, edited by Fernando Lefort and Klaus Schmidt-Hebbel, Santiago, Chile.

other inflationary experiences. This peculiar feature has often been justified by the institutionality of Brazilian indexation mechanisms.

These mechanisms, which date back to 1964, concentrated on price-level indexation well before the country began to experience the high inflation of the late 1980s and early 1990s.

This paper investigates Brazilian indexation in the financial sector over the last few decades, focusing, in particular, on indexation of the public debt. Not only were government indexed securities a sizable portion of total securities, but they also took a central role (as reference values and even as a unit of account) in spreading indexation mechanisms to other contracts in the economy, such as wages, rents, taxes, and other private financial contracts. Important government indexed securities include the Obrigações Reajustáveis do Tesouro Nacional (ORTN, later OTN) in 1964-89 and the Bonus do Tesouro Nacional (BTN) in 1989-91.

This paper examines the composition of public debt among price-level-indexed, nominal, and foreign-denominated securities. It argues that the volatility of inflation, the level of total debt, the volatility of the real exchange rate, and the correlation between expenditures and inflation are important determinants of the composition of public debt. To illustrate the main government incentives for issuing different public debt securities, the paper derives a simplified model of debt indexation and denomination. It models a government that wants to minimize both the fluctuation of the government budget and inflation. The smoothing of the budget allows for smaller changes in the tax rate, which implies higher utility for a representative consumer, given convex distortion costs. The main trade-off can be summarized as follows. On the one hand, issuing indexed securities allows the government to minimize fluctuations of the real value of its debt as a result of inflation variability, and it eliminates the temptation of inflating away the debt, which, in equilibrium, would lead to costly higher inflation. On the other hand, if expenditure shocks are positively correlated to inflation shocks, nominal securities serve as implicit contingent debt, thus reducing the value of debt when it is most needed.

The paper also investigates when it is preferable to issue foreign-denominated securities. These are a better option when the real exchange rate does not fluctuate substantially and the correlation between the real exchange rate shocks and government expenditures is negative.

The paper is organized as follows. The next section summarizes Brazilian experience with indexation. Section 2 presents the model and section 3 looks at the composition of public debt in Brazil. Finally, section 4 concludes.

1. Indexation in Brazil

Most of Brazil's institutionalization of indexation dates back to 1964 during the first military government of President Castelo Branco.[2] Before that date, two laws inhibited the emergence of automatic adjustments of contracts. The 1933 law passed by President Vargas simply prohibited contracts from being stipulated in currencies other than the milreis, the Brazilian currency at that time. Besides being a nationalistic reaction in favour of the Brazilian sovereign monetary unit, the law attempted to curb the established practice of foreign companies indexing their prices to the exchange rate in order to neutralize the effect of the devaluation of milreis on their receipts measured in foreign currency. From an economic point of view, the law was based on the fact that exchange rate indexation significantly impaired the correction of balance-of-payments imbalances.

The second law, the Lei da Usura, established a nominal interest rate ceiling of 12 percent. Since inflation generally exceeded this ceiling, implying negative real rates, several mechanisms were established to bypass the law. Long-term contracts were nonexistent, however, since they required explicit indexation mechanisms to deal with uncertainty regarding future inflation rates.

In 1964, the military government decided to reduce the distortions in the economy resulting from these two laws. It therefore introduced the *correção monetária*, a sophisticated indexation mechanism that adjusted taxes, tariffs, and some financial contracts, but not the exchange rate, wages, or bank deposits. The government wanted to avoid the negative effects that the absence of indexation had on public receipts and some financial contracts. The absence of indexation on the exchange rate and wages was justified to allow corrections of external imbalances and to avoid the inflationary consequences of wage indexation.

The government also issued the Obrigações Reajustáveis do Tesouro Nacional (ORTN). These were public debt securities that had maturities ranging from one to twenty years and that were adjusted automatically for past inflation plus interest rates of 6 percent per year. The objective was to avoid financing the deficit through inflationary monetary expansion. The government believed that indexing the debt would increase the demand for long-term securities with fixed real rates and also allow for lower debt service, since it

2. This section draws on Simonsen (1995).

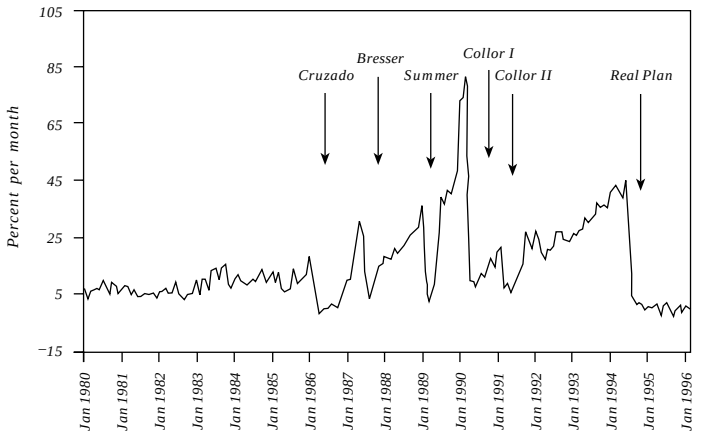
expected inflation to decline below market expectations embedded in nominal interest rates paid on nominal securities.

The ORTN rapidly became an important reference value for other contracts. Starting in 1964, mortgage contracts were adjusted by the quarterly variation of the ORTN. This adjustment became known as the UPC (the unit of reference of capital). Indexation spread to almost all areas of the economy beginning in 1967, during the Costa e Silva administration. Wages could no longer be denied automatic indexation. The exchange rate policy was based on purchasing power parity, and rents were adjusted every six months. In short, the Brazilian economy became highly indexed.

Both indexation and inflation continued to increase under the next two governments, from 1974 to 1985. The Mexican default and the resulting crisis led to higher inflation and renewed efforts to implement restrictive monetary and fiscal policies. With the economy highly indexed to past inflation, all attempts to reduce inflation through traditional policy instruments proved inappropriate.

The inflation process was thought to be inertial and its reduction to require measures that eliminate widespread indexation in the economy. In March 1986, the Cruzado Plan was implemented; this was the first in a long series of stabilization plans. This first attempt was unsuccessful, as were the following four plans (namely, the Bresser, Summer, Collor I, and Collor II plans) (see figure 1). The widespread indexation of contracts persisted, and inflation continued to increase.

Figure 1. Inflation and Stabilization Plans



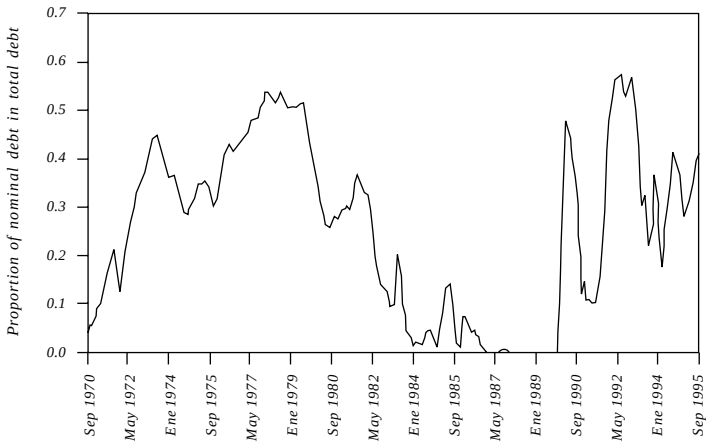
Source: Conjuntura Economica (IPA/DI).

Given the high levels of uncertainty with respect to inflation, nominal contracts could not survive. The proportion of nominal public debt reached zero during the megainflation process that preceded the Collor plan. Figure 2 shows the proportion of nominal debt in the hands of the public.

The Real Plan of July 1994 succeeded in reducing inflation. It was an ingenious scheme of changing numeraires. In March 1994 nominal prices, wages, and other contracts were allowed to be quoted in a unified reference value (URV) that would be replaced by a new currency, the real, in July 1994. Given that prices were already indexed to several different references, the innovation of the URV was to coordinate a unified unit of account that would substitute for all other indexation mechanism. In the interim period after the introduction of the URV and before its replacement by the real, it was expected that relative prices would converge to their equilibrium value. This was important for the second phase of the conversion, when the URV would be transformed into real on a one-to-one basis and then pegged to the dollar. This pegging, in fact, caused inflation to plunge from 46 percent in June 1994 to 1.5 percent in September 1994.

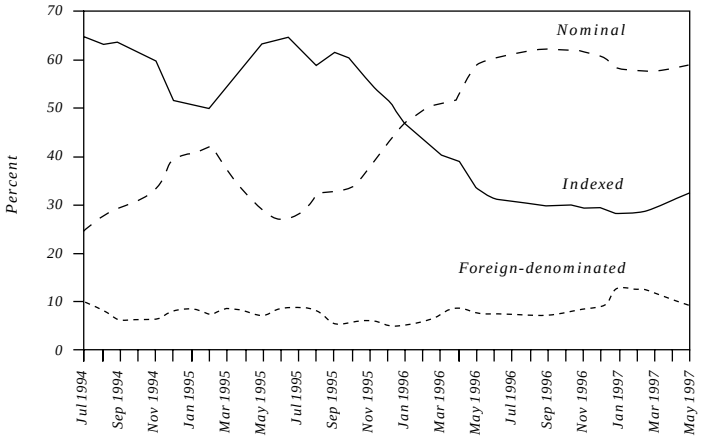
Lower inflation and deliberate government legislation to eliminate the indexing of the economy together reduced the indexation of short-term contracts substantially. In particular, the proportion of indexed public debt diminished considerably. Figure 3 shows the composition of public debt after the Real Plan. The most striking fact is that the proportion of nominal debt has increased significantly, as one should expect from the increasingly stable inflation environment.

Figure 2. Nominal Debt in Brazil



Source: Associação Nacional das Instituições do Mercado Aberto (Andima).

Figure 3. Composition of Public Debt



Source: Central Bank of Brazil.

2. The Model

The government decision to manage its public debt hinges on the trade-off between time-consistency problems and tax-smoothing motives. The former generate higher inflation than is optimal; credibly committing to low inflation therefore requires a structure based on securities indexed to either foreign or domestic inflation. Tax smoothing calls for issuing securities whose returns are negatively correlated with the tax needs of the government. This may be the case of both nominal debt and debt linked to a foreign currency.

The model uses a two-period example to derive the optimal composition of debt, including nominal, indexed, and foreign-denominated liabilities. The objective is to highlight the effects of both tax smoothing and time-consistency considerations on the optimal composition in the simplest possible framework.[3]

The government's objective is to minimize distortions from taxes (τ) and inflation (π), both of which are assumed to be quadratic. There are three sources of uncertainty: government spending, the real exchange rate, and the money demand are assumed to be stochastic.

3. A multiperiod model is developed in Goldfajn (1996). For a related model of public debt indexation, see Calvo and Guidotti (1990).

The latter introduces uncertainty with respect to the inflation rate:

$$\text{Min} \quad \mathrm{E}\left(A\frac{\tau^2}{2} + \frac{\pi^2}{2} \right) . \tag{1}$$

In the first period, the government chooses the composition of the debt that it sells to the public, which will mature at the end of period two. Three financial instruments are available: nominal bonds that are sold at a nominal interest rate (i) and have a realized rate of return of

$$\frac{(1+i)}{(1+\pi)} ,$$

indexed bonds that pay a real rate of r plus the realized rate of inflation (π); and foreign-denominated bonds that pay the foreign interest rate (i^*) plus the rate of depreciation (e) and have a realized real rate of return in domestic currency equal to

$$\frac{(1+i^*)(1+e)}{(1+\pi)} .$$

No shocks or other financing decisions take place in the first period.

In the second period, the government decides about the optimal money growth, given the level of debt and its composition. Subsequently, the shocks are realized and taxes are levied to balance the budget.[4] Consumers are in the background; they enter the model as risk-neutral debt holders who demand a nominal interest rate that includes a fixed real interest rate (r) plus the expected rate of inflation (π^e):[5]

$$1 + i = (1 + \pi^e)(1 + r) . \tag{2}$$

The assumption of risk neutrality on the part of the investors is not restrictive and is made for simplicity. Had I assumed risk-averse investors, they would have demanded an extra premium to hold nominal debt, but the main results would still hold.[6]

4. The budget has to balance since this is the last period. In the multiperiod model, taxes and money growth are decided simultaneously, and the amount of debt financing is adjusted for the shocks.

5. It is assumed that the real interest rate r is equivalent to that demanded on indexed bonds. Even with risk neutrality, equation 2 is an approximation.

6. The results depend on the fact that the government wants to minimize the fluctuations on the real value of its debt, since they generate costly changes in the tax rates. The investors' degree of risk aversion does not change this fact.

The paper assumes uncovered interest rate parity:

$$1+i=\left(1+e^{e}\right)\left(1+i^{*}\right). \tag{3}$$

The money market equation determines the equilibrium inflation rate:

$$\pi=\hat{m}+\tilde{v}, \tag{4}$$

where $\hat{m}$ is money supply growth created by the government and $\tilde{v}$ represents velocity shocks that are assumed to be white noise. Here the paper assumes that the government sets the money supply and allows the nominal exchange rate to be determined endogenously.[7]

In equilibrium, rational investors will anticipate the government's decision on money supply growth. In the model, this implies that investors anticipate the average inflation generated by the government:

. (5)

The government's budget constraint in the second period is that taxes have to be equal to spending plus the real value of debt.[8] Using equations 2 and 3 and linearizing the budget constraint, I obtain

$$\tilde{\tau}=\tilde{G}+\left(1+r\right)B\left[1-\theta\left(\tilde{\pi}-\pi^{e}\right)-\theta^{*}\left(\tilde{q}-q^{e}\right)\right], \tag{6}$$

where θ and θ^{*} are the proportions of nominal and foreign-denominated debt, respectively, B is the level of total debt, and

$$\tilde{q}=\tilde{\pi}-\tilde{e}. \tag{7}$$

Unexpected increases in inflation reduce nominal debt, and unexpected real appreciations reduce foreign-denominated debt. (Assume for simplicity that foreign inflation is zero.)

2.1 The Commitment Solution

The commitment solution is derived first. It is assumed that the government can credibly commit in the first period to the decisions

7. An alternative and equivalent assumption is to allow the government to set the rate of depreciation and let money be determined endogenously.

8. For simplicity, revenues from cash balance holdings are ignored.

taken in the second period. In the first period, therefore, the government will choose both the composition, θ and θ^*, and the way it will finance itself between taxes and money growth in the second period. Minimizing equation 1 subject to equations 5 and 6, I obtain the solution

$$\hat{m}^* = 0 , \tag{8}$$

and the optimal proportions are

$$\theta = \frac{\sigma_{g\pi}\sigma_q^2 - \sigma_{gq}\sigma_{\pi q}}{B\left[\sigma_\pi^2\sigma_q^2 + \left(\sigma_{\pi q}\right)^2\right]} \quad \text{and} \tag{9}$$

$$\theta^* = \frac{\sigma_{gq}}{B\sigma_q^2} - \frac{\sigma_{\pi q}\theta}{\sigma_q^2} , \tag{10}$$

where σ denotes variance or covariance. It is assumed, for simplicity, that $r = 0$.

The optimal money supply growth is zero because there are no benefits from announcing a higher money path: nominal interest rates will increase proportionally to higher inflation rates. Moreover, higher inflation rates imply higher distortion costs, such that governments will optimally commit to a zero inflation path.

The optimal proportion of the debt in nominal terms increases with the covariance of inflation with spending but diminishes with the variance of inflation. The intuition is that shocks to the other components of the budget should be optimally hedged. On the one hand, nominal debt is a good hedging device for the government whenever shocks to spending (or any other component of the primary deficit) are positively correlated to inflation shocks and, therefore, negatively correlated to the debt value. This avoids having to raise taxes in bad states of the world. On the other hand, pure inflation variance only introduces noise to the budget and induces the use of more indexed debt. This will be the case in countries that face large nominal shocks relative to real movements. The real value of the their debt would fluctuate without a corresponding change in other budgetary components. This induces the use of a high proportion of indexed debt. The empirical section of the paper demonstrates that this is precisely the case of Brazil.

Having liabilities in foreign currency introduces another instrument for hedging, provided the correlation between the real exchange rate and other domestic budget components (in this case spending) are not zero. The trade-off with foreign-denominated liabilities is that they may introduce more noise to the budget. If the value of foreign currency used to peg part of the debt is not very stable, that is, if there is a high variance of the real exchange rate, taxes will fluctuate more to compensate the movements in the real value of foreign-denominated debt.

The optimal proportions of nominal and foreign-denominated debt derived above imply a specific relationship between them. A larger share of nominal debt is associated with a larger share of foreign-denominated debt depending on whether the covariance between inflation and the real exchange rate is positive or negative. If the returns covary negatively, the two bonds are complements in the government's portfolio and they should increase proportionally.

2.2 Absence of Commitment

In this section, the assumption of commitment is relaxed. If the government cannot commit its future behavior, it will face time-consistency problems arising from the fact that it controls the average inflation rate. Optimal behavior in the second period will be to inflate some of the existing nominal debt. Ex ante, rational investors will anticipate the future temptation to inflate, adjust expected inflation, and demand a higher nominal interest rate. The inflation rate will be higher in this equilibrium than in the previous one, in which the government could commit itself.[9]

It is interesting to calculate the effect of future incentives to inflate on the debt composition chosen in the first period. Solving backwards, the government minimizes taxes and inflation costs in period two, but takes as given the level of debt (B), its composition (θ and θ^*), and the nominal interest rate (i). Minimizing equation 1 subject to equations 5 and 6 in the second period, I obtain the following solution:

$$m^* = A\,B\,\theta\,\Omega \quad \text{and} \tag{11}$$

$$\Omega = \left(\overline{G} + B\right), \tag{12}$$

9. The government here cannot systematically affect the real exchange rate, q.

where $\overline{G}$ is expected spending. The first-order condition of equation 11 uses equation 5. It says that in the second period the government equates the expected marginal costs of raising taxes and inflation. The equilibrium values of taxes and inflation, after shocks are realized, are

$$\tilde{\tau} = \tilde{G} + B\left(1 - \theta\hat{\pi} - \theta^{*}\hat{q}\right) \quad \text{and} \tag{13}$$

$$\pi = m^{*} + \tilde{v}, \tag{14}$$

where $\hat{\pi}$ and $\hat{q}$ are the unexpected shocks to inflation and the real exchange rate.

In comparison with the previous case, the absence of commitment increases the average rate of inflation, creating expected distortion costs. The incentive to inflate and the resulting equilibrium inflation depend on the proportion of nominal debt outstanding, θ. The government in period one would therefore need to adjust its optimal θ to reduce the incentive to inflate. Thus it will deviate from the optimal proportion of nominal debt for hedging purposes. In other words, the absence of other commitment technologies forces the government to use indexation to satisfy two objectives, hedging and commitment, leaving it worse off.

The government in period one minimizes the loss function in period two by choosing the appropriate indexation of debt. For this purpose, it is possible to explicitly derive the loss function that the government faces in the first period (dropping irrelevant terms and using the values from equations 11 through 14):

$$\begin{aligned} \text{Loss} = \; & A^{2}B^{2}\theta^{2}\Omega^{2} - 2\theta B\sigma_{g\pi} - 2\theta^{*}B\sigma_{gq} \\ & + B^{2}\left(\theta^{2}\sigma_{\pi}^{2} + \theta^{*2}\sigma_{q}^{2} + 2\theta\theta^{*}\sigma_{\pi q}\right). \end{aligned} \tag{15}$$

The first term on the right-hand side of the equation is the price of not being able to commit to not inflating the nominal debt. It is the traditional inflationary bias of time-consistent solutions. Indexing the debt is one of the commitment technologies. The government will now take into account this term when choosing its optimal proportion of nominal debt. It is clear that setting $\theta = 0$ will completely avoid this type of cost. The second and third terms are the hedging role of nominal debt and foreign-denominated debt, respectively. If inflation (or the real exchange rate) and government spending are positively correlated, tax rates will fluctuate less and governments

can reduce distortions in the economy. It is thus optimal to have contingent debt that reduces the real value of debt when financing needs are higher. Nominal and foreign-denominated debt are implicitly contingent debt. The last term on the right-hand side of the equation works against issuing both nominal and foreign-denominated debt. If the variance of inflation or the real exchange rate is high, it will imply large changes in the real value of debt, which will increase the variance of tax rates. Setting $\theta = 0$ and $\theta^* = 0$, completely indexing the debt, eliminates this last effect.

The government minimizes the loss function in the first period and obtains the optimal proportion of debt in nominal and foreign currency:

$$\theta = \frac{\sigma_{g\pi}\sigma_q^2 - \sigma_{gq}\sigma_{\pi q}}{B\left[\left(A^2\Omega^2 + \sigma_\pi^2\right)\sigma_q^2 + \sigma_{\pi q}^2\right]} \quad \text{and} \tag{16}$$

$$\theta^* = \frac{\sigma_{gq}}{B\sigma_q^2} - \frac{\sigma_{\pi q}\theta}{\sigma_q^2} \ . \tag{17}$$

This optimal value has an additional term, $\Omega^2 A$, when compared to the commitment case. The government now has to take into account the marginal cost, in terms of higher average inflation, of not indexing one extra unit of debt. This additional cost will reduce the optimal proportion of nominal debt. The higher the term $\Omega^2 A$, the more tempted the government appears to be to inflate the debt. To credibly commit itself to not inflate, the government will thus use a higher proportion of indexed debt. This will reduce the amount of nominal debt available for hedging purposes, deviating further from the commitment solution. The $\Omega^2 A$ term depends on both the level of total debt and average spending. If the total debt, B, is larger, the government is more tempted to inflate the debt. The higher the debt, therefore, the lower the optimal proportion of nominal debt. This effect is similar to the one derived in Blanchard and Missale (1994).

The effect of the debt level on foreign-denominated debt is more ambiguous. First, there is the direct effect of the level of debt on the composition through the hedging mechanisms. For given variances and covariances and a given level of shocks to spending, the higher the total debt, the lower is the proportion of foreign-denominated debt needed to obtain the same amount of hedging. Second, the impact of

the term $\Omega^2 A$ (through θ in equation 17) depends on whether the covariance between inflation and the real exchange rate is positive or negative. The latter also defines whether foreign-denominated debt and nominal debt are complements or substitutes in the government's portfolio.

I could restrict the values of θ and θ^* to between 0 and 1, which means that there is no negative debt in any component of the debt, that is, governments do not hold net positive claims with the private sector. In this case corner solutions may arise.

Two relevant issues on debt management are not stressed in the model. First, governments frequently claim that they manage debt to minimize borrowing costs. However, if markets work efficiently and there is no free lunch, any gains from shifting to cheaper securities should imply higher risks to the government.[10] Since higher risks to the government ultimately imply higher risks to society (for example, through a higher probability of raising taxes to close the budget), it is not clear that anyone gains from this strategy. In the model, I have omitted this aspect by assuming risk-neutral investors and equivalent real returns for all the securities. Second, governments can, in principle, smooth shocks intertemporally by raising debt in bad moments and repaying debt in good times. The nature of the shock then becomes irrelevant, and debt composition is indeterminate. In a previous paper, I show that even if governments smooth taxes through time, there is a role for smoothing taxes through states of nature; this is the hedging argument described above (see Goldfajn, 1996). The relative importance of the hedging argument is an empirical matter. The following section evaluates the importance of hedging and credibility arguments in the case of Brazil.

3. Empirical Analysis

The implications of the model can be summarized as follows:

• The proportion of nominal debt should decrease with the level of total debt.

• Nominal debt should be negatively related to the variance of inflation.

10. This occurred, for example, when the Mexican central bank shifted from domestically denominated CETES to dollar-denominated *Tesobonos* and implicitly assumed the exchange rate risk.

• Nominal debt should increase when the covariance of inflation and spending is larger, whereas foreign-denominated debt should increase when the covariance between the real exchange rate and spending is larger.

• Foreign-denominated debt should be negatively related to the variance of the real exchange rate.

This section tests the main determinants of public debt indexation and denomination. The analysis focuses on the joint behavior of the macroeconomic series that determines the budget constraint of the government (that is, government spending and inflation), the level of the debt, and its composition for Brazil.

3.1 Data

The paper uses monthly public debt data for the period 1980-97, obtained directly from the Central Bank of Brazil and from the historical series published in Andima (1992). The data set incorporates disaggregated data on the composition of public debt between indexed and nominal debt held by the public (net of the holdings of the Central Bank).

The paper also uses monthly data on the real exchange rate, inflation, and spending. Inflation is measured by changes in the wholesale price index, and spending is the total disbursment of the government net of interest rate payments. The original source of the series is the Central Bank of Brazil. The series of real exchange rate values is multilateral, based on the wholesale price index; it is calculated in Goldfajn and Valdés (1996).

3.2 First Stage: Obtaining the Variance and Covariance Series

The paper first obtains the four variance and covariance series for Brazil: the variance of inflation, the covariance of inflation with government spending, the variance of the real exchange rate, and the covariance of the real exchange rate with spending. The variance-covariance structure of innovations in government spending, real exchange rate, and inflation was obtained for Brazil by performing a vector autoregression (VAR) of these variables. The variances were obtained from the residuals of the VAR. In the same manner, the covariances were obtained from the off-diagonal-terms covariance matrix of the residuals.

The variance and covariance series were estimated with a series of rolling VAR estimations. A new VAR was estimated for each year, with a different data set available to estimate the covariance matrix. For each estimation, the last forty observations and two lags were used. In this way a time series of estimates of the four relevant variances and covariances were obtained. The series start in January 1980 and end in December 1997.

Three series of correlations are relevant to the discussion. First, the correlation between spending and real exchange rate innovations in Brazil tends to be positive in most of the sample, giving a hedging role to the foreign-denominated debt. This is an expected result, since higher spending increases the demand for nontradables, which appreciates the currency. Second, the correlation between spending and inflation is positive at the beginning of the sample and at the very end (1980-85 and 1994-96), but it becomes negative in the late 1980s when inflation reached hiperinflationary levels. The reason is that for low and medium levels of inflation, either government spending created pressures on prices or, in the reverse causality, increases in prices generated more government spending. In this case, nominal debt played a role as a hedging device. When inflation rates became very high, however, shocks to inflation tended to reduce government spending, since wages and payments in the public sector were not perfectly indexed to the price level. Finally, the correlation between inflation and the real exchange rate is positive in the whole sample. Because prices and exchange rates were not perfectly flexible, positive shocks to inflation did not always translate into proportional shocks to the nominal devaluation rates, which led to real appreciations of the currency. Nominal and foreign-denominated debt were therefore substitutes in the government portfolio.

3.3 Second Stage: OLS Regressions

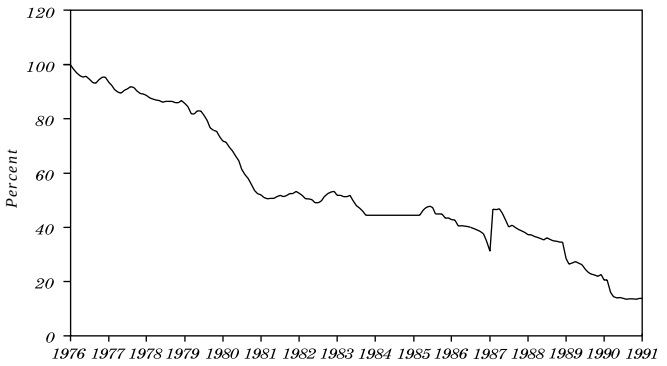
The second stage uses the estimated variances and covariances obtained in the first stage to estimate their influence on the choice of θ and θ^*, in an ordinary least squares (OLS) regression. The period of estimation is 1980-95, and the frequency is monthly.

The proportion of nominal debt is regressed against the variance of inflation, the covariance of spending and inflation, the level of public debt as a proportion of gross domestic product (GDP), a constant, a time trend, and dummy variables to control for both the Collor and

Real plans.[11] The dummies are included because both plans caused important structural breaks with a potentially important influence on the composition of public debt. The Collor Plan of March 1990 froze a good part of the financial securities available, including public debt securities. The Real Plan represented a structural break from the previous inflationary environment; it therefore had potentially important effects on the composition of public debt.

Indexed debt in Brazil was not a guaranteed positive real return to its holders. Figure 4 shows the real value of an indexed bond from 1976 to 1991. It is clear from the figure that indexation in Brazilian indexed securities was far from perfect. The indexation mechanism lagged behind actual inflation and did not protect the real value of this type of debt. An interesting way to test the effect of imperfect indexation is to observe the behavior of the average maturity of all public debt, including indexed debt. If indexation is imperfect, agents will require shorter maturities, even in indexed debt, to avoid large fluctuations in the real value of debt. I can therefore repeat the OLS regressions above using the average maturity as the dependent variable, since the predictions of the model can be equally applied to the average maturity of debt. The effects of the variance of inflation, the level of public debt, and the covariance of inflation and spending on the real value of debt should be correlated to the average maturity of debt.

Figure 4. Real Value of Government Indexed Bond (January 1976 =100)



Source: E. Tanner, "Intertemporal Solvency and Indexed Debt: Evidence from Brazil", *Journal of International Money and Finance* 14(4): 549-73, 1995

11. Neto (1996) runs similar regressions to test the model outlined in Goldfajn (1996). His specification and results differ somewhat from those obtained below, however.

Finally, the proportion of foreign-denominated debt is regressed against the variance of the real exchange rate, the covariance of spending and the real exchange rate, the level of public debt as a proportion of GDP, a constant, a time trend, and dummy variables to control for both the Collor and Real plans.

3.4 Results

The results of the regression are presented in tables 1 through 3. The expected signs are listed in the bottom row.

In table 1, the level of debt seems to have a significant effect and in the direction predicted by the model. A higher level of debt reduces the long nominal proportion of debt. This supports the model, since having a higher total debt affects the incentives to inflate and influences the decision on whether to issue nominal debt.

The variance of inflation has a negative effect on the proportion of nominal debt, as uncertainty with regard to inflation tends to reduce maturities. As predicted by the model, a high variance of inflation should reduce the amount of nominal debt. This phenomenon was an important feature of the Brazilian economy, in which the deepening of financial indexation was positively correlated to the uncertainties that accompanied high inflation rates.

Table 1. Determinants of Debt Indexation in Brazil, 1980–95[a]

Explanatory variable	*D/Y*	*Trend*	σ_{π}	*Collor I Plan dummy*	*Real Plan dummy*	$\sigma_{\pi g}$	R^2
Inflation	–0.05	0.26	–0.14	...	...	...	0.30
	(–3.8)	(4.93)	(–2.38)	...	...	...	...
Inflation and spending	–0.06	0.27	–0.21	20.3	...	...	0.34
	(–3.86)	(5.01)	(–3.39)	(1.7)	...	...	...
Real exchange rate	–0.07	0.24	–0.20	20.1	19.1	...	0.40
	(–4.93)	(3.48)	(–3.09)	(1.7)	(2.85)	...	...
Real exchange rate and spending	–0.06	0.23	–0.11	18.5	20.85	1.04	0.44
	(–4.78)	(3.41)	(–1.54)	(1.56)	(2.9)	(2.64)	...
Expected sign	–	...	–	+	+	+	...

Source: Author's calculations.

a. The dependent variable is the proportion of nominal debt. A constant was included in each regression; *t* statistics were corrected by the Newey-West consistent matrix and are shown in parentheses.

The covariance with spending also fit the predictions of the model. The coefficient on the covariance of inflation and spending have the correct sign: it is positive and significant at the 5 percent level. This confirms the prediction of the model that the higher this covariance, the higher the proportion of nominal debt.

The results further show that both the Collor and Real plans increased the proportion of nominal public debt, the former through a compulsory freezing of financial assets and the latter through a structural change in the inflationary regime.

Table 2 presents the regressions with the average maturity of public debt. The coefficients on debt-to-GDP ratio, variance of inflation, the covariance of inflation with spending, and the Collor plan have the same signs as predicted by the model and are equivalent to the ones obtained in the regressions presented in table 1.

Table 3 contains the results of the regressions with foreign-denominated debt. The coefficients on the variance of the real exchange rate and the covariance of the real exchange rate with spending have the right signs but are insignificant. The level of debt has a negative effect on the proportion of foreign denominated debt. Credibility arguments should imply a positive sign.[12]

To take into account the covariance between the residuals of the regressions that underlie the results in tables 1 and 3, a seemingly unrelated regression (SUR) system was estimated. The results are similar to those obtained in the previous tables (see table 4).

Table 2. Determinants of Debt Maturity in Brazil, 1986–95[a]

Explanatory variable	*D/Y*	*Trend*	σ_{π}	*Collor I Plan dummy*	*Real Plan dummy*	$\sigma_{\pi g}$	R^2
Inflation	–0.03	0.12	–0.07	...	...	...	0.62
	(–6.6)	(6.99)	(–5.02)	...	...	...	...
Inflation and spending	–0.03	0.12	–0.09	5.43	...	...	0.65
	(–6.9)	(7.14)	(–5.73)	(3.79)	...	...	...
Real exchange rate	–0.03	0.13	–0.09	5.46	–1.94	...	0.65
	(–5.83)	(4.41)	(–6.34)	(3.88)	(–0.59)	...	...
Real exchange rate and spending	–0.03	0.11	–0.06	4.98	0.18	0.27	0.65
	(–6.17)	(3.94)	(–4.43)	(3.59)	(0.06)	(2.57)	...
Expected sign	–	...	–	+	+	+	...

Source: Author's calculations.

a. The dependent variable is the average maturity of debt. A constant was included in each regression; *t* statistics were corrected by the Newey-West consistent matrix and are shown in parentheses.

12. The regressions in tables 1 and 3 were repeated using the amount of nominal or foreign-denominated debt as the independent variable. This isolates the direct negative effect of total debt from the credibility effect that I want to stress. The results are qualitatively identical.

Table 3. Determinants of Foreign Denominated Debt in Brazil, 1980–95[a]

Explanatory variable	*D/Y*	*Trend*	σ_{RER}	*Collor I Plan dummy*	*Real Plan dummy*	σ_{RERg}	R^2
Inflation	–0.01	0.05	...	...	...	...	0.38
	(–2.87)	(4.81)	...	...	...	...	...
Inflation and spending	–0.02	0.10	–0.27	...	...	...	0.52
	(–2.42)	(5.13)	(–1.12)	...	...	...	...
Real exchange rate	–0.02	0.10	–0.23	–2.34	1.72	...	0.52
	(–2.96)	(4.12)	(–0.88)	(–0.87)	(0.84)	...	...
Real exchange rate and spending	–0.02	0.10	–0.21	–2.36	1.66	0.11	0.44
	(–2.95)	(4.16)	(–0.84)	(–0.87)	(0.80)	(0.88)	...
Expected sign	+	...	–	...	...	+	...

Source: Author's calculations.
a. The dependent variable is the proportion of foreign-denominated debt. A constant was included in each regression; *t* statistics were corrected by the Newey-West consistent matrix and are shown in parentheses.

Table 4. Determinants of Debt Composition, Seemingly Unrelated Regression (SUR) System Estimation[a]

Variable	*Nominal debt*	*Foreign-denominated debt*
D/Y	–0.05	–0.01
	(–6.7)	(–6.2)
Trend	0.25	0.11
	(8.9)	(7.8)
σ_{π}	–0.09	0.001
	(–2.04)	(0.07)
$\sigma_{\pi g}$	1.4	0.36
	(2.87)	(3.68)
σ_{RER}	0.13	–0.10
	(0.42)	(–0.97)
σ_{RERg}	–1.57	–0.02
	(–3.63)	(–0.11)
Collor I Plan dummy	16.9	–0.64
	(3.22)	(–0.38)
Real Plan dummy	21.6	1.81
	(5.27)	(1.36)
R^2	0.47	0.57

Source: Author's calculations.
a. A constant was included in the regressions; *t* statistics in parentheses.

4. Conclusions

Since the implementation of the Real Plan, the share of public indexed debt has dropped from 70 to 30 percent of total debt, while the shares of both nominal and foreign-denominated debt have increased. This paper offers a simple model and preliminary evidence to explain these facts.

The paper develops a model of public debt management that concentrates on hedging and credibility motives. The model demonstrates that indexed debt should be issued to enhance the credibility of the government or to avoid unnecessary fluctuations in the real value of debt as a result of variable inflation rates. In contrast, nominal debt serves the purpose of hedging shocks to the budget when inflation is positively correlated to spending. Foreign-denominated debt may also serve as a hedging device if the real exchange rate is positively correlated with spending and does not fluctuate substantially.

The evidence from OLS regressions confirms that the variance of inflation, the size of the public debt, and the correlations of inflation with spending are important determinants of public debt indexation in Brazil.

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