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Abstract

This paper derives the optimal composition of the Brazilian public debt by looking at the relative impact of the risk and cost of alternative debt instruments on the probability of missing the stabilization target. This allows to price risk against the expected cost of debt service and thus to find the optimal combination along the trade off between cost and risk minimization. The optimal debt structure is a function of the expected return differentials between debt instruments, of the conditional variance of debt returns and of their covariances with output growth, inflation, exchange-rate depreciation and the Selic rate. We estimate the relevant covariances by: i) exploiting the daily survey of expectations; ii) simulating a small structural model of the Brazilian economy under different shocks; iii) estimating the unanticipated components of the relevant variables with forecasting regressions. The empirical evidence strongly supports the funding strategy of Brazilian Treasury in 2003 of relying heavily on fixed-rate LTN bonds. It also supports its recent decision to revitalize the market for price-indexed bonds with the new NTN-B program of IPCA indexation. Though decreasing, the exposure to exchange rate risk appears too large suggesting that more efforts should be made to reduce funding in foreign currencies.

JEL Classification: E63, H63.

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1. Introduction

There are many different views as to the objectives of debt management but in the case of Brazil the paramount objective of debt management should be that of reducing the country's fiscal vulnerability.[1] This calls for funding at low cost but also for minimizing the risk of large interest payments due to unexpected changes in interest rates and/or in the exchange rate.[2] Risk minimization is accomplished, as shown by Goldfajn (1998), by choosing debt instruments which both ensure a low volatility of returns and provide a hedge against fluctuations in the primary budget, in the interest payments and in the value of the other liabilities.

In this paper we present a simple model where debt management helps to stabilize the debt ratio and thus reduces the probability of a debt crisis. Reducing the uncertainty of the debt ratio, for any expected cost of debt service, is valuable in that it lowers the probability that the fiscal adjustment may fail because of a bad shock to the budget.

The optimal debt composition is derived by looking at the relative impact of the risk and cost of alternative debt instruments on the probability of missing the stabilization target. This allows to price risk against the expected cost of debt service and thus to find the optimal combination along the trade off between cost and risk minimization.

The optimal debt structure is thus a function of the expected return differentials between debt instruments, of the conditional variance of debt returns and of their covariances with output growth, inflation, exchange-rate depreciation and the Selic rate. We estimate the relevant covariances with three alternative methods. The first approach exploits the daily survey of expectations on GDP growth, inflation, the exchange rate and the Selic rate. The second method relies on a small structural model of the Brazilian economy estimated on monthly data for the period 1999:03-2003:07. The one-year ahead unanticipated components of the Selic rate, the exchange rate, inflation and output growth are estimated as the 12-month cumulated impulse responses of these variables to shocks to inflation, the output gap and the EMBI spread. The third approach approximates the one-year ahead unanticipated components of the relevant variables using the residuals of forecasting regressions run on quarterly data for the period 1995:3-2003:1.

The empirical evidence suggests that a large share of the Brazilian debt should be indexed to the price level. Price indexation should be preferred to Selic-rate indexation while the share of dollar denominated (and indexed) bonds should be further reduced from the current high level.[3] These policy prescriptions appear robust to alternative methods of estimating the optimal debt structure. The share of fixed-rate bonds should also be increased. Fixed-rate debt avoids large interest payments when the Selic rate rises during a crisis or reacts to negative supply shocks and thus when debt stabilization is endangered by slow output growth. Because of their short maturity, below two years, fixed-rate bonds

[1] See Missale (1999) for a review of the literature on the objectives of debt management.

[2] see, Garcia (2002).

[3] For a similar conclusion in favor of price indexation see Bevilaqua and Garcia (2000). Goldfajn (1998) also hardly finds an explanation for the high share of foreign-denominated debt.

ensure a sufficiently fast reduction of debt servicing costs in the event of a rapid fall in interest rates. If the term premium required on fixed-rate bonds is not too high, issuing such bonds in exchange for Selic-rate bonds increases the probability of debt stabilization. We provide evidence on the term premium which suggests that such a strategy is indeed optimal.

The empirical evidence strongly supports the funding strategy of Brazilian Treasury in 2003 of relying heavily on LTN bonds. It also supports its recent decision to revitalize the market for price-indexed bonds with the new NTN-B program of IPCA indexation. Though decreasing, the exposure to exchange rate risk remains too large suggesting that more efforts should be made to reduce funding in foreign currencies.

2. The government problem

In this section we present a simple model where debt management helps to stabilize the debt ratio and thus reduces the probability of a debt crisis. Debt stabilization calls for funding at low cost but also for minimizing the risk of large payments due to unexpected changes in interest rates and the exchange rate. Hence, the choice of debt instruments trades off the risk and the expected cost of debt service.

Risk minimization is accomplished by choosing debt instruments which both ensure a low return variability and provide a hedge against variations in the primary budget, in the interest payments and in the value of the other liabilities (see e.g. Goldfajn 1998). Reducing the uncertainty of the debt ratio, for any expected cost of debt service, is valuable in that it lowers the probability that debt stabilization may fail because of bad shocks to the budget. This strategy is consistent with the asset-and-liability management approach adopted by the Brazilian Treasury (see Tesouro National 2003).

To provide insurance against variations in the primary surplus and the debt ratio, public bonds should be indexed to nominal GDP. However, this would be a costly innovation. Indeed, a high premium would have to be paid: for insurance; for the illiquidity of the market and; for the delay in the release of GDP data and their revisions. Therefore, we focus on the main funding instruments that are currently available to the Brazilian Treasury: bonds indexed to the Selic rate (LFT), fixed-rate bonds (LTN), bonds indexed to the IPG-M price index (NTN-C) or to the IPCA index (NTN-B), domestic bonds indexed to the US dollar and external debt denominated in foreign currency. (We refer to the latter two instruments as dollar denominated bonds in what follows.)

The aim of the government is to stabilize the debt ratio, B_t. To this end, the government decides a fiscal correction taking into account the realization of debt returns, output, inflation and the exchange rate.[4] However, since the result of the government's efforts is uncertain (and the fiscal adjustment is costly) a crisis cannot be prevented with certainty. Denoting the result of the fiscal adjustment (in terms of GDP) with $A_{t+1} - X$, a debt crisis arises if

$$B_{t+1}^T - B_t > A_{t+1} - X \quad (1)$$

where A_{t+1} is the expected adjustment, X, denotes the uncertain component of the fiscal

[4] The choice of the government can be modeled by assuming that it wheighs the cost of the adjustment and the probability of debt default. The formal analysis of the government problem is not carried out since it does not affect the results for debt management.

adjustment, B_t is the debt-to-GDP ratio and B^T_{t+1} is the trend debt ratio, that is, the debt ratio that would prevail in period $t+1$ in the absence of the fiscal correction.

Alternatively, X, can be viewed as a shock to the budget that occurs after the fiscal adjustment has been carried out or as a debt increase due to the discovery of hidden liabilities —"skeletons in the closet".

Absent government intervention the debt ratio (at market values) increases because of the interest payments on the outstanding debt minus the trend primary surplus and the growth of nominal GDP. The debt also increases because of the revaluation of the dollar-denominated debt due to the depreciation of the domestic currency. Hence, debt accumulation $\Delta B^T_{t+1} = B^T_{t+1} - B_t$ is equal to:

$$\Delta B^T_{t+1} = I_{t+1}B_t + \Delta e_{t+1} q B_t - S^T_{t+1} - (\Delta y_{t+1} + \pi_{t+1})B_t \tag{2}$$

where $I_{t+1}B_t$ are the nominal interest payments, e_t is the log of the nominal exchange rate, q is the share dollar-denominated debt, S^T_{t+1} is the trend primary surplus, y_{t+1} is the log of output and π_{t+1} is the rate of inflation.

The interest payments depend on the composition of public debt chosen at the end of period t. The government can choose between bonds indexed to the Selic rate, dollar denominated bonds, price-indexed bonds and fixed-rate bonds. We take the time period as corresponding to one year and assume that all bonds have a one-year maturity, since the relevant decision for the Brazilian Treasury is whether 1-year fixed-rate bonds should be issued. Focusing on a one-year horizon is a reasonable approximation even if LFT, NTN and dollar denominated bonds have much longer maturities, because the stochastic component of their returns is dominated by movements in the Selic rate, the rate of inflation and the exchange rate. Within a one-year horizon, the nominal rate of return on fixed-rate 1-year bonds is equal to the long-term interest rate, R_t, at which such bonds are issued. The nominal return on fixed-rate bonds is thus known at the time of issuance. The return in Reais on dollar denominated bonds depends on the US interest rate, R^{US}_t and the risk premium RP_t and exchange rate depreciation. The nominal return on price-linked bonds is equal to the sum of real interest rate, R^I_t, known at the time of issuance, and the rate of inflation, π_{t+1}. Finally, the return on Selic-indexed bonds is determined by the path of the Selic rate over the life of the bond and thus between period t and $t+1$. The (average) Selic rate over this period, i_{t+1}, is not known at time t when the composition of the debt is chosen.

The interest payments are equal to

$$I_{t+1}B_t = i_{t+1} s B_t + (R^{US}_t + RP_t) q B_t + (R^I_t + \pi_{t+1}) h B_t + R_t(1 - s - q - h)B_t \tag{3}$$

where s is the shares of Selic-indexed debt, q is the share of dollar-denominated debt and h is the share of price-indexed debt at the beginning of period t and where the return on dollar denominated bonds $(R^{US}_t + RP_t)(1 + \Delta e_{t+1})$ has been approximated by $R^{US}_t + RP_t$.

Finally, the ratio of the trend primary surplus to GDP, S^T_{t+1}, is uncertain, since it depends on cyclical conditions and on the rate of inflation as follows

$$S^T_{t+1} = E_t S^T_{t+1} + \eta_y(y_{t+1} - E_t y_{t+1}) + \eta_\pi(\pi_{t+1} - E_t \pi_{t+1}) \tag{4}$$

where η_y is the semi-elasticity of the government budget (relative to GDP) with respect to output, η_π is the semi- elasticity of the budget with respect to the price level and E_t denotes expectations conditional on the information at time t.

Hence, the surplus-to-GDP ratio may be higher than expected because of unanticipated output, $y_{t+1} - E_t y_{t+1}$, and inflation, $\pi_{t+1} - E_t \pi_{t+1}$. While the impact of economic activity on the budget is well known from a number of studies, inflation also reduces the deficit if tax systems and spending programs are not fully indexed.[5]

3. The choice of debt denomination and indexation

The objective of the Treasury is to minimize the probability that debt stabilization fails because the adjustment effort is unsuccessful; because revenues falls short of expected and/or spending programs cannot be cut. The government chooses s, q and h to minimize

$$Min\ E_t Prob[X > A_{t+1} - \Delta B^T_{t+1}] = Min\ E_t \int_{A_{t+1}-\Delta B^T_{t+1}}^{\infty} \phi(X) dx \tag{5}$$

subject to (2), (3) and (4).
where $\phi(X)$ denotes the probability density function of X.

Deriving (5) with respect to s, q and h yields

$$E_t \phi(A_{t+1} - \Delta B^T_{t+1})[i_{t+1} - R_t] = 0 \tag{6}$$
$$E_t \phi(A_{t+1} - \Delta B^T_{t+1})[R^{US}_t + RP_t + e_{t+1} - e_t - R_t] = 0 \tag{7}$$
$$E_t \phi(A_{t+1} - \Delta B^T_{t+1})[R^I_t + \pi_{t+1} - R_t] = 0 \tag{8}$$

where $A_{t+1} - \Delta B^T_{t+1}$ is the planned reduction in the debt-to-GDP ratio and $\phi(A_{t+1} - \Delta B^T_{t+1})$ is a function of s, q and h.

The first order conditions (6)-(8) have a simple interpretation: they shows that the debt structure is optimal only if the increase in the probability of failure that is associated with the interest cost of additional funding, in a particular type of debt, is equalized across debt instruments. If this were not the case, the government could reduce the probability of failure by modifying the debt structure; i.e. it could substitute fixed-rate bonds for Selic-rate indexed bonds or vice versa.[6]

To gain further intuition we observe that the difference between the interest cost of Selic-indexed bonds and fixed-rate bonds is equal to the difference between the (average) Selic rate between time t and $t+1$ and its value as expected at the time t, minus the term premium on fixed-rate bonds:

$$i_{t+1} - R_t = i_{t+1} - E_t i_{t+1} - TP_t \tag{9}$$

[5]in output by one percent are reported in the *OECD Economic Outlook* (1999) and Van der Noord (2000). With the notable exceptions of Austria, Denmark, Ireland, the Netherlands and Sweden, OECD countries have elasticities in the 0.4 to 0.7 range. The effects of inflation on government budgets have not been measured to the same extent, but appear substantial. For Sweden, Persson, Persson and Svensson (1998) estimate a budget improvement of 0.4% of GDP on a yearly basis for a one percent increase in the inflation rate.

[6]The argument assumes that there are non-negative constraints to the choice of debt instruments.

where TP_t is the term premium on fixed-rate bonds and where $E_t i_{t+1}$ is the expected average Selic rate between time t and $t+1$.

Equation (9) shows that the expected cost of funding with Selic-indexed bonds is lower than fixed-rate bonds because of the term premium but, ex-post, the cost may be greater if the Selic rate turns out to be higher than expected. It is also worth noting that equation (9) implicitly assumes that investors expectations coincides with the expectations of the government. If this were not the case, the expected cost differential relevant for the government, TP_t, would include an informational spread:

$$TP_t = TP_t^I + (E_t^I i_{t+1} - E_t i_{t+1}) \tag{10}$$

where E_t^I denotes investors' expectations and TP_t^I is the true term premium.

The difference between the cost of funding with dollar denominated bonds and fixed-rate bonds depends on the realization of the exchange rate. Between time t and $t+1$ the return on dollar denominated bonds (evaluated in domestic currency) differs from the return on fixed-rate bonds as follows

$$R_t^{US} + RP_t + e_{t+1} - e_t - R_t = e_{t+1} - E_t e_{t+1} - FP_t \tag{11}$$

where FP_t is the 1-year exchange-rate risk premium which is relevant for the government. Although the true exchange-rate risk premium is likely to be small, dollar denominated bonds may enjoy a liquidity premium due to the greater liquidity and efficiency of international bond markets. FP_t may also reflect the different views of the investors and the government regarding the exchange rate. If we consider this "credibility spread", FP_t, is equal to

$$FP_t = FP_t^I + E_t^I e_{t+1} - E_t e_{t+1} \tag{12}$$

where E_t^I denotes investors' expectations and FP_t^I is the true foreign exchange risk premium.

Finally, the difference between the interest payments on price-indexed bonds and fixed-rate bonds is equal to

$$R_t^I + \pi_{t+1} - R_t = \pi_{t+1} - E_t \pi_{t+1} - IP_t \tag{13}$$

where IP_t is the inflation risk premium which is relevant to the government and may include, in addition to the true premium, a spread reflecting the lack of credibility of the announced inflation target:

$$IP_t = IP_t^I + E_t^I \pi_{t+1} - E_t \pi_{t+1} \tag{14}$$

The return differentials (9)-(11)-(13) allow us to write the first order conditions (6)-(8) as follows

$$E_t \phi(A_{t+1} - \Delta B_{t+1}^T)(i_{t+1} - E_t i_{t+1}) = TP_t E_t \phi(A_{t+1} - \Delta B_{t+1}^T) \tag{15}$$

$$E_t \phi(A_{t+1} - \Delta B_{t+1}^T)(e_{t+1} - E_t e_{t+1}) = FP_t E_t \phi(A_{t+1} - \Delta B_{t+1}^T) \tag{16}$$

$$E_t \phi(A_{t+1} - \Delta B_{t+1}^T)(\pi_{t+1} - E_t \pi_{t+1}) = IP_t E_t \phi(A_{t+1} - \Delta B_{t+1}^T) \tag{17}$$

Equations (15)-(17) show the trade off between the risk and expected cost of debt service that characterizes the choice of debt instruments.

At the margin, the impact on the probability of debt stabilization of assuming more risk must be equal to the impact of reducing the expected cost of debt servicing. Hence, the marginal increase in probability can be used to price risk against the expected cost of debt service and thus find the optimal combination along the trade off between cost and risk minimization. For example, equation (15) shows that issuing bonds indexed to the Selic rate is optimal until the uncertainty of the Selic rate raises the probability of failure as much as paying the term premium on fixed-rate bonds.

Therefore, the objective of debt stabilization offers a solution to the identification of the optimal debt structure which is independent of the government's preferences towards risk. This is because both the risk and the expected cost of debt service affect the probability of debt stabilization.

To derive an explicit solution for the the optimal shares of the various types of debt we must specify the probability density function, $\phi(X)$. Since this function cannot be estimated, we take a linear approximation of $\phi(X)$ over the range of bad realizations, $X > 0$, of the fiscal adjustment.[7] This implies a triangular probability density function equal to

$$\phi(X) = \frac{\bar{X} - X}{\bar{X}^2} \tag{18}$$

where $X > 0$ and $\bar{X}$ is the worst possible realization of the fiscal adjustment.

In fact, the triangular density is the linear approximation of any density function decreasing with X (for $X > 0$); it implies that bad realizations of the fiscal adjustment are less likely to occur the greater is their size.

Substituting equations (18) and (2)-(4) in the first order conditions (15)-(17) yields the optimal shares of Selic rate indexed debt, s^*, dollar denominated debt, q^*, and price-indexed debt, h^*:

$$\begin{aligned} s^* = \frac{(\eta_y + B_t)}{B_t}\frac{Cov(y_{t+1}i_{t+1})}{Var(i_{t+1})} &+ \frac{(\eta_\pi + B_t)}{B_t}\frac{Cov(\pi_{t+1}i_{t+1})}{Var(i_{t+1})} - q^*\frac{Cov(e_{t+1}i_{t+1})}{Var(i_{t+1})} \\ &- h^*\frac{Cov(\pi_{t+1}i_{t+1})}{Var(i_{t+1})} + TP_t\frac{\sqrt{2Pr}}{1-\sqrt{2Pr}}\frac{E_t(A_{t+1} - \Delta B^T_{t+1})}{B_t Var(i_{t+1})} \end{aligned} \tag{19}$$

$$\begin{aligned} q^* = \frac{(\eta_y + B_t)}{B_t}\frac{Cov(y_{t+1}e_{t+1})}{Var(e_{t+1})} &+ \frac{(\eta_\pi + B_t)}{B_t}\frac{Cov(\pi_{t+1}e_{t+1})}{Var(e_{t+1})} - s^*\frac{Cov(e_{t+1}i_{t+1})}{Var(e_{t+1})} \\ &- h^*\frac{Cov(\pi_{t+1}e_{t+1})}{Var(e_{t+1})} + FP_t\frac{\sqrt{2Pr}}{1-\sqrt{2Pr}}\frac{E_t(A_{t+1} - \Delta B^T_{t+1})}{B_t Var(e_{t+1})} \end{aligned} \tag{20}$$

$$\begin{aligned} h^* = \frac{(\eta_y + B_t)}{B_t}\frac{Cov(y_{t+1}\pi_{t+1})}{Var(\pi_{t+1})} &+ \frac{(\eta_\pi + B_t)}{B_t} - q^*\frac{Cov(e_{t+1}\pi_{t+1})}{Var(\pi_{t+1})} \\ &- s^*\frac{Cov(\pi_{t+1}i_{t+1})}{Var(\pi_{t+1})} + IP_t\frac{\sqrt{2Pr}}{1-\sqrt{2Pr}}\frac{E_t(A_{t+1} - \Delta B^T_{t+1})}{B_t Var(\pi_{t+1})} \end{aligned} \tag{21}$$

[7] We assume that the fiscal adjustment is expected to stabilize the debt, so that $A_{t+1} > B^T_{t+1} - B_t$.

where $Var(.)$ and $Cov(.)$ denote variances and covariances conditional on the information available at time t and Pr is the probability of a debt crisis as perceived by the government.

The optimal debt shares depends on both risk and cost considerations. Risk is minimized if a debt instrument provides insurance against variations in the primary budget and the debt ratio due to output and inflation uncertainty and if the conditional variance of its returns is relatively low. This is captured by the first two terms in equations (19)-(21).

Equation (19) shows that floating-rate debt is optimal for risk minimization when the Selic rate and thus the interest payments are positively correlated with unanticipated output and inflation. This allows the government to pay less interests when output and inflation and thus the primary surplus are unexpectedly low. More importantly, since lower output growth tends to increase the debt ratio, instruments with returns correlated to nominal output growth help to stabilize the debt ratio, thus reducing the risk of a debt crisis. However, the case for indexation weakens as the conditional variance of the Selic rate increases, thus producing unnecessary fluctuations in interest payments.

Equation (20) shows that the optimal share of dollar denominated debt increases as the exchange rate co-varies positively with output and inflation. If the exchange rate appreciated at times of unexpectedly low output —-an unlikely event—, cyclical variations in the government budget could be hedged by dollar denominated debt. To the extent that exchange rate depreciation is associated with inflation, foreign currency debt helps to stabilize the debt ratio. Clearly, exposure to exchange-rate risk becomes less attractive as the volatility of the exchange rate increases.

Equation (21) shows that the optimal share of price- indexed debt increases with the covariance between output and inflation. If this covariance is positive, lower interest payments on price-indexed debt provides an insurance against the cyclical deficit due to unexpected slowdowns in economic activity. However, inflation-indexed debt is optimal even if the covariance between output and inflation were zero. The reason is that price-indexed debt provides the perfect hedge against an increase in the debt ratio due to lower than expected nominal output growth.

Risk minimization also depends on the conditional covariances between the returns on the various debt instruments. For instance, a positive covariance between the returns on two types of debt makes the two instruments substitutes in the government portfolio. This is captured by the third and fourth terms in equations (19)-(21).

Leaving aside cost considerations, the government should choose the debt composition which offers the best insurance against the risk of deflation and low growth. But insurance is costly; higher expected returns are generally required on hedging instruments, and this leads on average to greater debt accumulation. Debt stabilization thus implies a trade off between cost and risk minimization. The effect of expected return differentials (or risk premia) on the optimal debt composition is captured by the last term in in the right-end-side of equations (19)-(21). This term increases with the risk premia, TP_t, FP_t and IP_t, more precisely, with the excess return (as perceived by the government) of fixed-rate bonds relative to the instrument considered. As shown in equations (15)-(17), the impact of the excess return on the optimal share depends on the marginal increase in the probability of a debt crisis. The latter has been written as a function of the expected debt reduction $E_t(A_{t+1} - \Delta B^T_{t+1})$ and the probability of a debt crisis, Pr, as perceived by the government. (It is worth noting, that the probability Pr also depends on the expected debt reduction, so that the overall effect of a larger debt reduction is to reduce the impact of the expected cost differential.) Finally, a greater variance of the return on a given debt instrument reduces the importance and the impact of interest cost differentials on its optimal share as much as it reduces the relevance of its hedging characteristics. For example, equation (20) points out that the share of bonds denominated or indexed to foreign currencies should increase with the excess return, FP_t. However, as the variance of the exchange rate increases, cost considerations become less important for the choice of dollar denominated bonds.

4. Estimating the optimal debt structure

The optimal debt composition depends on the sensitivity of the primary surplus to unexpected variations in output and inflation, η_y and η_π, on the reduction in the debt ratio, and on the probability of debt stabilization as perceived by the government. At the end of October 2003, mainly because of lower nominal GDP growth, the net public debt was 57.2% of GDP, one percentage point higher than in 2002. Although the debt ratio is currently above the "optimistic" scenario presented in "Politica Economica e Reformas Estruturais" (Ministerio da Fazenda, April 2003), the debt should stabilize next year at around 56% of GDP. Therefore the expected debt reduction is assumed to be 1%. The probability that the stabilization plan may fail is tentatively set at 2% which corresponds to a maximum negative shock to the budget, $\bar{X}$, equal to 1.5% of GDP. This scenario reflects the lower interest rates associated with restored market confidence as well as the high primary surplus targeted by the government.

For the increase of the primary surplus (as a percentage of GDP) due to a 1% growth in real GDP we rely on the estimate by Blanco and Herrera (2002) who suggest a 0.2 semi-elasticity of the primary surplus with respect to GDP (see also Bevilaqua and Werneck (1997)). Evaluating the effect of unexpected inflation on the primary surplus (as a percentage of GDP) is a more difficult task. Although the effect should be substantial, as witnessed by the remarkable budget improvement in the first quarter of 2003, coming down to a single number is difficult.[8] As indirect taxation is the main source of revenues, these should remain roughly constant in terms of GDP. Public spending should instead fall relative to GDP because many categories of spending remains constant in nominal terms as set in the budget.[9]

Primary public spending is equal to 32% of GDP, but social security benefits and other components are linked to the inflation rate. This suggests a tentative estimate of the price elasticity of the primary surplus equal to 0.2, that is, lower than the ratio of primary public spending to GDP.

4.1 Expected return differentials

The expected return differential between fixed-rate bonds and Selic indexed bonds over one-year horizon, TP_t, is the difference between the yield at auction of fixed-rate LTN bonds and the expected return on Selic indexed LFT bonds. The latter can be estimated as the sum of expected Selic rate from the daily survey of expectations and the discount at which 1-year LFT bonds are issued. At the end of October the average auction yield on 1-year

[8] The positive effect of inflation is known as "Patinkin effect" (acc. to Eliana Cardoso); it is the opposite of the Olivera-Tanzi effect.

[9] This information was provided by Paulo Levy at IPEA.

LTN bonds was 17.7%, the Selic rate expected for the end of October 2004 was 14,8% and LFT bonds were issued at a 0.4% discount. The expected return differential, TP_t, can thus be set at 2.5%.

To estimate the expected cost differential between 1-year fixed-rate bonds and dollar denominated bonds, FP_t, the 1-year yield on LTN bonds must be compared to the expected return in Reais on US$ Global bonds. At the end of October Global bonds with a 5-year maturity have been issued at a rate of 9.45% but the yield on bonds with a 1-year to maturity appears much lower; the yield curve shown on the Treasury website points to a 4% 1-year yield (see Tesouro Nacional 2/12/2003). On the other hand, in the same period, the expected depreciation from the daily survey was 9.4%. With an interest rate of 17.7% on LTNs, the expected return differential, FP_t, can thus be estimated at around 4.3%.

The premium on price-linked bonds (NTN-C and NTN-B) over 1-year fixed-rate bonds, IP_t, is the sum of an inflation-risk premium and, eventually, a "credibility spread" due the higher inflation expected by the market than by the government. The inflation risk premium can be estimated as the difference between the interest rate on LTN bonds and the (real) yield at issue of 1-year price-linked NTN-C bonds augmented by the expected IPG-M inflation. At the end of October NTN-C bonds with a 3-year maturity were issued at 9.32% while, according to the daily survey, the expected 12-month ahead IPG-M inflation was around 6.5%. This implies an inflation risk premium of 1.9% in October. As the real yield on 1-year bonds might be lower than the yield on 3-year bonds, the cost advantage of 1-year NTN-C bonds could even be greater than 1.9%. We do not add to this estimate the difference between the inflation expected by the market and by the government, i.e. the "credibility spread", since there is no official target for IPG-M inflation. It is worth noting, however, that expected IPCA inflation from the daily survey was 6.2% slightly higher than the inflation rate implicit in the projection of the 90^{th} COPOM meeting of November.

4.3 Uncertainty of debt returns

The conditional variance of debt returns and their covariances with output growth and inflation can be estimated from one-year ahead forecast errors of the Selic rate, inflation, the exchange rate, inflation and output growth. Ideally, one would like to run forecasting regressions on yearly data for such variables. Then, the residuals of the regressions could be taken as the estimates of the one-year ahead unanticipated components of the Selic rate, the exchange rate, inflation and output growth. Unfortunately, this procedure is precluded in the case of Brazil both because time series at yearly frequency are not sufficiently long and, more importantly, because of the frequent regime shifts experienced over the last two decades.

To circumvent this problem we consider the following three alternatives. The first approach exploits the daily survey of expectations of GDP growth, inflation, the exchange rate and the Selic rate. The unexpected components of these variables can be obtained as the difference between the realization of the relevant variables and their expectations one year earlier. The conditional covariances can then be computed as the mean of their cross products.

The second method focuses on the most recent period of inflation targeting, starting in mid 1999, and relies on a structural backward-looking model of the Brazilian economy estimated with monthly data. The model, which is presented in the Appendix, is consistent with that proposed by Favero and Giavazzi (2003) under the hypothesis of "Ricardian fiscal policy". As we use monthly data, the one-year ahead unanticipated components of the Selic rate, the exchange rate, inflation and output growth are estimated as the 12-month cumulated impulse responses of these variables to shocks of inflation, the output gap and the EMBI spread.

The third approach approximates the one-year ahead unanticipated components of the relevant variables using the residuals of forecasting equations estimated on quarterly data for the period Q3 1995 to Q1 2003.

This method requires the extension of the sample period to include the fixed exchange rate period and the currency crisis of 1999. On the other hand, the estimated stochastic structure is independent of the modeling strategy.

5.1 Estimating the debt composition from the daily survey of expectations

Table 1 decomposes GDP growth, IPCA inflation, exchange-rate depreciation (relative to the US dollar), and the Selic rate between its expected and unexpected component for the years 2000, 2001 and 2002 for which expectations can be obtained from the daily survey.

Except for the first year when output growth was higher than expected, the Brazilian economy performed much worse than expected. Output growth was substantially lower in 2001, while inflation and exchange-rate depreciation exceeded expectations in both 2001 and 2002. The Selic rate also turned out much higher than expected. Had the government issued fixed-rate conventional bonds instead of Selic-rate indexed bonds and dollar denominated debt, debt sustainability would not be a problem for Brazil. Hence, prima facie evidence appears to make a strong case for fixed-rate long-term debt. This depends however on the specific –short– period considered. If times of unexpected deflation, falling short-term interest rates and unexpected appreciation, as those experienced in 2003, are as likely as the events of the period 2000-2002, then issuing fixed-rate bonds paying a high term premium would be a poor strategy.

To correctly address the issue of the optimal debt composition we must look at the covariances of debt returns with output and inflation. Table 1 clearly points to a negative correlation between all types of indexation and unexpected output growth but also shows that unexpected inflation has been positively associated with higher returns on dollar-indexed bonds and Selic-rate bonds. Unexpected inflation has also led to higher returns on price-indexed bonds. This suggests a role for price-indexation (and, to a lesser extent, for the other types of indexation) in hedging against unexpected deflation. This requires, however, that the observed comovements between inflation and debt returns were a systematic feature of the Brazilian economy and not just an episode confined to the period under consideration. The qualification makes it clear that policy indications are not robust when the available evidence is limited to a short period of time as in the present case.

The conditional covariances of debt returns with output and inflation (relative to the conditional variance of returns) are presented in Table 2. The covariances of output growth are negative but small with all types of indexed debt, while inflation displays a strong positive correlation with the Selic-rate and a mild correlation with the exchange rate. Hence, all types of indexation are useful hedges against inflation, although they introduce additional risk when negative output shocks already impair debt sustainability.

Importantly, the magnitude of these effects is in sharp contrast with evidence from

OECD economies shown in Missale (2001). In the latter countries, a strong negative covariance between short-term interest rates and output growth is observed over the period 1970-1998 while the covariance between short-term rates and inflation is small and not significant. Only Greece, Portugal and Sweden display a correlation between short-term rates and inflation as strong as in Brazil. This fact can be explained by the specific shocks experienced by the Brazilian economy during the short period considered. However, these correlations could also reflect structural features of the economy and/or the need for a more flexible approach to inflation targeting in emerging economies exposed to large shocks. In particular, the low correlation of output with the policy rate may reflect a lower elasticity of the output gap to such rate or the case for a smoother convergence of the inflation rate to the target. Quoting the Open Letter sent by Banco Central do Brasil's Governor to the Minister of Finance (January 2003): "It is a standard practice among Central Banks when facing supply shocks of great magnitude to postpone the convergence of current inflation towards the targets over a longer period, avoiding unnecessary costs to the economy. This was the case faced by Brazil in the last year."

As the positive correlation of the Selic rate and the exchange rate with inflation dominates their negative but small correlation with output growth, bonds indexed to the Selic-rate, inflation and the exchange rate all provide some insurance against variations in the primary surplus and the debt ratio due to unexpected changes in nominal output growth. This is shown in the first Column of Table 3, which reports for each type of debt the optimal share for risk minimization in the case we abstract from hedging against variations in the interest payments of the other instruments. All shares are positive reflecting the same distribution of the returns of variable-rate instruments.

Column 2 shows the debt composition that allows to minimize both the risk of variations in the primary surplus and in the interest payments. As Selic-indexed, price-indexed and dollar denominated bonds are close substitutes in the government portfolio, variations in their interest payments should be hedged by holding a long position in Selic-indexed bonds (for example by means of foreign currency swaps).

When cost considerations are introduced into the analysis, the composition of the debt clearly moves in favor of price-indexed bonds. Column 3 shows that the government should issue price-indexed bonds in amount far exceeding the total debt and hedge this position by holding assets denominated in dollars, along with Selic-indexed bonds. This result may look surprising given the cost advantage, 2.3%, of dollar denominated bonds over price-indexed bonds, but it is worth recalling that expected return differentials must be normalized by the conditional variance or returns and the standard deviation of exchange-rate depreciation has been 3.6 times that of inflation. Since for practical reasons a structure of assets and liabilities as shown in Column 3 is clearly unfeasible, in Column 4 the share of price-indexed bonds is estimated in the case the government cannot hold Selic-indexed bonds. The case for price indexed bonds is again strong.

Evidence from the daily survey of expectations thus suggests price indexation as the optimal strategy for debt management, thus supporting the policy indications by Bevilaqua and Garcia (2000). As bonds indexed to the price level currently represent less than 15% of the domestic marketable federal debt (in the hands of the public) this would imply that funding in the next few years will have to rely on price indexation. It is however important to realize the risk of a strategy that increases the exposure of the government budget to unexpected output fluctuations. In fact, fixed-rate bonds appear the only available instruments to insure against the impact of unanticipated output slowdowns on debt sustainability. As highlighted in the discussion above, the fact that such shocks have played a minor role compared to variations in the exchange rate and inflation over the period considered does not mean that they will continue to do so in the future. A debt structure that comprises fixed-rate conventional bonds along with price-indexed bonds would better balance the risks that the Brazilian economy may face in the years ahead.

In order to examine whether and how the optimal debt composition depends on the types of shocks hitting the economy, in the next Section we present results for different shocks identified with a structural model of the Brazilian economy.

5.2 Estimating the debt composition with a structural model

The structural model used to estimate the optimal debt composition is made of five equations for: (i) the inflation rate; (ii) the output gap; (iii) the Selic rate; (iv) the exchange rate and; (v) the EMBI spread.

The model is estimated on monthly data for the period 1999:3-2003:7 and is presented in the Appendix. We consider three types of shocks: a supply shock (in the inflation equation), a demand shock (in the output-gap equation) and a shock to the EMBI spread. Then, we compute the 12-months cumulated impulse responses of the Selic rate, the exchange rate, inflation and output for 1000 extractions from the distribution of each type of shock.[10] The cumulated responses are then used to estimate the ratios of conditional covariances relative to conditional variances which are shown in Tables 4, 6 and 8 for the demand shock, the supply shock and the EMBI shock, respectively. The optimal debt composition is reported in Tables 5 7 and 9 for each type of shock.

5.2.1 Demand shocks

Table 5 shows the debt composition that stabilizes the debt ratio against demand shocks -i.e. against shocks to the output gap equation. The first Column of Table 5 reports the shares of each type of debt which are optimal for minimizing the risk of variations in the primary surplus and the debt ratio, that is, when we abstract from hedging against variations in the interest payments (or returns) of the other instruments. The shares of Selic and price indexed bonds are positive and exceed several times the total debt. This evidence suggests that such instruments offer a valuable insurance against variations in the primary surplus and in the debt ratio. As demand shocks induce a positive covariance of output and inflation and a strong reaction of the policy rate, the returns on both Selic and price indexed bonds are strongly correlated with output and inflation. As the monetary reaction leads to an appreciation of the exchange rate, the return on dollar denominated bonds is negatively correlated with both output and inflation. This explains the large negative share of dollar denominated debt; the government should rather hold foreign assets to hedge against output shocks.

Column 2 shows the debt composition that minimizes risk when we consider, along with budget and debt-ratio uncertainty, the role of each instrument in hedging against the returns of the other instruments. Since Selic and price indexed bonds are close substitutes

[10] For the exchange rate the response at the 12th month was used instead of the cumulated responses.

in the government portfolio (they returns covary positively), their optimal shares decrease. The long position in foreign assets also decrease as Selic and price indexed bonds are hedged by dollar denominated bonds.

The risk minimizing debt structure calls for issuing large amounts of indexed instruments to fund unlimited holdings of foreign assets. Since taking such position is clearly unfeasible, in Column 3 we restrict the shares of dollar denominated debt and fixed rate debt to be non-negative. In this case, risk minimization clearly favors price indexation over Selic rate indexation.

The optimal debt composition does not change when cost minimization is considered along with risk insurance. Column 4 shows that both Selic rate and price indexed bonds should be issued if large holdings of foreign assets were feasible. However, when the debt shares are constrained to be non-negative price indexation clearly emerges as the optimal choice: Column 5 shows that all the debt should be indexed to the price level.

5.2.2 Supply shocks

Table 7 shows the optimal debt composition that stabilizes the debt ratio against supply shocks, i.e. against shocks to the inflation equation. Column 1 shows that fixed-rate bonds, Selic rate and price indexed bonds, all provide insurance against variations in the primary surplus and in the debt ratio due to lower than expected inflation and output growth. In particular, more than one third of the debt should be at fixed rate while the other two thirds should be indexed to the Selic rate and the price level. Although, Selic-rate and price indexed bonds are good hedges against lower than expected inflation, they provide limited insurance against budget risk, since their returns are now negatively correlated with output (see Table 6). Since supply shocks lead to a negative covariance of output with both inflation and the Selic rate, fixed-rate debt helps to stabilize the debt ratio.

Column 2 shows that, when we consider the risk of variations in debt returns along with budget risk and debt-ratio uncertainty, a role emerges for dollar denominated bonds. The optimal composition for risk minimization comprises a small share of dollar denominated bonds and a negative share of Selic indexed bonds. The reason is that, even if dollar denominated bonds are poor hedges against variations in the primary surplus, they help to stabilize the interest payments on price indexed bonds. This is because, the exchange rate covaries negatively with inflation; it appreciates when the Selic rate is raised to counter negative supply shocks. Since Selic indexed bonds are close substitutes for price indexed bonds but offer a limited insurance against inflation uncertainty, their share becomes negative. By contrast, fixed-rate bonds still appear to play an important role in risk minimization; about one fourth of the debt should be at fixed rate.

Although fixed-rate debt helps to stabilize the debt ratio by insulating the budget from supply shocks, its higher expected cost has a negative impact on the probability of stabilization. Columns 3 shows the debt composition that maximizes the probability of stabilizing the debt ratio when cost considerations are taken into account. Since variable-rate bonds have lower expected returns than fixed-rate bonds, their shares increase substantially leaving no role for fixed-rate bonds; it would even be optimal to hold fixed-rate assets and fund this position with the other instruments. Finally, Column 4 shows that, when the optimal shares are constrained to be non-negative, there is a strong case for price-indexation; more than 80% of the debt should be indexed to the price level with the remaining part denominated in dollars.

The lack of fixed-rate bonds in the optimal debt structure is partly explained by the strong complementarity between price-indexed and dollar denominated bonds which arises because of the exchange rate appreciation that follows an inflation shock. If we abstract from the hedge provided by dollar debt against the returns of the other instruments, issuing some fixed-rate debt is optimal. Column 5 shows that, in this case, fixed-rate bonds still account for 16% of the debt in spite of their higher expected return. This case could be relevant if negative supply shocks, by inducing a deterioration of the fiscal position (that our model fails to capture), led to a greater EMBI spread and a depreciation of the exchange rate. The effects of shocks to the country risk premium are discussed in the next section.

5.2.3 EMBI shocks

Tables 9 shows the debt composition that stabilizes the debt ratio against shocks to the EMBI spread. Changes in the country risk premium may capture changes in international risk factors or in the perception of risk as well as domestic fiscal shocks, for example, negative shocks to the budget that increase country risk.

The first Column of Table 9 reports the debt composition that stabilizes the debt ratio against variations in output and inflation, that is, in the case we abstract from hedging against variations in the interest payments. The shares of Selic indexed bonds and dollar denominated bonds are negative, reflecting the strong negative covariances of their returns with output growth that are shown in Table 8. In fact, EMBI shocks also lead to both unexpected inflation and exchange-rate depreciation, but the negative covariances of the Selic rate and the exchange rate with output dominate their positive covariances with inflation. It follows that fixed-rate bonds should be issued in amounts exceeding the total debt so as to insulate the budget from unexpected output contractions.

Column 2 shows that issuing fixed-rate debt is still optimal for risk minimization when we consider the role of each instrument in hedging the returns of the other instruments. The government should issue an amount of fixed-rate bonds larger than the total debt and hold both foreign assets and Selic indexed bonds. When, as in Column 4, the debt shares are constrained to be non-negative, the share of fixed-rate debt reaches 93%.

When cost considerations are introduced into the analysis, as in Column 4 an 5, the optimal debt composition moves towards price indexation, but the share of fixed-rate bonds remains substantial despite their higher expected return. Column 5 shows that, when debt shares are constrained to be non-negative, the optimal share of fixed-rate bonds is as high as 82%.

5.2.4 Policy conclusions from the structural model

Results from the structural model suggest that a large share of the Brazilian debt should be indexed to the price level. Price indexed bonds appear to consistently provide a good hedge against all types of shocks, although their role is limited in the case of EMBI shocks. Indexation to the Selic rate should be avoided if supply shocks and EMBI shocks prevail while LFT bonds are a worse alternative to price indexation in the case of demand shocks. Importantly, there appears to be little role for dollar denominated bonds. Exposure to exchange rate risk should be avoided in case of demand shocks and EMBI shocks while it should be limited in the case of supply shocks. In particular, the greater volatility of the exchange rate implies that for dollar denominated bonds to be preferred to price indexed bonds their expected return differential should be much higher than that currently observed.

Whether 1-year fixed-rate bonds should be issued depends on the type of shocks hitting the economy. While fixed-rate LTN bonds have no role in the case of demand shocks, they are the best instruments to cope with shocks to the country risk premium. If EMBI shocks prevail, a share of such bonds substantially higher than that currently observed would be optimal even after considering their greater expected cost. LTN bonds may also provide insurance against variations in the primary budget and the debt ratio induced by supply shocks, but their optimal share is small because of their higher expected return. A stronger argument for fixed-rate bonds (in exchange for dollar denominated bonds) can be made if negative supply shocks increase fiscal vulnerability, thus leading to a depreciation of the exchange rate.

These policy implications obviously depend on the correct specification of the structural model. It is thus important to check whether they continue to hold under different estimation methods.

5.3 Estimating the debt composition with forecasting equations

In this section the conditional covariances of debt returns, output and inflation are estimated using the residuals of forecasting equations run on quarterly data for the period Q3 1995 to Q1 2003. We proceed in two steps. We first run regressions of output, inflation, the exchange rate and the Selic rate separately on one lag of each variable and take the residuals as an estimate of the unanticipated component of the dependent variable. Then, we estimate the ratio of the conditional covariance between, say, output and inflation to the variance of inflation as the coefficients of the regression of the residuals of output on the residuals of inflation obtained in the first stage.

Table 10 shows that these ratios are small and not statistically significant except for the negative covariance of the Selic rate with output. This finding is consistent with the results from the structural model in the case of supply shocks and shocks to the EMBI spread: unexpected increases in the Selic rate appear to be associated with significant reductions in output growth. On the other hand, the Selic rate does not bear any systematic relation with unexpected inflation. The conditional covariance between inflation and output (and thus between the returns on price-indexed bonds and output) is negative but small and not significant. The exchange rate also appears to be uncorrelated with both output and inflation over the period considered.

Table 11 presents the optimal debt composition. Column 1 reports the shares of the various types of debt which are optimal for risk minimization, that is, in the case that all bonds had the same expected return. Column 2 does the same when the debt composition is computed using only the covariance/variance ratios that are statistically significant. Column 1 and 2 show that, for the purpose of minimizing risk, all the debt should be indexed to the price level. While dollar denominated bonds play no role, the government should hold assets indexed to the Selic-rate and fund this position with fixed-rate bonds. This is probably the result of including the 1999 currency crisis into the sample. Indeed, the negative and large share of Selic-indexed bonds reflects the negative covariance between output and the policy rate that characterizes crisis events. This evidence suggests that a large exposure to floating rates makes the budget vulnerable to high interest rates when this is less desirable; i.e. at times of output contractions and when credit availability is a problem.

Although the share of fixed-rate debt in Column 1 and 2 is substantial, such debt is used to fund the long position in Selic-indexed bonds. If the share of Selic debt is constrained to be non-negative as in Column 3, then fixed-rate bonds should not be issued. Hence, price-indexed bonds appear the optimal choice for risk minimization. This is because their returns are unrelated to output fluctuations and provide a natural hedge against lower than expected inflation.[11]

Then, the interesting issue is whether differences in expected returns imply a role for Selic-rate bonds and dollar denominated bonds in debt stabilization. The optimal debt shares are shown in Column 4. Cost differentials make it optimal to issue larger amounts of indexed and dollar denominated bonds in exchange for fixed-rate debt. However, the share of Selic-indexed bonds remains negative while that of dollar denominated debt is positive but small. Since price-indexd bonds should be issued in amounts exceeding the total debt, Column 4 also shows a long, though small, position in fixed-rate bonds. Since these large asset holdings are clearly unfeasible, Column 6 shows the optimal debt composition when the shares of Selic indexed bonds and fixed-rate bonds are constrained to be non negative. The case for price indexation is again strong; almost the whole debt should be indexed to the price level.

Therefore, results from forecasting equations strengthen our previous conclusions: price indexation should be preferred to Selic-rate indexation while the share of dollar denominated (and indexed) bonds should be drastically reduced from the current high level. Indeed, the lack of correlation of the Selic-rate with inflation and its negative covariance with economic activity provide strong evidence against Selic-rate indexation. This risk-return characteristics may have changed with the monetary regime and/or reflect the particular events covered by the sample period.

However, if the observed negative correlation between the Selic rate and economic activity were due to the 1999 currency crisis, policy indications against floating rate debt would even be stronger.

The results of forecasting regressions strongly support the decision of the Brazilian Treasury to revitalize the market for price-indexed bonds. It is however worth recalling that the simulations of the structural model presented in the previous section suggest that fixed-rate bonds are better instruments than price-indexed bonds to cope with shocks to the EMBI spread.

Even if we restrict the attention to the results of forecasting regressions there are several reasons why indexing a large share of debt to the price level may not be optimal or feasible. For instance, while we focus on 1-year bonds, NTN-C and NTN-B bonds are issued at longer maturities, probably, reflecting the preferred holding periods of institutional investors. Issuing 5- to 20-year bonds at a real 10% interest rate may not be advisable if the fiscal authorities were determined to carry out the fiscal stabilization. In this case issuing fixed-rate bonds with a one-year maturity would be a more effective strategy for

[11] Note that the debt composition that is optimal for risk minimization does not depend on the covariances between the returns on the various types of debt, that is, on complementarities and substitutabilities between debt instruments.

cost minimization (at the cost of increasing the exposure to roll-over risk.)

Secondly, it is likely that the amount of price-indexed bonds that the market is willing to absorb at current interest rates is limited. If the government placed increasing amounts of such debt its interest rate would rise. The extent of indexation may also be limited by reasons of political opportunity: inflation indexation of interest income may give rise to pressures for extending indexation to other types of income. Moreover, it is often argued that indexation reduces the cost of inflation and thus the incentives for anti-inflationary fiscal and monetary policy. Fixed-rate debt may also enhance the effectiveness of monetary policy in controlling aggregate demand (see Falcetti and Missale 2002). Finally, issuance of fixed-rate conventional bonds can be motivated by the objective of developing a domestic market for fixed-rate bonds.

It is worth examining under which conditions substituting fixed-rate 1-year bonds for dollar denominated bonds and for Selic-rate bonds is optimal, while taking the shares of the other types of debt constant at the current level. Table 12 shows (for various pairs of the expected debt reduction and the probability that debt stabilization fails) the interest rate differential between 1-year fixed-rate bonds and dollar denominated bonds, FP, below which it is optimal to issue fixed-rate bonds in exchange for dollar denominated bonds. Since the current exposure to exchange rate risk (after swaps), considering the net external debt, is currently as high as 40%, substituting fixed-rate bonds for foreign currency debt would be optimal even for a very high perceived probability that debt stabilization may fail. For instance, with the current 4.3% expected return differential the exposure to exchange rate risk would be optimal only if the perceived probability of failure were as high as 40%.

Table 13 shows the interest rate differential between 1-year fixed-rate bonds and Selic-indexed bonds, TP, below which issuing fixed-rate bonds in exchange for Selic-indexed bonds is optimal. With an expected debt reduction equal to 2% of GDP, and 6% probability that the debt ratio would not stabilize, fixed-rate bonds should replace Selic-indexed bonds as soon as the term premium falls below 2.8%. However, if the probability of failure were lower, say 3%, then fixed-rate bonds should be issued even if the term premium were as high as 4.6%. Although, these numbers should be regarded as just indicative, they show the large scope for improvement in the composition of the Brazilian debt.

6. Policy conclusions

In this paper we have presented a framework for the choice of debt instruments that is relevant for countries where fiscal vulnerability makes debt stabilization the main goal of debt management.

The optimal debt composition has been estimated by looking at the relative impact of the risk and cost of various debt instruments on the probability that the government might miss the stabilization target, which we have defined as a pre-assigned level of the debt-to-GDP ratio.

The empirical evidence suggests that a large share of the Brazilian debt should be indexed to the price level. Price-indexed bonds appear to consistently provide a good hedge against all types of shocks, although their role is limited in the case of EMBI shocks. Price indexation should be preferred to Selic-rate indexation, and the share of dollar denominated (and indexed) bonds should be drastically reduced. These policy prescriptions are robust to alternative methods of estimating the optimal debt structure.

Fixed-rate LTN bonds also help to stabilize the debt ratio. Although such bonds have no role in the case of demand shocks, they are the best instruments to cope with shocks to the country risk premium. If EMBI shocks prevail, a share of fixed-rate bonds substantially higher than that currently observed would be optimal even after considering their greater expected cost. Fixed-rate bonds can also provide insurance against fluctuations in the primary budget and in the debt ratio induced by supply shocks, but their optimal share should be smaller than that of price-indexed bonds because of their higher expected return.

The scope for improving on the current structure of the Brazilian debt is substantial. The composition of the net public debt in Brazil is strongly biased toward debt denominated or indexed to foreign currencies. Once we account for net external debt and for the foreign currency swaps of the Central Bank, the exposure to the exchange rate reaches 40%. The share of debt indexed to the Selic rate is also as high as 40%. By contrast the share of debt indexed to the price level is slightly above 10% and the fixed-rate component is about 8%.

These facts suggest simple policy prescriptions. First of all, the exposure to exchange rate risk should be reduced. The cost advantage of bonds denominated or indexed to foreign currency is not sufficient to compensate for the high risk of variations in the exchange rate. The exposure to the exchange rate is so high that betting in the direction of a further appreciation of the exchange rate is highly risky. One of the reasons such a large share of the domestic debt is indexed to the dollar is the demand for hedge by the private sector. In Brazil the only entities that bear exchange rate risk are the government and the Central Bank: the private sector fully hedges its dollar exposure by entering into swap contracts with the Central Bank. Such a large amount of outstanding hedge cannot be rapidly reduced: the currency falls sharply whenever the Central Bank announces that it will not fully roll over the outstanding stock of hedge. The current account surplus that Brazil is now running offers an opportunity to reduce the demand for hedge by the private sector. This constraints, however, does not apply to Treasury funding in foreign currencies, which should be avoided, thus reducing exchange rate exposure at least on this front. Since vulnerability to exchange rate risk is valued by investors, a smaller share of dollar denominated debt could lower the risk premium on the Brazilian debt.

The second advice is to increase issuance of price-indexed bonds. Price indexation, especially the new IPCA indexation program, provides a natural hedge against the impact of inflation on both the primary surplus and the debt ratio. In the perspective of the asset-and-liability management approach of the Brazilian Treasury, NTN-C and NTN-B bonds do not only match future revenues but also the risks of price indexed assets in the government portfolio (see Ministerio de Fazenda 2003). Since NTN-C bonds have a long maturity, they also insulates the government budget from roll-over risk, thus representing an important factor of stability for public debt dynamics. Thus, the decision of the Brazilian Treasury to revitalize the market for price-indexed bonds finds a strong support in our analysis.

How large the share of price-indexed bonds should be, is more difficult to say. Although our analysis suggests that such a share should be large, there are a number of reasons why this may not be optimal or feasible. The amount of price indexed bonds that could be issued may be limited by reasons of political opportunity or by the likely increase in the expected return that investors require to hold such bonds when their share increases.

The main obstacle against a strategy of price indexation lies, however, in the long maturity of price-indexed bonds, that would lock in the cost of debt service at real interest rates as high as 10% for many years ahead. In fact, this could be too high a cost for a government fully determined to carry out the fiscal stabilization.

A role for nominal debt instruments of short duration emerges if the stabilization program does not enjoy full credibility and long-term interest are too high relative to government expectations of future rates. The decision of the Treasury to rely on bonds indexed to the Selic rate clearly finds a strong motivation in this argument; floating-rate LFT debt ensures that a fall in interest rates would be immediately transmitted into a lower debt service cost. Although our analysis cannot capture such an effect, it points to fixed-rate bonds with a one-year maturity as an attractive alternative to Selic-rate indexation.

Indeed, the third policy indication that emerges from this paper is to substitute fixed-rate bonds for bonds indexed to the Selic rate. Fixed-rate debt avoids large interest payments when the Selic rate rises during a crisis or reacts to negative supply shocks and thus when debt stabilization is endangered by slow output growth. We find evidence that issuing fixed-rate bonds in exchange for Selic-indexed bonds increases the probability of debt stabilization even if the 12-month term premium is as high as 4%. Since realistically the maturity of fixed-rate bonds will have to remain relatively short, within two years, a greater share of such bonds would not preclude the benefit of a fall in interest rates.

Issuance of fixed-rate bonds can bring additional benefits as they play a key role in the creation of a domestic bond market. The resumption in 2003 of LTN auctions for maturities longer than one year goes in the right direction. The Treasury should commit to this strategy by announcing a regular program of fixed-rate bond auctions, since the success of this strategy hinges on the market perception that the program will not be changed or interrupted because of unfavorable market conditions.

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Table 1 - Economic Indicators

	Realized			
	π	Δy	Δe	Selic
2000	5.97	4.4	9.3	15.84
2001	7.67	1.4	18.7	19.05
2002	12.53	1.5	52.3	24.90
	Unanticipated			
	π	Δy	Δe	Selic
2000	-1.03	1.4	0.3	-0.81
2001	3.37	-2.6	16.4	5.05
2002	7.73	-0.9	26.0	7.90

Notes: IPCA inflation, US dollar exchange-rate depreciation, end-of-period Selic rate

Table 2 - Covariances from Survey of Expectations

$Cov(yi)/Var(i)$	-0.24	$Cov(i\pi)/Var(i)$	0.89
$Cov(ye)/Var(e)$	-0.07	$Cov(e\pi)/Var(e)$	0.27
$Cov(y\pi)/Var(\pi)$	-0.24	$Cov(e\pi)/Var(\pi)$	3.55
$Var(i)$	0.30	$Cov(ie)/Var(i)$	3.25
$Var(e)$	3.15	$Cov(ie)/Var(e)$	0.30
$Var(\pi)$	0.24	$Cov(i\pi)/Var(\pi)$	1.09

Notes: Variances are multiplied by 100.

Table 3 - Debt Composition from Survey of Expectations

	Risk No hedge	Risk	Risk+Cost	Risk+Cost Fix=Selic=0
Selic Rate	0.88	-4.14	-1.80	0
Foreign Exchange	0.27	0.73	-0.12	0.01
Price Index	1.03	2.98	2.61	0.99
Fixed Rate	-1.18	1.43	0.08	0

Notes: The debt composition is derived from equations (19)-(21).

Table 4 - Covariances - Structural Model - Demand Shock

$Cov(yi)/Var(i)$	12.9	$Cov(i\pi)/Var(i)$	0.76
$Cov(ye)/Var(e)$	-10.7	$Cov(e\pi)/Var(e)$	-0.63
$Cov(y\pi)/Var(\pi)$	11.3	$Cov(e\pi)/Var(\pi)$	-0.70
$Var(i)$	0.038	$Cov(ie)/Var(i)$	-0.80
$Var(e)$	0.054	$Cov(ie)/Var(e)$	-0.56
$Var(\pi)$	0.049	$Cov(i\pi)/Var(\pi)$	0.58

Notes: Variances are multiplied by 100^2.

Table 5 - Debt Composition for Demand Shock

	Risk No hedge	Risk	Risk Fix=For=0	Risk+Cost	Risk+Cost Fix=For=0
Selic Rate	18.4	7.5	-3.3	8.3	-3.2
Foreign Exch	-15.3	-6.2	0	-5.1	0
Price Index	16.6	7.9	4.3	8.3	4.2
Fixed Rate	-18.6	-8.1	0	-10.5	0

Notes: The debt composition is derived from equations (19)-(21).

Table 6 - Covariances - Structural Model - Supply Shock

$Cov(yi)/Var(i)$	-0.42	$Cov(i\pi)/Var(i)$	0.64
$Cov(ye)/Var(e)$	0.33	$Cov(e\pi)/Var(e)$	-0.57
$Cov(y\pi)/Var(\pi)$	-0.53	$Cov(e\pi)/Var(\pi)$	-1.23
$Var(i)$	0.109	$Cov(ie)/Var(i)$	-0.96
$Var(e)$	0.172	$Cov(ie)/Var(e)$	-0.61
$Var(\pi)$	0.079	$Cov(i\pi)/Var(\pi)$	0.89

Notes: Variances are multiplied by 100^2.

Table 7 - Debt Composition for Supply Shock

	Risk No hed	Risk	Risk+Cost	Risk+Cost Fix=Sel=0	Risk+Cost No oth
Selic Rate	0.30	-0.26	0.03	0	0.37
Foreign Exchange	-0.32	0.06	0.54	0.18	-0.24
Price Index	0.63	0.89	1.35	0.82	0.71
Fixed Rate	0.38	0.26	-0.92	0	0.16

Notes: The debt composition is derived from equations (19)-(21).

Table 8 - Covariances - Structural Model - EMBI Shock

$Cov(yi)/Var(i)$	-2.14	$Cov(i\pi)/Var(i)$	1.50
$Cov(ye)/Var(e)$	-0.38	$Cov(e\pi)/Var(e)$	0.27
$Cov(y\pi)/Var(\pi)$	-0.95	$Cov(e\pi)/Var(\pi)$	1.65
$Var(i)$	0.038	$Cov(ie)/Var(i)$	3.71
$Var(e)$	1.187	$Cov(ie)/Var(e)$	0.12
$Var(\pi)$	0.194	$Cov(i\pi)/Var(\pi)$	0.30

Notes: Variances are multiplied by 100^2.

Table 9 - Debt Composition for EMBI Shock

	Risk No hed	Risk	Risk Sel=For=0	Risk+Cost	Risk+Cost Selic=For=0
Selic Rate	-0.86	-1.24	0	-0.79	0
Foreign Exchange	-0.15	-0.22	0	-0.25	0
Price Index	0.07	0.80	0.07	0.76	0.11
Fixed Rate	1.95	1.66	0.93	1.28	0.89

Notes: The debt composition is derived from equations (19)-(21).

Table 10 - Covariances - Forecasting Regression

$Cov(yi)/Var(i)$	-0.536 (0.002)	$Cov(i\pi)/Var(i)$	-0.016 (0.93)
$Cov(ye)/Var(e)$	0.018 (0.38)	$Cov(e\pi)/Var(e)$	-0.017 (0.45)
$Cov(y\pi)/Var(\pi)$	-0.042 (0.81)	$Cov(e\pi)/Var(\pi)$	-1.170 (0.45)
$Var(i)$	0.012	$Cov(ie)/Var(i)$	-2.166 (0.19)
$Var(e)$	0.899	$Cov(ie)/Var(e)$	-0.027 (0.19)
$Var(\pi)$	0.013	$Cov(i\pi)/Var(\pi)$	-0.014 (0.93)

Notes: P-values in parenthesis. Quarterly data. Variances are multiplied by 100.

Table 11 - Debt Composition - Forecasting Regressions

	Risk	Risk Significant	Risk Selic=0	Risk+Cost Significant	Risk+Cost Fix=Selic=0
Selic Rate	-0.72	-0.73	0	-0.42	0
Foreign Exch	0.00	0.00	0.0	0.01	0.01
Price Index	1.30	1.36	1.35	1.56	0.99
Fixed Rate	0.42	0.37	-0.35	-0.15	0

Notes: The debt composition is derived assuming a that the 1-year ahead conditional variances are four times the 3-month ahead conditional variances.

Table 12 - Cut-off Exchange-Rate Risk Premium
Fixed Rate for Foreign Exchange

	$Debt-ratio\ \ expected\ \ reduction$			
$Prob\ \ Fail$	2.5%	2.0%	1.5%	1.0%
20%	18,9	23,7	31,6	47,4
25%	13,5	16,8	22,5	33,7
30%	9,4	11,8	15,8	23,7
35%	6,3	7,9	10,6	15,9
40%	3,8	4,8	6,4	9,6

Notes: Risk premium in percent.

Table 13 - Cut-off Term Premium
Fixed Rate for Selic Rate

	$Debt-ratio\ \ expected\ \ reduction$			
$Prob\ \ Fail$	2.5%	2.0%	1.5%	1.0%
2%	4,80	6,00	8,01	12,0
3%	3,70	4,63	6,17	9,25
4%	3,04	3,81	5,07	7,61
5%	2,60	3,25	4,33	6,49
6%	2,27	2,83	3,78	5,66

Notes: Risk premium in percent.

Appendix

The model used in the simulation exercises to obtain the impulse responses to supply, demand and Embi spread shocks is made of the following equations:

Embi Spread equation

$$Embi_t = \mu_0 + \mu_1 Embi_{t-1} + \mu_2 B_{t-1} i_{t-1} + \mu_3 SpBaa_t + \mu_4 DU + v_{embit} \quad (1)$$

where $Embi_t$ is the Embi spread, $SpBaa$ is the US Corporate bond spread and DU is a dummy variable taking the value of 1 for the crisis period 2002:06 -2002:12.

Exchange rate equation

$$e_t = \delta_0 + \delta_1 e_{t-1} + \delta_2 (i_{t-1} - i^{US}_{t-1}) + \delta_3 Embi_t + \delta_4 \Delta Embi_t + v_{et} \quad (2)$$

where i^{US} is the US federal funds rate.

Output gap equation

$$y_t = \gamma_0 + \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + \gamma_3 i_{t-6} + \gamma_4 Embi_{t-1} + v_{yt} \quad (3)$$

Inflation equation

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 y_{t-1} + \alpha_3 (e_{t-6} - e_{t-12}) + \alpha_4 \Sigma_{i=1}^{4} Embi_{t-i} + v_{\pi t} \quad (4)$$

Selic rate equation

$$i_t = \rho i_{t-1} + (1-\rho)[\beta_0 + \beta_1 (\pi_{t-1} - \pi^T) + \beta_2 \Delta e_{t-4}] + v_{it} \quad (5)$$

where π^T is the inflation target.

The inflation rate, the interest rates, the spreads and the output gap are monthly and have not been multiplied by 100. The exchange rate e_t is the logarithm of the $Real/US-dollar exchange rate. An Embi spread shock is a one standard deviation shock to equation (1), a demand shock is a one standard deviation shock to equation (3) and a supply shock is a one standard deviation shock to equation (4).
The model is estimated by Iterative Least Squares.

Table A1 - Estimated Model, sample 1999:03 2003:07

	$Coeff$	$S.E.$	$t-ratio$	$Adj.R^2$	$SE\,eq.$ $SE\,dep.va$	DW
μ_0	-0.132	0.182	-0.72	0.85	0.156 0.406	2.01
μ_1	0.254	0.114	2.23			
μ_2	19.78	11.22	1.76			
μ_3	187.8	68.34	2.75			
μ_4	0.618	0.116	5.32			
δ_0	0.032	0.021	1.53	0.97	0.036 0.249	1.95
δ_1	0.977	0.032	30.2			
δ_2	-2.724	1.010	-2.69			
δ_3	0.044	0.019	2.23			
δ_4	0.215	0.028	7.47			
γ_0	0.037	0.013	2.79	0.40	0.020 0.026	1.77
γ_1	0.465	0.173	2.68			
γ_2	-0.244	0.162	-1.50			
γ_3	-1.452	0.680	-2.13			
γ_4	-0.020	0.007	-2.56			
α_0	-0.0005	0.0002	-2.04	0.98	0.0004 0.0028	1.44
α_1	0.9470	0.0370	25.0			
α_2	0.0077	0.0039	1.99			
α_3	0.0017	0.0005	3.42			
α_4	0.0002	0.00004	5.97			
ρ	0.866	0.034	24.9	0.94	0.0006 0.0025	1.04
β_0	0.012	0.001	10.1			
β_1	1.569	0.394	3.97			
β_2	0.025	0.013	1.97			

Figure 1

DEMAND SHOCK
Impulse responses for a shock to output gap equation

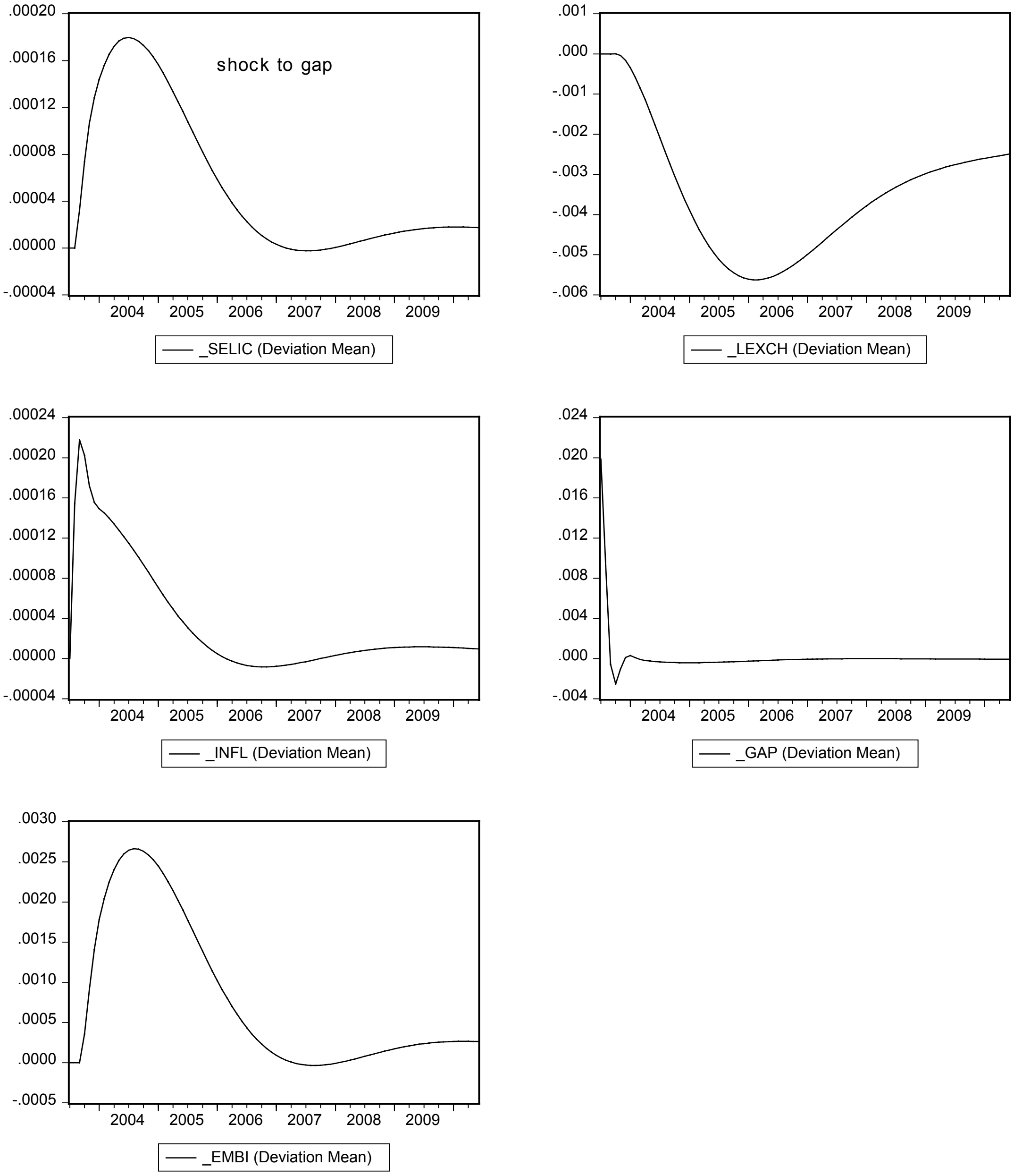

Figure 2

SUPPLY SHOCK
Impulse responses for a shock to inflation equation

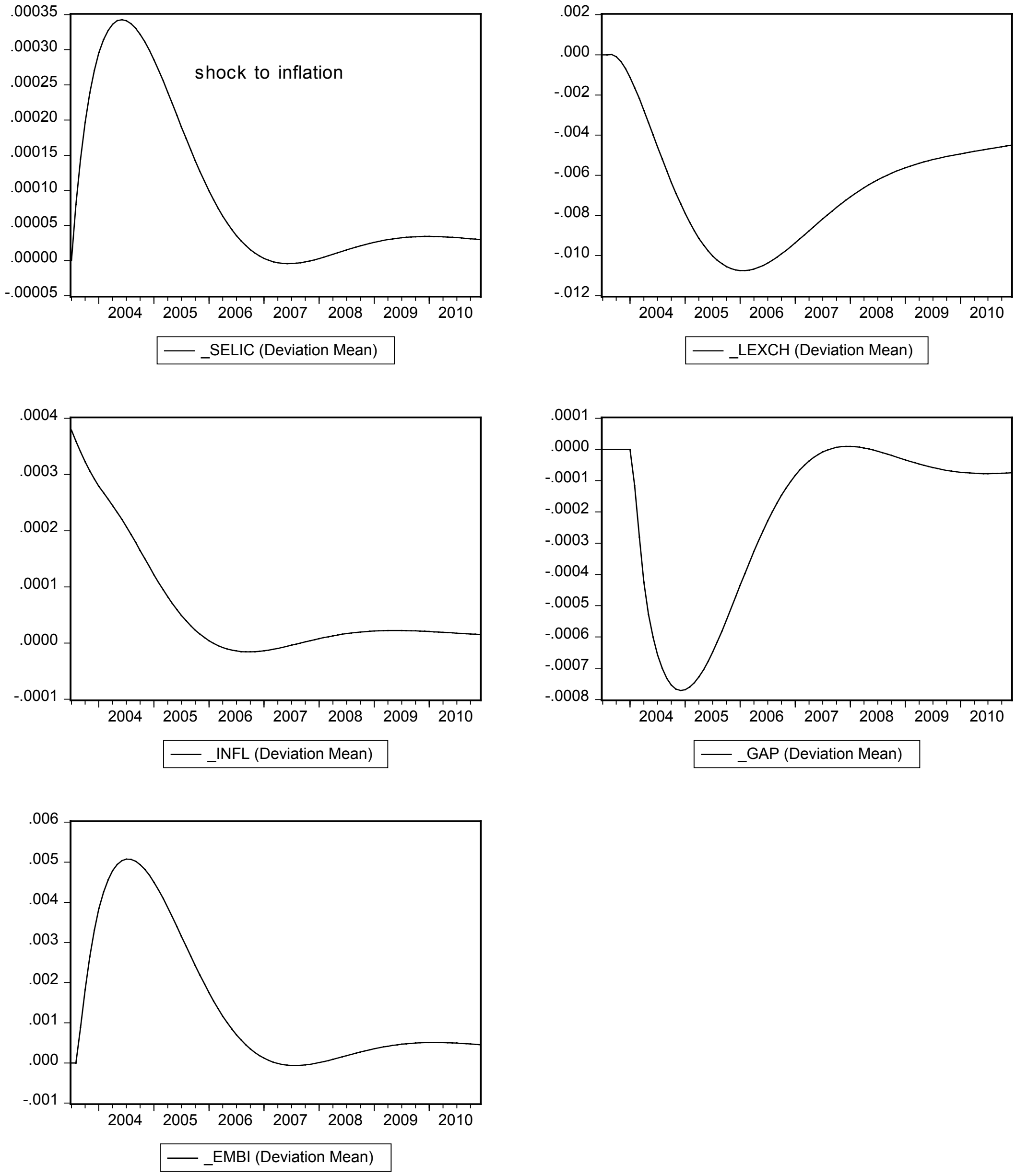

Figure 3

EMBI SHOCK
Impulse responses for a shock to Embi spread equation