WP/11/107

IMF Working Paper

Identifying Fiscal Policy Transmission in Stochastic Debt Forecasts

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INTERNATIONAL MONETARY FUND

 WP/11/107

IMF Working Paper

Western Hemisphere Department

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May 2011

Abstract

A stochastic debt forecasting framework is presented where projected debt distributions reflect both the joint realization of the fiscal policy reaction to contemporaneous stochastic macroeconomic projections, and also the second-round effects of fiscal policy on macroeconomic projections. The forecasting framework thus reflects the impact of the primary balance on the forecast of macro aggregates. Previously-developed forecasting algorithms that do not incorporate these second-round effects are shown to have systematic forecast errors. Evidence suggests that the second-round effects have statistically and economically significant impacts on the direction and dispersion of the debt-to-GDP forecasts. For example, a positive structural primary balance shock lowers the domestic real interest rate, in turn raising GDP and lowering the median debt-to-GDP projection by an additional 10 percent of GDP in the medium term relative to prior forecasting algorithms. In addition, the framework employs a new long-term (five decade) data base and accounts for parameter uncertainty, and for potentially non-normally distributed shocks.

JEL Classification Numbers: C15, E62, H62, H63
Keywords: Debt sustainability, forecasting, Brazil, IMF
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[1] Economics Department, University of Melbourne and IMF Fiscal Affairs Department, respectively. The authors thank the IMF Western Hemisphere Regional Studies Division for their support of this research, and Ana Corbacho, Marcos Chamon, Ben Clements, Irineu de Carvalho, Gabriel Di Bella, Marcio Garcia, Steve Phillips, Rodrigo Valdés, Francisco Vázquez, David Vegara, and WHD seminar participants for helpful comments.

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I. INTRODUCTION

This study proposes a stochastic debt forecasting framework that identifies and estimates the impact of feedback between fiscal policy and macroeconomic projections – effects which are largely absent from current debt forecasting algorithms. In such algorithms, a distribution of fiscal and debt forecasts is projected by combining simulated macroeconomic scenarios, a fiscal policy reaction function, and a debt motion equation. In the proposed framework, fiscal projections reflect contemporaneous macroeconomic shocks through automatic stabilizers, and also reflect discretionary fiscal policy shocks. In addition, forecasts of macroeconomic fundamentals are driven by lagged primary balances, reflecting lags in recognition, implementation, transmission, and legislative uncertainty of fiscal policy. Finally, the proposed framework's measures of uncertainty reflect the stochastic properties of the estimated parameters employed in forecasting, and are robust to structural changes and non-normally distributed shocks. Hence, debt projections result from macroeconomic aggregates and fiscal primary balances that are jointly forecast from a data generating process that depends on fiscal policy, macroeconomic shocks, and uncertainty over estimated parameters.

Prior studies– which exclude either the contemporaneous impact of macroeconomic shocks on the fiscal balance or the lagged effect of the fiscal balance on macroeconomic projections, or both – project fiscal policy in three broad ways. A first strand of the literature yields passive debt projections based on an agnostic view of fiscal policy – either some rule or a fixed primary balance with shocks.[2] A second strand models the primary balance as a function of past values of itself and other macroeconomic variables in a standard vector autoregression. Under this approach, the primary balance reflects past macroeconomic conditions, but not contemporaneous macroeconomic shocks.[3] A third strand models the fiscal position as a (non-linear) function of contemporaneous and past macroeconomic variables, but there is no channel for fiscal outcomes to feed back into macroeconomic forecasts.[4] The framework proposed here combines parts of the second and third approach in an empirical framework where macroeconomic shocks affect the fiscal balance contemporaneously, which in turn affects macroeconomic projections. Hence, this framework reflects both the contemporaneous correlation between macroeconomic shocks and the primary fiscal balance and the impact of the primary balance on macroeconomic projections.

Stochastic debt forecasts are closely related to various strands of the literature on monetary policy rules and inflation forecast targeting, such as in Svensson (1991). The fan charts of inflation forecasts produced by central banks as part of inflation targeting regimes strongly influenced debt sustainability fan charts that result from stochastic debt forecasts. The assumptions identifying structural fiscal shocks employed here are similar to prior work in monetary policy that employs structural vector autoregressions to identify shocks. In monetary policy, for example, Bernanke and Blinder (1992) and Bernanke and Mihov (1998) impose

[2] For example, Ferrucci and Penalver (2003), Tanner and Samake (2008) and Frank and Ley (2009).

[3] For example, Garcia and Rigobón (2005) and Penalver and Thwaites (2006).

[4] For example Celasun, Debreu and Ostry (2006), Di Bella (2008) and Hajdenberg and Romeu (2010).

structure on the (monetary) policy reaction function to identify the monetary stance while simulating the rest of the macroeconomy with a VAR. Similarly, the framework proposed here imposes structure on the fiscal policy reaction function which allows the fiscal primary balance to be decomposed into structural and cyclical factors. These different factors then help drive the simulations of macroeconomic aggregates and the debt motion equation, yielding a distribution of future debt outcomes that can be presented in a fan chart.

Prior work that seeks to identify the impact of discretionary fiscal policy changes on the economy also influences the framework proposed here.[5] These studies attempt to separate structural fiscal shocks from automatic stabilizers and measurement or other shocks through a "semi-structural" VAR. In such a VAR, non-policy macroeconomic variables are generally unrestricted. Structural changes in fiscal policy are identified either through indicator variables based on narrative records or through identifying assumptions regarding policy transmission lags. The framework proposed here identifies structural fiscal policy shocks through assumptions regarding policy transmission lags. Specifically, changes in the structural fiscal balance are assumed to impact macroeconomic aggregates only with a lag. In prior work, identification based on either the narrative record or timing assumptions has been employed largely to assess the effectiveness of countercyclical policy, particularly for the United States. To our knowledge, this type of identification of fiscal policy shocks has rarely been employed to assess debt sustainability and the impact of discretionary fiscal policy in emerging markets.

In addition, the proposed framework builds on prior work that both reduces and more accurately depicts the uncertainty surrounding debt forecasts. As in Litterman (1983) and Hajdenberg and Romeu (2010), forecast uncertainty in this study reflects the uncertainty stemming from parameter estimates. Hence, at each step of the forecasting algorithm, macroeconomic aggregates and the primary balance are projected from a draw of the distribution of the estimated parameters, rather than the estimates themselves. Also, restrictions imposed on the forecasting of the macroeconomic fundamentals reduce noise in the projections and parameter estimate uncertainty is incorporated in to the forecast, similar to Tanner and Samake (2008).[6] As in Frank and Ley (2009), the proposed framework does not assume normally distributed shocks and addresses the potential for structural breaks.

The literature routinely turns to Brazil as a case study for debt forecasting and management, and for comparability, the framework presented is tested on these data as well.[7] Some studies, however, rely on quarterly or monthly data to estimate the impact of fiscal policy on debt sustainability. One potential difficulty with this is that a country's fiscal stance is usually reviewed less frequently since substantive changes in revenue or expenditure policy require

[5] For example, Ramey and Shapiro (1998), Blanchard and Perotti (2002), Romer and Romer (2004), Ramey (2006), Romer and Romer (2009), among others.

[6] For example, that study uses a "near VAR" to project oil prices independently of country fundamentals.

[7] For example, Goldfajn (1998), Issler and Lima (1998), Goretti (2005), Goldstein (2003), Tanner and Ramos (2003), Giavazzi and Missale (2004), Garcia and Rigobón (2005), Celasun, Debreu and Ostry (2006), Penalver and Thwaites (2006), Tanner and Samake (2008), and Frank and Ley (2009).

legislative review as part of the annual budget planning exercise. Data at monthly or quarterly frequencies may also mask changing economic conditions because of seasonality or other measurement error that could present further difficulties in interpreting results. While for the country studied here (Brazil) a long quarterly historical time series is not available, for comparison with prior studies, the existing quarterly data is used. Nevertheless, as in Issler and Lima (1998) and Hajdenberg and Romeu (2010), a long-term (45 year) data set is constructed for the system estimation.

Estimations of the proposed framework yield empirical results in three areas. First, the proposed framework is compared to prior estimations that exclude feedback from fiscal policy to macroeconomic fundamentals. The mean and the variance of final projection year debt distribution are found to be (statistically) significantly different. The baseline debt forecast projects a modest decline in debt over the next five years, however, it omits significant second-round effects from policy decisions identified by the proposed framework. Estimations of the debt to GDP ratio could decline by between 10-15 percent more than projected in the baseline.

Second, estimations of the proposed framework test two channels through which fiscal policy feeds back into the economy: through the real interest rate and GDP growth (jointly), and through the real domestic interest rate. All else equal, a one percent of GDP increase in the primary balance in a given year is found to reduce economic growth in the following year one-sixth of a percent, though tests fail to reject that this effect is zero. Hence, this evidence does not support the effectiveness of fiscal policy as a means to spur or slow growth in the short run. A stronger and statistically significant effect is found for the domestic interest rate, where the analogous one percent of GDP increase in the primary balance reduces real domestic interest rates by two percentage points in the following year. This result is robust, consistent with estimates in other studies, and is to some extent expected given the high growth and real interest rates declines observed in recent years in Brazil.[8] Moreover, the results are consistent with evidence from the United States of a stronger impact of fiscal policy on long-term interest rates than on short-term growth.[9] Nevertheless, important caveats apply in that it remains a challenge to disentangle the impact of tighter fiscal policy on domestic real interest rates from, for example, the impact of institutional improvements or financial liberalization. For example, restrictions on the capital account and other financial constraints that could be reflected in historically high domestic real interest rates may have been part of an endogenous institutional policy response to an overwhelming fiscal problem. For example, Reinhart and Rogoff (2008) argue that financial repression of this nature was the main adjustment mechanism employed by

[8] As to the impact of fiscal policy on interest rates in other studies, Penlaver and Thwaites (2006), for example, estimates a vector autoregression on quarterly Brazillian data from 1999 Q2 - 2005 Q1 and finds that a one percent increase in the primary balance lowers the domestic interest rate by 6.2 percent.

[9] The negligible impact of structural changes in the primary balance on GDP growth found here is consistent with Romer and Romer (2010) – discussed below – which fails to find large output costs from tax policy changes intended to reduce the U.S. budget deficit, but could have expansionary effects through long-term interest rates. The empirical results presented do not parse the impact of changes in the structural primary balance in Brazil into revenue or expenditure measures, but does find a strong impact through real domestic interest rates rather than growth.

advanced economies to lower debt after the Second World War, for example, through Regulation Q in the United States.[10] This result suggests that improvements in the structural fiscal balance may have important second-round institutional effects; however, empirically confirming and measuring these are beyond the scope of this study.

Finally, the results suggest that the dynamics of the debt forecast depend on whether fiscal policy impacts predominantly GDP growth or the real domestic interest rate. That is, debt forecasts based on the two channels for fiscal policy feedback (to either real domestic interest rates or GDP growth) are found to be statistically significantly different. At the start of the forecasting period, both exercises depart from a relatively low primary balance and an increasing debt level (both variables appear lagged in the first year of the projection period), alongside a negative output gap from the global financial crisis which is quickly closed in the first year. In the simulation with fiscal policy feedback to domestic real interest rates, the debt-to-GDP ratio initially declines slowly, but then falls much faster in the medium term–to nearly 50 percent of GDP (from approximately 65 percent), as the lower initial primary balance increases borrowing costs. Hence, despite a higher primary balance (due to both the economic recovery and the need to service higher debt) and higher growth in the first projection year, debt does not initially decline as quickly because higher borrowing costs absorb the higher primary balance. Nevertheless, the higher primary balance in the first year lowers domestic real interest rates for the rest of the projection period, and a virtuous cycle of falling debt and falling primary balances is unleashed. In model where the primary balance feeds back primarily into real GDP growth, a lower primary at the outset increases GDP growth in first year and hence the debt to GDP ratio initially declines. Nevertheless, to the extent that there is no mechanism for lowering real borrowing costs, further debt reduction is limited. As the primary balance returns to its pre-crisis levels, the forecast resumes a slow but steady debt reduction path.

The estimations provide evidence supporting important feedback effects from fiscal policy to real domestic borrowing costs and GDP growth in a country such as Brazil. Moreover, the forecasts presented suggests that structural fiscal consolidation could have a significant impact on the debt level in Brazil primarily through lower real interest rates, with the median debt forecast declining by approximately 10-15 percent of GDP from present levels in the projection period.

More broadly, stochastic forecasts provide a systematic approach to making fiscal policy decisions and help shape expectations of medium-term debt outcomes. In the case of forecasts based on fiscal rules, projected declines in debt may lend support to the policy commitment, thereby helping to isolate decision-making from short-term political pressures.[11] The problem of

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[10] In addition to its direct impact on domestic real interest rates, an improved fiscal balance may have important second-round effects on these borrowing costs by allowing policy makers to relax some of the financial restrictions historically implemented in response to deteriorating conditions and arising in the wake of fiscal crises. Finding an instrument to identify these effects is beyond the scope of this study.

[11] For example, in 1997, the UK set two fiscal rules (the Sustainable Investment and the Golden Rule) that were intended to limit the level and purpose of government borrowing. In the *Budget Report* and *Pre-Budget Report*, the economic forecast is presented by the UK authorities in terms of forecast ranges, based on alternative assumptions about the supply-side performance of the economy. See HM Treasury (2008).

omitting automatic stabilizers or the transmission of fiscal policy to macroeconomic fundamentals in existing forecasting algorithms ultimately leads to misspecified dynamics. In such cases, policy decisions made during the forecast periods will diverge from the path of fiscal policy initially assumed in the forecast. Currently, institutions employ stochastic forecasting frameworks for inflation or budgets that account for the endogeneity of policy decisions and parameter estimate uncertainty to varying degrees; examples include the IMF, the Bank of England, the Norges Bank, the Riksbank, and the United States Congressional Budget Office, United States Social Security Administration Office of Policy, and the UK Treasury, among others. For example, the Bank of England describes its estimated probability distribution function at any period as a mixture of past forecast errors and subjective assessment.[12] The US Congressional Budget Office adopts a similar strategy in basing the published probability distribution of its fiscal policy forecasts on the historical distribution of past forecast errors. While it adjusts for the business cycle and structural changes (tax legislation), the impact of these changes appears largely assumption-driven rather than endogenously determined.[13] The estimations presented suggest that endogenizing policy explicitly in the projection of macroeconomic aggregates introduces statistically and economically significant directional changes in both the median forecast and its dispersion measures. Hence, failing to account for these effects could understate potential gains from a virtuous feedback cycle from fiscal policy decisions as well as the risks from lax policies.

The next section compares the framework proposed in this study with the structural VAR approach of Blanchard and Perotti (2002, and with two representative stochastic debt forecasting frameworks, Garcia and Rigobón (2005) and Hajdenberg and Romeu (2010). Section III lays out the building blocks of the baseline stochastic debt forecasting framework based on Hajdenberg and Romeu (2010) and estimates a comparator stochastic debt forecast. Section IV then introduces into the baseline framework feedback channels from policy variables to macroeconomic aggregates, estimates it, and compares its debt forecasts to the baseline. Section V concludes.

II. Identifying Policy Transmission: A Comparison to Prior Work

This section shows the fiscal policy transmission identification used to forecast debt in this study and relates it to similar prior monetary and fiscal policy studies. The proposed framework is compared to the SVAR of Blanchard and Perotti (2002) and others used to identify fiscal transmission mechanisms as well as two representative approaches to stochastic debt forecasting, Hajdenberg and Romeu (2010) and Garcia and Rigobón (2005).

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[12] See Bank of England (2002), pp. 48-49.

[13] See Congressional Budget Office (2006), pp.8-18, Congressional Budget Office (200a, b).

Fiscal policy feedback into macroeconomic forecasts

Bernanke and Blinder (1992), Bernanke and Milov (1995), and Blanchard and Perotti (2002), identify the effects of dynamic policy shocks through a "semi-structural VAR." Suppose an economy with a structure that follows:

$$X_t = \sum_{i=0}^{k} A_i X_{t-1} + \sum_{i=0}^{k} B_i y_{t-i} + Cu_{1t} \tag{1.1}$$

$$y_t = F\left(X_t, X_{t-1}, \ldots, X_{t-k}, y_{t-1}, \ldots, y_{t-k}\right) + u_{2t}. \tag{1.2}$$

Equations (1.1) and (1.2) define a (possibly non-linear) model which allows both contemporaneous and lagged values in any equation. Upper case letters identify vectors or matrices of variables or coefficients. Equation (1.1) represents a vector of non-policy macroeconomic variables, and y_t represents either the primary fiscal balance or the monetary policy rate, depending on whether the objective is fiscal or monetary policy. Here, equation (1.2) is a generalized fiscal reaction function of past fiscal and both contemporaneous and past macroeconomic variables, and can be linear or non-linear in form. Equation (1.1) represents the structural relationships in the rest of the economy. As in prior work, econometric identification is achieved by assuming that because of timing, implementation lags, or some other mechanism, contemporaneous macroeconomic shocks in equation (1.1) impact equation (1.2) and not vice versa.

The framework proposed in this study assumes the following:

$$X_t = \mathrm{A}_{10} + \mathrm{A}_{11} X_{t-1} + \mathrm{A}_{12} y_{t-1} + \mathrm{A}_{13} \mathrm{E}_{1t}, \quad and \tag{1.3}$$

$$y_t = \alpha_{20} + \alpha_{31} debt_{t-1} + \alpha_{41} gap_t + \alpha_{51} xr_t + \varepsilon_{2t}. \tag{1.4}$$

In equation (1.3), macroeconomic fundamentals depend on one period lagged values of themselves and the fiscal primary balance. The next section develops (1.4), the primary fiscal reaction function, which depends on the lagged debt to GDP ratio ($debt_{t-1}$), the output gap (gap_t), and the change in the real exchange rate (xr). These three components follow Taylor (2000) and Di Bella, Phillips and Valdés (2011) in identifying the structural, cyclical, and commodity revenue components of the fiscal reaction, respectively. Hence, the error in (1.4) is interpreted as a structural fiscal policy shock. The contemporaneous macroeconomic errors (1.3), given by E_{1t}, appear in the fiscal primary balance through the output gap and the change in the real exchange rate. Thus, the primary fiscal balance reflects contemporaneous macroeconomic conditions (i.e. E_{1t} impacts y_t) but macroeconomic aggregates reflect structural fiscal policy shocks only with a lag (i.e. ε_{2t} will only impact X_{t+1}). This assumption, common to Bernanke and Minov (1995), Blanchard and Perotti (2002), Perotti (2007), among others, the system is identified, and A_{12} can be interpreted as the macroeconomic impact of a structural policy shock. Nevertheless, Ramey (2006), among others, argues that fiscal shocks potentially could be contemporaneously correlated with macroeconomic shocks insofar as policy outcomes are anticipated. Such anticipation effects would undermine identification here, but Romer and

Romer (2010) reject these effects for the US economy. In the framework proposed here, structural policy decisions are assumed to be sufficiently uncertain and delayed so as to allow identification (due to, for example, uncertainty regarding specifics of legislation or recognition, implementation, and transmission lags).

Structural VAR and fiscal policy transmission

Studies of fiscal policy transmission such as Blanchard and Perotti (2002) propose estimating the following system:

$$X_t = \mathrm{A}(L)X_{t-1} + U_t. \tag{1.5}$$

In (1.5), X_t is a vector consisting of government taxes (*t*) and primary expenditure (*g*), as well as output growth (*y*). This approach does not model the primary balance but rather includes the revenue and expenditure policy variables directly in the VAR. The relation between the structural shocks (U_t) and the reduced form residuals are given by:

$$u_t^t = a_1 u_t^y + a_2 e_t^g + e_t^t\,, \tag{1.6}$$

$$u_t^g = b_1 u_t^y + b_2 e_t^t + e_t^g\,,\ \ and \tag{1.7}$$

$$u_t^y = c_1 u_t^t + c_2 u_t^g + e_t^y\,. \tag{1.8}$$

Identification is achieved by assuming that contemporaneous impact of fiscal shocks on taxes (a_1) and expenditure (b_1) reflect only automatic stabilizers and not discretionary policy, because of the aforementioned timing effects. Direct information about tax systems yield tax and expenditure elasticities with respect to output, (i.e. a_1 and b_1), allowing u_t^g and u_t^t to be adjusted for the cycle, and identifying c_1 and c_2. Finally, that study assumes alternatively that either spending reacts to tax shocks or vice versa to identify a_2 and b_2. The main difference with this study is in the linear form of the fiscal reaction function, given by (1.8).

Including output growth rather than the output gap in predicting the fiscal reaction implies relying on institutional information about tax and expenditure, both for the elasticity of tax base to output changes, and the elasticity of the tax base to GDP. Whatever the validity of these calculations, they are imposed from outside of the system estimation and hence, there is limited information regarding the uncertainty of these estimates, or how any errors in the calculations are biasing other errors in the forecasting exercise. This linear fiscal reaction function also lacks the non-linear presence of lagged debt, which Hajdenberg and Romeu (2010) and Favero and Giavazzi (2009) find to be important drivers of fiscal policy, and hence could affect the estimates of the error term e_t^y, interpreted to be the structural policy shock in the debt forecasts.

Stochastic Debt Forecasting Frameworks

Fiscal policy passively reacting to macroeconomic conditions

Unlike Blanchard and Perotti (2002) studies such as Hajdenberg and Romeu (2010) project debt based on a fiscal reaction function that responds to macroeconomic developments but lacks feedback from fiscal policy to macroeconomic forecasts. For simplicity, suppose that GDP is the only non-policy economic aggregate in the economy, and that the fiscal balance depends linearly on output growth (rather than the fiscal reaction functional actually used, given in equation (1.4)). The Hajdenberg and Romeu (2010) framework would be given by:

$$\begin{aligned} x_t &= \alpha_{10} + \alpha_{11} x_{t-1} + \varepsilon_{1t}, \quad and \\ y_t &= \alpha_{20} + \alpha_{31} x_t + \varepsilon_{2t}. \end{aligned} \tag{1.9}$$

Hence, declining GDP lowers the primary balance contemporaneously, but there is no impact of a primary balance shock to GDP growth. Equation (1.9) can be simplified to structural form:

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \begin{pmatrix} \alpha_{10} \\ \alpha_{20} + \alpha_{31}\alpha_{10} \end{pmatrix} + \begin{pmatrix} \alpha_{11} & 0 \\ \alpha_{31}\alpha_{11} & 0 \end{pmatrix} \begin{pmatrix} x_{t-1} \\ y_{t-1} \end{pmatrix} + \begin{pmatrix} 1 & 0 \\ \alpha_{31} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} . \tag{1.10}$$

Not factoring policy outcomes into macroeconomic forecasts could quickly lead to inconsistent results if, for example, fiscal policy is effective in stabilizing the macro economy. Romer and Romer (1994) show that for the United States, automatic stabilizers are important immediate drivers of output recoveries, and for Brazil, the case studied here, de Mello and Moccero (2006) show the elasticity of the primary balance to the output gap to be comparable to OECD countries. This study extends the system in (1.10) to capture feedback from fiscal policy to output and measure the impact of allowing such a feedback channel on debt sustainability.

Fiscal policy reflecting lagged macroeconomic developments

Continuing with the previous example, frameworks such as Garcia and Rigobón (2005) would estimate debt using a vector autoregression of the form:

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix} \begin{pmatrix} x_{t-1} \\ y_{t-1} \end{pmatrix} + \begin{pmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{pmatrix} \tag{1.11}$$

The system in (1.11) does not identify the contemporaneous impact of macroeconomic shocks on the primary balance. Including the primary balance in the VAR implies that there is no fiscal reaction function to decompose the fiscal balance in to cyclical and structural components, as in Hajdenberg and Romeu (2010). Nor is the error term on the primary balance equation decomposed into the structural or cyclical components, as in Blanchard and Perotti (2002). Hence, from (1.10), υ_{2t} will include the impact of both $\alpha_{31}\varepsilon_{1t}$, which would reflect automatic stabilizers, and ε_{2t}, which could be interpreted as the structural, measurement, or some other orthogonal fiscal shocks.

III. Baseline Estimation and Comparison against No Fiscal Policy Feedback

This section develops and estimates the proposed framework, which extends a basic stochastic debt forecasting algorithm to capture feedback from fiscal policy in its macroeconomic projections. The framework consists of three blocks. The first block models the primary balance as a function of past debt to GDP ratio as well as to other economic fundamentals. This fiscal reaction function is estimated from a forty-five year sample of data to produce the distribution of the fiscal reaction function parameters. In simulating future primary balances, a realization of macroeconomic fundamentals is combined with a draw from the distribution of estimated fiscal reaction function coefficients and a draw of historical fiscal shocks. The second block models economic fundamentals using a restricted vector auto regression. Future economic scenarios are simulated by combining the values of lagged macroeconomic fundamentals with a draw from the distribution of the estimated VAR coefficients as well as a draw of economic shocks. Thousands of these scenarios are simulated and then fed into the first block to produce thousands of corresponding fiscal balances. The last block consists of a debt motion equation. It links the first two blocks, incorporating uncertainty from the distribution of both shocks and the estimated parameters in forecasting debt.

A. Fiscal Reaction Function

Estimating the fiscal policy reaction based on historical data must overcome limitations on data availability as well as potential parameter instability over time. The ability to overcome data limitations is straightforward – sources must be found that can be used to piece together a historical record of a given country's fiscal performance. Figure 1 graphs the historical data set constructed in this study, which is based on annual data for Brazil spanning five decades (sources are documented in the data appendix). Given these data, the question arises as to the comparability of both historical shocks with the distribution of future shocks, and their impact on policy outcomes. Insofar as these potential difficulties are addressed below, these long historical data overcome interpretation difficulties in studies employing multi-country panel estimates to project policy in one country.

The primary balance (denoted *pb*) is estimated as a function of the debt to GDP ratio (denoted *debt*), the annual growth rate in real effective exchange rate (denoted *xr* and defined such that the larger value implies depreciation of domestic currency), and the GDP gap (denoted *gap* and defined as deviation from hp-filtered trend),[14]

$$pb_t = \alpha_0 + \alpha_1 debt_{t-1} + \alpha_2 xr_t + \alpha_3 gap_t, \tag{1.12}$$

As in Tanner and Samake (2008), indicator variables are included to control for two important measurement changes in the data recorded during the estimation period 1965-2009. The first indicator variable is unity from 1965–84 to control for the use of estimated primary balances rather than direct measures. The primary balance is estimated from revenue, expenditure and debt service data, and may be subject to a litany of measurement errors and other issues related

[14] Hajdenberg and Romeu (2010), Celasun Debreu and Ostry (2008), Penalver and Thwaites (2006) and Garcia and Rigobón (2005) employ variations of this equation to estimate fiscal policy.

to the economic events during that period.[15] The left panel of Figure 2 shows the primary balance from 1965-2009 (in percent of GDP, right scale). The gray bars indicate the period in which it is estimated rather than taken from official sources. The right panel of Figure 2 shows the debt to GDP ratio from 1965-2009. During this period, varying forms of debt restructuring and exceptional financing were reported in these data. At these times, the fiscal reaction to the debt level may differ from periods when changes in the debt are driven largely by the evolution of macroeconomic variables. As a result, an indicator variable is included to control for these periods. The indicator is unity when the data record a restructuring amount or positive exceptional financing. This dummy is included by itself, and is also interacted with the debt, inflation and the output gap, as these are found to have a statistically significantly different effect on the fiscal reaction during restructuring periods.

Hence, the fiscal reaction function controlling for these changes in measures and debt restructurings is:

$$pb_t = \alpha_0 + \alpha_1 debt_{t-1} + \alpha_2 xr_t + \alpha_3 gap_t + \ldots$$

$$\ldots + \alpha_4 dum2_t + \alpha_5 dum_t{*}debt_{t-1} + \alpha_6 dum_t{*}gap_t + \alpha_7 dum_t{*}inf_t + v_t, \tag{1.13}$$

where *dum* is a dummy variable for the period of debt restructuring, and *dum2* indicates the period of discontinuity in primary balance series. Note that the dummies reflect only recorded measurement changes and not normative judgments. For example, the indicator graphed against the primary balance in Figure 2 allows estimation during the entire sample while controlling for potential measurement issues during high inflation periods. Table 1 gives summary statistics for the explanatory macroeconomic variables in the fiscal reaction function by decade and for the entire sample. An inverse relationship between the real interest rate and both output growth and the primary balance is observed. The table also shows decades of negative real interest rates followed by two decades of high real interest rates and high inflation rates.

Equation (1.13) is estimated in Table 2 via ordinary least squares, instrumental variable regression (for potentially endogenous output gap), and GMM estimation. The estimated coefficients are significant at all conventional levels and measures of the goodness of fit are high. The positive and significantly estimated coefficient on lagged debt is consistent with evidence of fiscal adjustment driven by increasing debt to GDP rations found for the United States.[16] The results also identify two reactions to debt restructuring periods. First, the fiscal reaction to debt is much weaker and is consistent with employing restructuring, exceptional financing, and other unconventional policies because of potential fiscal difficulties. Second, inflation appears to improve the primary balance during periods of restructuring, perhaps reflecting potential short-run fiscal benefits from the inflation tax.

[15] Chapter 9 in Boughton (2001) recounts policy adaptation to changing economic conditions during this period. The data sources are given in the appendix.

[16] As shown by Bohn (1998), a positive estimated response of the primary balance to public debt is sufficient to ensure long-run solvency.

The fit of the estimated OLS and instrumental variable equations is graphed in Figure 3 (lower left and right panels, respectively) and alongside the primary balance and debt levels (upper left and right panels). The fitted model closely tracks the actual measures of fiscal performance. While breaks could be present in these data, the evidence suggests that the proposed empirical specification captures these potential changes. The model residuals are tested and are not found to have structural breaks.[17] In addition, no evidence is found of unit roots, autocorrelation in the residuals, or endogeneity of the output gap. Figure 4 shows a rolling OLS regression on fifteen, twenty-five, and thirty-five year windows of data for the fiscal reaction function (equation (1.13)). The dashed line shows the full-sample point estimate, while the dark solid line and shaded area shows the rolling regression point estimate and ninety-five percent confidence interval, respectively. The full sample estimated coefficient remains within the confidence interval for most of the sample for all three determinants of fiscal policy used in the debt projection. Moreover, they appear stable for most of the period. Hence, the high goodness of fit, the lack of structural breaks, and broadly stable rolling estimates that fail to reject the null of equality with the full sample estimate for most of the period are jointly taken as evidence that the historical estimate of the fiscal reaction overcomes the aforementioned data and robustness difficulties.

B. Estimation of the Fundamental Macroeconomic Variables

The second block of the algorithm requires vector auto regression estimates of the macroeconomy to generate future potential debt scenarios. As data for past economic fundamentals are available at quarterly frequency, a VAR(1) specification for 1995-2008 given in equations (1.14) through (1.17) is estimated: [18]

$$ius_t = C_{10} + C_{11}ius_{t-1} + C_{12}ibra_{t-1} + C_{13}gdp_{t-1} + C_{14}xr_{t-1} + \varepsilon_{1t}, \tag{1.14}$$

$$ibra_t = C_{20} + C_{21}ius_{t-1} + C_{22}ibra_{t-1} + C_{23}gdp_{t-1} + C_{24}xr_{t-1} + \varepsilon_{2t}, \tag{1.15}$$

$$gdp_t = C_{30} + C_{31}ius_{t-1} + C_{32}ibra_{t-1} + C_{33}gdp_{t-1} + C_{34}xr_{t-1} + \varepsilon_{3t}, \tag{1.16}$$

$$xr_t = C_{40} + C_{41}ius_{t-1} + C_{42}ibra_{t-1} + C_{43}gdp_{t-1} + C_{44}xr_{t-1} + \varepsilon_{4t}, \tag{1.17}$$

Where *ius* is US real interest rate (10 year government bond yield deflated by GDP deflator), *ibra* is Brazil real interest rate (money market rate deflated by CPI), *gdp* is real GDP growth, and *xr* is growth rate of real effective exchange rate. Table 3 shows the estimation result, in which a number of coefficients are neither statistically significant nor economically sensible. For example, projecting the US interest rate based on lagged values of Brazilian macroeconomic variables does not appear reasonable and is statistically insignificant. Inclusion of such

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[17] Supremum tests for multiple structural breaks in unknown locations finds no breaks in the residuals at conventional significance levels. The implementation of the Andrews (1993) test used here is based on Bai and Perron (1998). At better than 5 and 1 percent significance levels, the sequential break test found no structural breaks.

[18] This estimation period avoids high volatility, for example, high domestic real interest rates in the early 1990s. Throughout the study, the annual interest rate is taken as the compound average of the monthly interest rates during the year to avoid biases introduced during high inflation periods.

insignificant variables in the projection of macroeconomic scenarios introduces large model uncertainty in forecast – particularly when accounting for estimation error. As shocks work their way through the system, they are amplified by these nonsensical estimated coefficients and introduce noise into the forecast. Hence, a restricted VAR shown in equations (1.18) – (1.21) is also estimated which discards irrelevant right hand side regressors. In this restricted system, the US and domestic real interest rates are a function of their lagged values, GDP growth depends on lags of the domestic rate and itself, and the real exchange rate depends on lags of GDP growth and itself.

$$ius_t = C_{10} + C_{11} ius_{t-1} + \varepsilon_{1t}, \tag{1.18}$$

$$ibra_t = C_{20} + C_{22} ibra_{t-1} + \varepsilon_{2t}, \tag{1.19}$$

$$gdp_t = C_{30} + C_{32} ibra_{t-1} + C_{33} gdp_{t-1} + \varepsilon_{3t}, \tag{1.20}$$

$$xr_t = C_{40} + C_{43} gdp_{t-1} + C_{44} xr_{t-1} + \varepsilon_{4t}. \tag{1.21}$$

Table 4 shows the restricted VAR estimation using seemingly unrelated least squares. Forecasting macroeconomic fundamentals based on equations (1.18) through (1.21) minimizes the propagation of shocks through non-sensible channels and imprecise estimates. For example, a shock to GDP growth in Brazil would not be transmitted into US interest rates, as in (1.14) through (1.17). Moreover, accounting for parameter uncertainty only worsens this problem, as the confidence interval is likely to be large. Hence, the proposed framework projects the macroeconomy based on the more parsimonious model.

C. A Baseline Debt to GDP Forecast

As in prior work, the debt to GDP ratio evolves according to the following motion equation:

$$\begin{aligned} debt_t &= (1 + gdp_t)^{-1} \{ (1 + ius_t)(1 + xr_t)\, debt^F_{t-1} + (1 + ibra_t)\, debt^D_{t-1} \} + \ldots \\ &\ldots - pb_t + \Delta assets. \end{aligned} \tag{1.22}$$

where $debt^F$ is a ratio of foreign currency or dollar-linked debt to GDP and $debt^D$ is a ratio of domestic currency debt to GDP. Hence, equation (1.22) gives the new debt level based on the fiscal reaction of equation (1.13) to each Monte Carlo simulation from the restricted VAR (equations (1.18) through (1.21)). The last term (*Δassets*) captures debt issuance by the authorities to offset asset accumulation at the central bank. This type of asset accumulation is a recent feature in some emerging markets but not an important driver of debt over the longer sample, and is operationalized here by assuming that a ten percent real appreciation increases the debt by one percent of GDP.[19]

[19] Issuing debt to offset reserve and other asset accumulation is a recent phenomenon, since approximately 2005, and as the authorities' strategy for intervention is not public, a stylized rule is used here (without loss of generality to the reported simulations). For example, from 2005-09 Brazil accumulated roughly US$185 billion in central bank reserves, while observing a nearly sixty percent cumulative appreciation in the real effective exchange rate, and

(continued…)

Figure 5 estimates the baseline model, including the restricted VAR and no feedback from fiscal policy to macroeconomic aggregates. The figure separately shows forecast variability originating from estimated coefficients (bottom left panel) and error terms (upper left panel). In the top-left panel, only the simulated errors are added while all the coefficients are set to point estimate values (mean of estimated distributions). In the bottom-left panel, the simulated coefficients are used while error terms are set to zero. The full uncertainty debt is forecast shown in the upper right panel. It results from simulating economic fundamentals each forecasting period and drawing coefficients from the fiscal reaction function and VAR independently from their estimated normal distributions. Errors are similarly drawn from the normal distribution with estimated covariance matrices, i.e., the estimated variance of v in the fiscal reaction function (equation (1.13)) and the estimated variance-covariance matrix of $\varepsilon=[\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4]'$ in VAR, (equations (1.18) - (1.21)).[20] This conventional debt simulation model, which excludes feedback from fiscal policy, suggests a broadly stable median debt forecast during the projection period.

IV. Debt Forecasts Including Feedback from Primary Fiscal Balance

This section extends the forecasting algorithm outlined above to include feedback from fiscal policy to macroeconomic aggregates. Hence, the prior year primary balance is used in projecting output growth and the domestic real interest rate, which are jointly estimated with the fiscal reaction function. Evidence is found supporting the existence of this feedback channel, and in particular, the real domestic interest rate is found to decline in response to higher primary balances. The results show debt declines faster relative to prior debt forecasting algorithms because higher primary balances lower real government borrowing rates. This suggests that excluding feedback from fiscal policy could, for example, underestimate debt declines in forecasts of countries with a "virtuous cycle."

Estimation proceeds with the inclusion of lagged primary balance in either output growth or the real domestic interest rate forecasting equations. As above, this section rules out the potential for Brazilian fiscal policy to impact US real interest rates, and no evidence is found supporting a short-term impact on the real exchange rate.[21] The box labeled equation system (1.23) shows the dynamic feedback, where the macroeconomic forecasting system (analogous to (1.18) through (1.21)) modified for the fiscal impact and jointly estimated with the fiscal reaction function. Equation (1.22), the debt motion equation, is imposed on the system as an identity alongside the evolution of the output gap.[22] Long-term growth (*ltg* in system (1.23)), which is necessary to calculate the output gap, is operationalized by estimating the average change in Hodrick-Prescott smoothed real output growth over the past twenty years.

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increasing its central bank claims on the central government by approximately 1 percent of GDP per year (unevenly, with greater accumulation of debt and reserves in recent years and more appreciation earlier on).

[20] In section 3, both normality and Bootstrapping are used to calculate the forecast errors.

[21] Estimates presented are robust to including both a fiscal feedback to the real exchange rate equation in system (1.23), and a squared lagged real exchange rate term.

[22] Garcia and Rigobón (2005) allow the debt evolution to include surprises in the debt level. In this framework, including a shock in (1.22) could capture such debt surprises, which would reflect the chosen shock distribution.

System Estimation with Endogenous Fiscal Policy (1.23)

$$ius_t = C_{10} + C_{11}iust_{t-1} + \varepsilon_{1t}$$

$$ibra_t = C_{20} + C_{22}ibra_{t-1} + C_{25}pb_{t-1} + C_{75}{*}intdum_t + \varepsilon_{2t}.$$

$$gdp_t = C_{30} + C_{32}ibra_{t-1} + C_{33}gdp_{t-1} + C_{34}xr_{t-1} + C_{35}pb_{t-1} + C_{76}dum2_t + \varepsilon_{3t}\ .$$

$$xr_t = C_{40} + C_{33}gdp_{t-1} + C_{44}xr_{t-1} + \varepsilon_{4t}.$$

$$pb_t = C_{50} + C_{53}gdp_t + C_{54}xr_t + C_{56}debt_{t-1} + \ldots$$

$$\ldots + C_{71}dum2_t + C_{72}dum_t{*}debt_{t-1} + C_{73}dum_t{*}gap_t + C_{74}dum_t{*}inf_t + \varepsilon_{5t}$$

Such that (1.22)*, and:*

$$GDP_t = GDP_{t-1}{*}(1+ gdp_t).$$

$$GDP\_HP_t = GDP\_HP_{t-1}{*}(1+ ltg).$$

$$gap_t = GDP_t / GDP\_HP_{t-1} - 1.$$

Table 5 presents the estimation results for system (1.23). The left panel estimates include fiscal policy feedback to real domestic interest rates, and the right panel estimates include fiscal policy feedback to both real domestic interest rates and output growth. Estimation is based on annual data (1965-2009) rather than quarterly data estimates of equations (1.18) through (1.21) shown in Table 4. The use of annual data synchronizes changes in the macro and fiscal variables driving the estimation. While quarterly data allows for more observations and may reasonably capture the evolution of macroeconomic fundamentals, it is not as useful in capturing the impact of fiscal policy which is generally not reviewed at the quarterly frequency (at least structural fiscal measures). Its impact also takes more than one-quarter to be reflected in aggregate data. Finally, data constraints limit the use of lags. Nevertheless, comparing the estimated coefficients on the macroeconomic variables in Table 5 (based on annual data) with Table 4 (based on quarterly data), the real foreign and domestic interest rates are consistent across estimation methods, and suggest that higher real rates are associated with increased output growth, perhaps reflecting fiscal crowding out. Moreover, higher output growth appreciates the domestic currency (a negative growth rate of the REER), perhaps reflecting capital inflows during boom periods.

Feedback from Fiscal Policy to Real Domestic Interest Rates

Table 5 suggests that higher lagged primary balances imply lower domestic real rates in the following year. This result (p-value of 0.01) supports the notion that fiscal consolidation lowers domestic borrowing costs. The estimate of approximately 2 is high – it implies that an increase in the primary balance of one percent (from an "average" primary balance) lowers real domestic interest rates by 2 percentage points the following year (e.g. borrowing costs decline from 16 percent to 14 percent real interest). While there are important caveats suggesting an upward bias in this estimate, there is also robust evidence supporting it.
To get a feel for this effect, Figure 7 shows scatter plots of the two-year moving average of the primary balance against the real interest rate by decade. Every decade since the 1960s shows a

negative slope except for the 1980s and 1990s – periods associated with bouts of hyperinflation and economic volatility. The result visible within each decade is also evident from Table 1 for the last three decades. Large changes in the average real domestic interest rate from the 1980s until 2009 are inversely related to changes in the average primary balance. Of course, the interest rates changes in each decade likely also reflect institutional changes, for example financial liberalization, or disinflation. Nonetheless, one could argue that institutional changes are no less endogenous than the primary balance, and it is difficult to imagine that resorting to capital account restrictions or an inflation tax is not related to fiscal difficulties reflected in lower primary balances, higher risk premiums, and higher domestic real interest rates. Moreover, Reinhart and Rogoff (2008) show that historically, advanced economies have responded to elevated debt levels by instituting financial repression in order to lower their real borrowing costs.

Further evidence is presented in Table 6, which shows bilateral regressions of the real domestic interest rates on the lagged primary balance using different estimation methods and functional forms, as well as the full sample and a shorter more recent period, 1996-2009. In the most recent period, the estimated coefficient of approximately -2 on the primary, while statistically insignificant in some cases, supports the inverse relationship found above. Hence, this evidence, alongside the estimated system of equations suggests that Brazilian fiscal policy can lower domestic real rates. Nevertheless, caveats remain relating to potential upward biased estimates from institutional and other changes that are difficult to disentangle from the primary balance.

The debt projection depicted in Figure 8 results from a five-year simulation of the system given in equation (1.23), and can be compared to Figure 5, which shows the analogous debt projection with no fiscal policy feedback. Including feedback from fiscal policy to macroeconomic fundamentals induces a faster decline in the median debt level as compared with the forecast that excludes fiscal policy feedback. Table 7 compares measures of dispersion for the three forecasts. By 2013, the median debt level has fallen to between 50 and 55 percent of GDP in Figure 8, whereas without feedback the debt increases slightly, to approximately 70 percent of GDP in Figure 5.

Figure 9 forecasts the macroeconomic fundamentals driving the debt forecast, with lagged fiscal policy impacting the real domestic interest rate.

- In 2009, the primary balance declines and debt-to-GDP increases reflecting the impact of the global economy.
- The model anticipates an increase in the primary balance in 2010 because of both the need to finance higher debt and a projected economic recovery closing the output gap.
- The effect of a lower primary in 2009, however, feeds back into higher domestic real interest rates in 2010, increasing debt servicing costs, so that the improvement in the primary balance does not lower the debt-to-GDP ratio in that year.
- The higher primary in 2010 then lowers the real interest rate in 2011, thereby lowering the debt service, and allowing for a virtuous cycle of lower primary and lower debt levels.
- As the debt level declines and the primary balance falls towards the end of the five-year projection period, the real interest rate increases.

Two effects are observed in the forecast; first, the primary balance responds to the (lagged) changes in the debt level, which in turn is driven by both economic shocks and debt servicing costs. Secondly, changes in the primary drive the following year real domestic interest rates. Hence, an improvement in the fiscal position in 2010 to levels consistent with the historical performance predicted by the fiscal reaction function would unchain a virtuous cycle of debt reduction. Based on the fiscal reaction function, the small increase in debt in 2009 and the recovering economy would both tend to produce a higher primary balance in 2010. This implies lower real domestic interest rates in the medium term, lower the debt, and lower future primary balances.

Feedback from Fiscal Policy to Real Output Growth

The left panel of Table 5 suggest that higher lagged primary balances imply both lower real domestic borrowing costs and lower real GDP growth in the following year – a one percent increase in the primary balance lowers growth by about one-sixth of a percent (though insignificantly different from zero.

Figure 10 shows the simulated macroeconomic and debt forecast based on this scenario, where fiscal policy feeds back to real GDP and real domestic borrowing costs with a lag:

- Similar to the prior simulation, as the economy absorbs the shock of the global financial crisis in 2009, the primary balance declines and the debt increases slightly;
- The (countercyclical) decline in the primary balance increases GDP growth in the following year. Hence, output growth is higher in 2010 as compared to the prior model (of feedback through real domestic interest rates);
- Given stronger GDP growth in 2010 alongside higher debt in 2009, a higher primary balance is projected for 2010 (debt in 2009 is observed for both models) relative to the prior model (which assumes feedback only to the real interest rate from lagged fiscal policy).

V. Conclusion

This paper presents a framework for simulating a distribution of debt-to-GDP ratios reflecting uncertainty from country-specific (potentially non-normal) future economic shocks, structural and cyclical fiscal policy changes, and parameter estimate uncertainty.

Incorporating fiscal policy feedback into the macroeconomic projections driving the fiscal and debt simulation ensures that debt forecasts reflect both the direct impact of the primary balance on paying down the debt, as well as its indirect impact through macroeconomic fundamentals such as GDP. Hence, this framework yields debt forecasts based on projections of domestic borrowing costs or output growth, that in turn are affected by changes in the primary balance. Prior methodologies that exclude the impact of contemporaneous macroeconomic shocks or that exclude feedback from fiscal policy to forecasts of macroeconomic fundamentals are likely to have predictable forecast errors.

The distribution of debt-to-GDP ratio produced by this framework also reflects an array of uncertainty present in any forecasting framework. The study employs a data set spanning five decades so that the sample of shocks from which simulation errors are drawn is ergodic. The estimated distributions of shocks and parameters are not assumed to be necessarily normally distributed. The equations predicting the fiscal reaction to macroeconomic realizations are checked for robustness to structural breaks. The forecast incorporates the stochastic distribution of the estimated parameters to project variables; i.e., the proposed framework incorporates parameter estimate uncertainty into the forecast.

The empirical results suggest that identifying the transmission of fiscal policy to macroeconomic fundamentals can change both the median and dispersion of the projected distribution of the debt-to-GDP ratio. Driving this change are the statistically and economically significant second-round effects of fiscal policy on macroeconomic fundamentals. Specifically, a one-percent higher primary balance in these data is found to lower future real domestic interest rates by approximately two percentage points, which in turn boosts GDP growth and reduces the debt-to-GDP ratio. In comparing debt forecasts with and without these effects, the difference in the forecasted debt decline is roughly 10-15 percent of GDP over a five years projection period for Brazil. Moreover, the channel through which the primary balance affects macroeconomic fundamentals is important. If a lower primary balance today raises growth next year, debt could fall initially but then decline slowly over the medium term, as the debt reduction effects of higher GDP are partially offset by the initial lower primary balance. If a higher primary balance today lowers the real domestic interest rate next year, debt may not decline initially, but the subsequent declining interest rates would bring the debt to GDP ratio lower over the medium term.

The empirical evidence suggests a historical link from primary balances to real domestic interest rates, and thus, a sufficiently high primary balance could bring substantial debt reduction and lower domestic real borrowing costs. More generally, the evidence presented suggests that forecast targeting of key economic aggregates that fail to incorporate feedback from policy decisions to macroeconomic outcomes could ultimately communicate projections containing economically significant directional biases and inaccurate measures of forecast uncertainty.

Tables

Table 1. A Summary of Macroeconomic Fundamentals, by Decade

Decade ending:	Debt to GDP Ratio	Primary balance	Domestic real interest	Real GDP Growth	Annual Inflation Rate
1969	16.7	-0.2	1.5	10.5	36.2
1979	27.0	2.4	0.0	7.9	30.6
1989	45.4	3.7	-0.7	3.0	328.1
1999	35.2	2.1	22.7	1.7	854.8
2009	67.5	3.7	9.0	3.3	6.9
Total	40.8	2.6	7.1	4.7	275.2

Sources: IFS, IPEA, Silva et al., WEO, and Authors' estimates.

Note: Simple average of macroeconomic aggregates by decade and for the full sample period for Brazil, annual data, 1965-2009. Annual interest is calculated as the compound average of the monthly real interest rates to correct for inflationary bias during part of the sample period.

Table 2. Estimation of Baseline Fiscal Reaction

Primary balance	OLS	IV	GMM
d_{t-1}	0.11***	0.10***	0.09***
yg_t	0.09*	0.15**	0.14***
Δe_t	0.05**	0.05***	0.05***
Dum2 (PB Data)$_t$	-0.03**	-0.03**	-0.03***
*Debt*Debtdummy*$_t$	-0.25**	-0.30***	-0.31**
*Output Gap*Debtdummy*$_t$	0.00***	0.00***	0.00***
*Inflation*Debtdummy*$_t$	0.03***	0.03***	0.02***
constant	-0.03**	-0.02**	-0.02**
N	44	44	44
R^2	0.62	0.6	0.6
Adj. R^2	0.55	0.53	0.52

Sources: Authors' estimates; P-values: *p<.1;**p<.05;***p<.01.

Note: The table shows estimations of the fiscal reaction function, where the dependent variable is the primary fiscal balance, d_{t-1} is the one-year lagged debt-to-GDP ratio, yg_{t-1} is the output gap, and Δe_{t-1} is the change in the real bilateral (U.S.-Brazil) exchange rate. OLS, Instrumental Variable and GMM estimation of the fiscal reaction function, including interactions with indicator variables for measurement error (Dum2) and for exceptional financing (Debtdummy).

Table 3. VAR Macroeconomic Fundamentals

	i^{US}	i^{BRA}	GDP	XR
i^{US}_{t-1}	0.86	2.33	-0.02	0.48
P-val	*0.00*	*0.00*	*0.91*	*0.73*
i^{BRA}_{t-1}	0.00	0.21	-0.02	0.32
P-val	*0.49*	*0.01*	*0.46*	*0.10*
GDP_{t-1}	-0.05	-0.44	0.56	0.42
P-val	*0.09*	*0.24*	*0.00*	*0.63*
XR_{t-1}	0.00	-0.07	-0.03	0.70
P-val	*0.20*	*0.13*	*0.04*	*0.00*
Constant	0.00	0.05	0.02	-0.06
P-val	*0.03*	*0.07*	*0.04*	*0.31*
N	59	59	59	59
R^2	0.89	0.38	0.51	0.52
Adj. R^2	0.89	0.33	0.48	0.49

Source: Authors' estimates, 1995Q2-2009Q4.

Note: Unrestricted VAR for simulating macroeconomic aggregates in the debt forecasting. As in prior studies, does not restrict any coefficients. Variables included are the U.S. real interest rate, the Brazilian real interest rate, the real GDP growth for Brazil, and the real bilateral U.S. Brazil exchange rate.

Table 4. Restricted VAR Estimation of Macroeconomy

	i^{US}	i^{BRA}	GDP	XR
i^{US}	0.93	…	…	…
P-val	*0.00*	…	…	…
i^{BRA}	…	0.26	-0.01	…
P-val	…	*0.00*	*0.63*	…
GDP	…	…	0.62	-0.07
P-val	…	…	*0.00*	*0.93*
XR	…	…	…	0.68
P-val	…	…	…	*0.00*
Constant	0.00	0.09	0.01	0.00
P-val	*0.21*	*0.00*	*0.01*	*0.87*
N	59	59	59	59
R^2	0.87	0.14	0.47	0.49
Adj. R^2	0.87	0.13	0.45	0.48

Source: Authors' estimates, 1995Q2-2009Q4.

Note: Restricted VAR for simulating macroeconomic aggregates in the debt forecasting. Some coefficients are restricted to be zero in the VAR. Variables included are the U.S. real interest rate, the Brazilian real interest rate, the real GDP growth for Brazil, and the real bilateral U.S. Brazil exchange rate.

Table 5. System Estimation of Macroeconomy and Fiscal Response

	Feedback to GDP and Real Interest Rate					Feedback to Real Interest Rate [1]				
	i^{US}	i^{BRA}	GDP	XR	PB^2	i^{US}	i^{BRA}	GDP	XR	PB^2
i^{US}_{t-1}	0.73	…	…	…	…	0.71	…	…	…	…
P-val	*0.00*	…	…	…	…	*0.00*	…	…	…	…
i^{BRA}_{t-1}	…	0.35	0.07	…	…	…	0.32	0.04	…	…
P-val	…	*0.00*	*0.06*	…	…	…	*0.01*	*0.21*	…	…
GDP_{t-1}	…	…	0.06	-0.74	…	…	…	0.17	-0.74	…
P-val	…	…	*0.61*	*0.02*	…	…	…	*0.11*	*0.01*	…
XR_{t-1}	…	…	…	0.05	0.12	…	…	…	0.04	0.13
P-val	…	…	…	*0.69*	*0.00*	…	…	…	*0.74*	*0.00*
PB_{t-1}	…	-1.84	-0.14	…	…	…	-1.92	…	…	…
P-val	…	*0.02*	*0.54*	…	…	…	*0.01*	…	…	…
Output Gap	…	…	…	…	0.13	…	…	…	…	0.13
P-val	…	…	…	…	*0.00*	…	…	…	…	*0.00*
$Debt_{t-1}$	…	…	…	…	0.10	…	…	…	…	0.10
P-val	…	…	…	…	*0.00*	…	…	…	…	*0.00*
Constant	0.01	0.09	0.02	0.04	-0.02	0.01	0.10	0.03	0.04	-0.02
P-val	*0.02*	*0.00*	*0.04*	*0.11*	*0.01*	*0.01*	*0.00*	*0.00*	*0.10*	*0.01*
N	44	44	44	44	44	44	44	44	44	44
R^2	0.58	0.25	0.26	0.07	0.43	0.58	0.24	0.09	0.07	0.28
Adj. R^2	0.57	0.19	0.16	0.02	0.32	0.57	0.18	0.05	0.02	0.15

Source: Authors' estimates. Iterative Seemingly Unrelated Regression, 1966 2009.
Notes: The left panel shows joint estimates of the restricted VAR and the fiscal reaction function, with fiscal policy feeding back into the real domestic interest rate with a lag. The right panel shows joint estimates of the restricted VAR and the fiscal reaction function, with fiscal policy feeding back into output growth and changes in the real effective exchange rate. Variables included are the U.S. real interest rate, the Brazilian real interest rate, the real GDP growth for Brazil, the real bilateral U.S. Brazil exchange rate, and the public sector primary balance for Brazil. The system also imposes the debt motion equation, the GDP and potential GDP motion equations, the output gap identity equation as constraints in the estimation (not shown).

[1] As measurement error and exceptional financing are assumed zero in the projection period, and hence, the indicator coefficients C(71)-C(76) are not reported.

[2] For notational convenience the coefficient estimated for the contemporaneous bilateral U.S.-Brazil real exchange rate in the fiscal reaction function is reported in the lagged real exchange rate change row.

Table 6. Bilateral Regressions of the Real Domestic Interest Rate on Primary Balance

Dependent Variable: $iBRA_t$										
Method:	GMM		GMM		OLS		OLS		OLS	
Sample	1968 2009		1996 2009		1967 2009		1996 2009		1969 2009	
	Estimate	**P-val**	**Estimate**	**P-val**	**Estimate**	**P-val**	**Estimate**	**P-val**	**Estimate**	**P-val**
Constant	0.05	0.32	0.43	0.00	0.02	0.69	0.29	0.31	0.08	0.74
$iBRA_{t-1}$	0.21	0.85	-0.29	0.04	0.74	0.00	-0.05	0.95	-0.31	0.14
$iBRA_{t-2}$	…	…	…	…	…	…	…	…	0.06	0.76
$iBRA_{t-3}$	…	…	…	…	…	…	…	…	0.03	0.88
iUS_t	3.80	0.65	-2.98	0.09	0.24	0.82	-0.97	0.61	1.62	0.31
PB_{t-1}	-1.90	0.46	-2.75	0.02	-0.22	0.79	-2.76	0.24	1.32	0.31
$Debt_{t-1}$	0.05	0.61	-0.22	0.00	-0.03	0.76	-0.11	0.71	-0.28	0.47
AR(1)	…	…	…	…	-0.40	0.03	-0.18	0.77	0.82	0.00
R-squared	0.09		0.46		0.34		0.58		0.41	
Adjusted R-squa	-0.04		0.23		0.23		0.32		0.27	
S.E. of regressic	0.15		0.05		0.13		0.05		0.13	
Sum squared re:	…		…		0.61		0.02		0.54	
Log likelihood	…		…		30.48		25.57		30.71	
F-statistic	…		…		3.10		2.22		2.81	
Prob(F-statistic)	…		…		0.02		0.15		0.02	

Source: Authors' estimates.

Note: Bilateral regressions of real domestic interest rate (the dependant variable) on its lags, lagged U.S. real interest rates, the lagged primary balance, lagged debt-to-GDP ratio, and an AR(1) error. Two sample periods are used, 1968-2009 and 1996-2009. Estimation by ordinary least squares and generalized method of moments.

Table 7. Measures of Dispersion of Debt Forecasts

(by year and feedback)

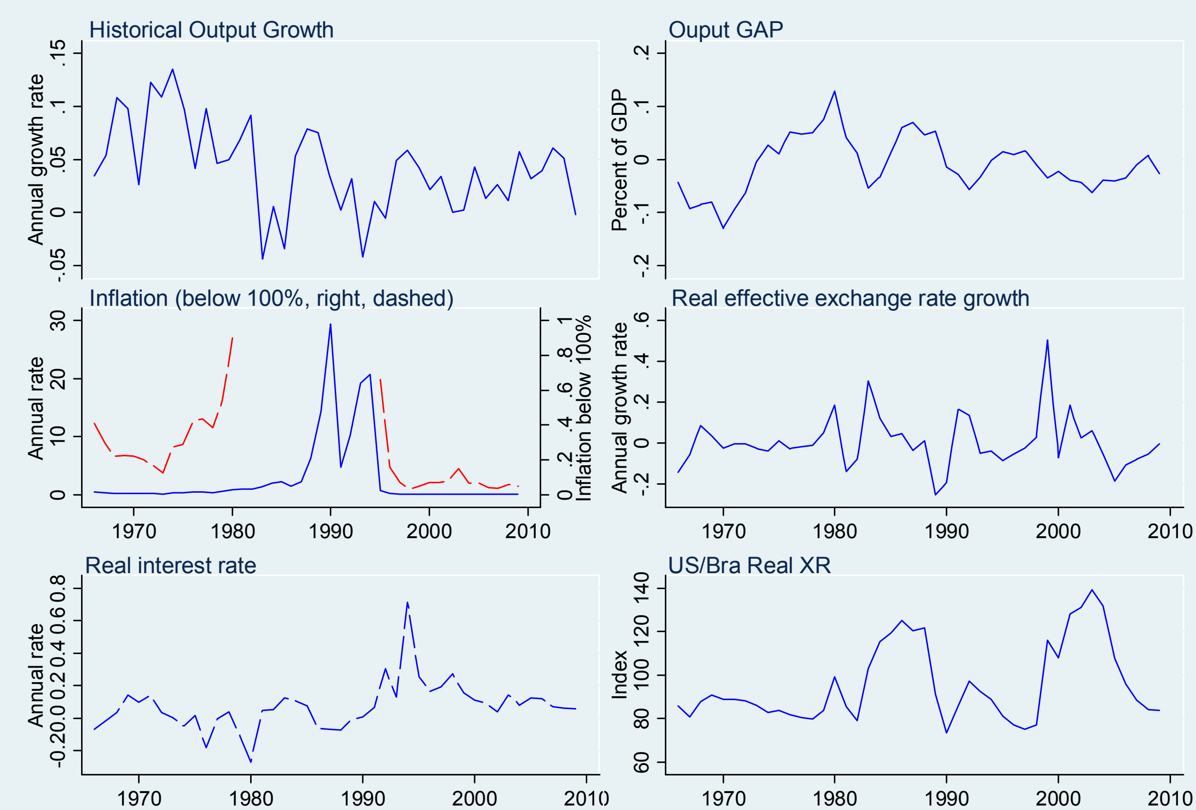
	No Feedback		GDP, Real i		Real i	
	2010	2014	2010	2014	2010	2014
Skewness	0.06	0.25	0.97	0.67	0.51	0.63
Median	0.66	0.68	0.66	0.60	0.66	0.56
Range	0.27	0.67	0.21	0.91	0.26	1.13
Interdecile	0.12	0.28	0.11	0.34	0.11	0.34

Source: Authors' estimates.

Note: Debt forecast distribution and dispersion measures are shown based on the model simulation from 2010-14. The simulations are shown based on where the primary balance feeds back into the system. In the left panel, macroeconomic aggregates are unaffected by the lagged primary balance. In the middle panel, the lagged primary balance affects output growth and the real domestic interest rate. The right panel estimates debt with feedback from the primary only to the real interest rate.

Figures

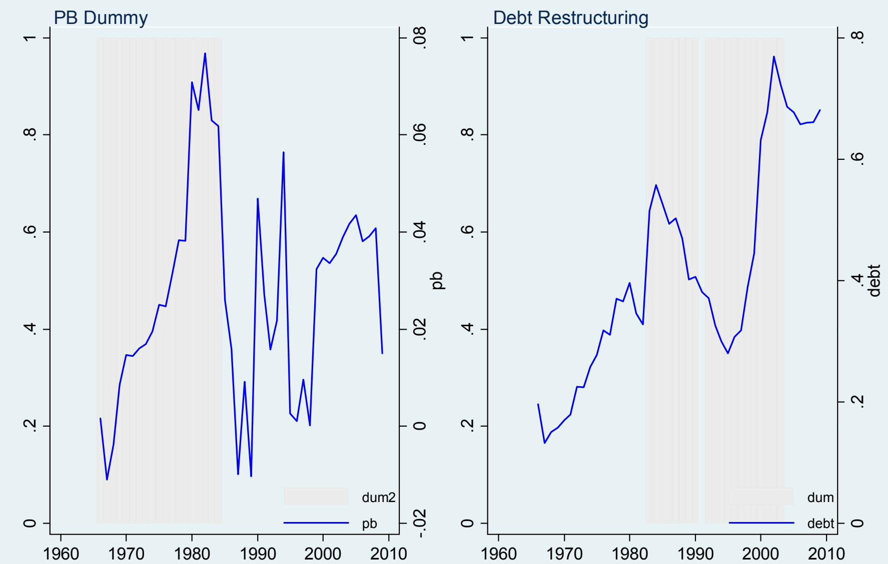
Figure 1. Evolution of Macroeconomic Aggregates in Brazil, 1965–2009



Source: IFS, IPEA, Silva et al., WEO, and Authors' estimates.

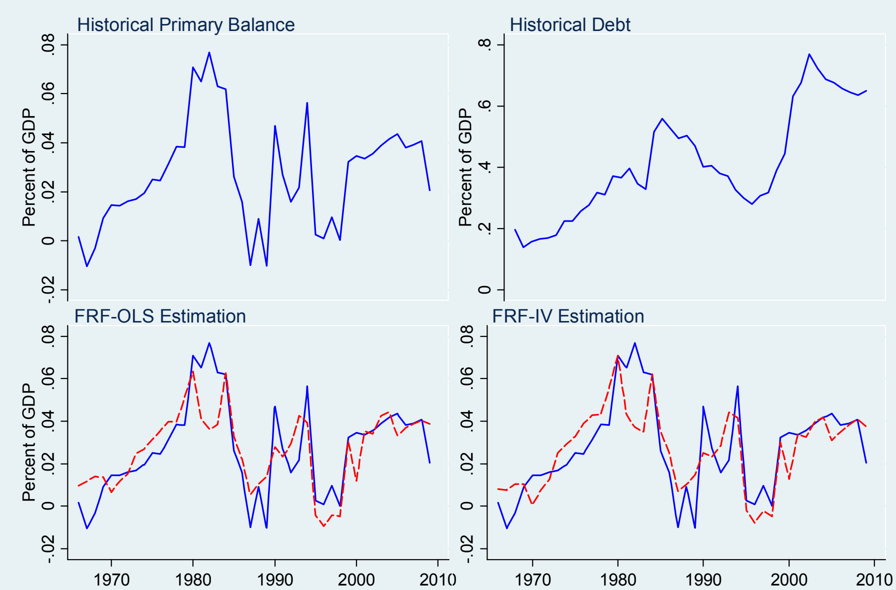
Note: The panel depicts the macroeconomic fundamentals based on annual data for Brazil, with output growth in the upper left, the output gap in the upper right, inflation (middle left), and the change in the real effective exchange rate (middle right), the real interest rate (lower left, compound annual monthly average), and the bilateral US/Brazil real exchange rate (lower right). Annual data, 1965-2009.

Figure 2. Historical Primary Balance and Debt



Source: IFS, IPEA, Silva et al., WEO, and Authors' estimates.
Note: left panel shows the primary balance (right scale) against its measurement error dummy, and the left panel shows debt (right scale) against debt restructuring dummy.

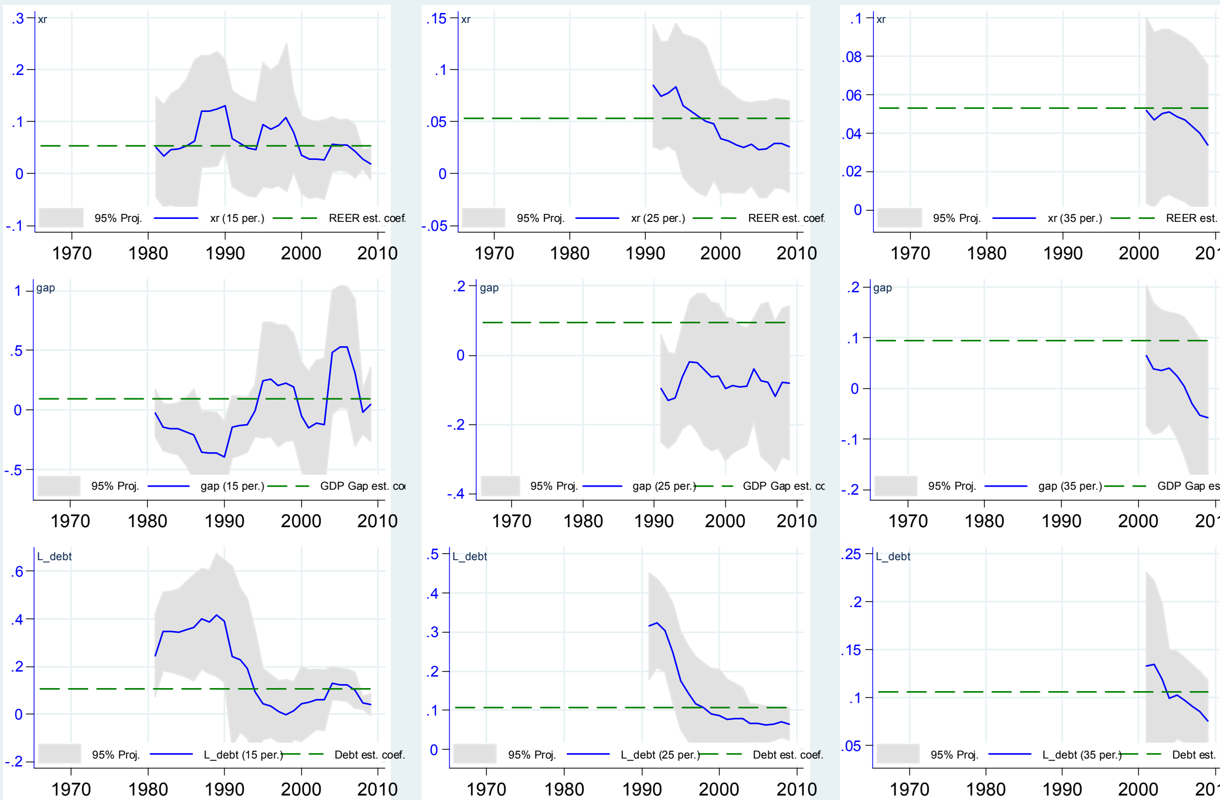
Figure 3. Fiscal Reaction Function Estimation and Debt



Fitted Value is Dashed.
Source: IFS, IPEA, WEO, Authors' estimates.

Note: The panel depicts the primary balance (upper left) and the debt-to-GDP ratio (upper right) as well as the fit of the fiscal reaction function. The actual (solid line) versus fitted values (dashed) of the estimated fiscal reaction function is shown in the bottom row, using ordinary least squares (bottom left) and IV estimation (bottom right). Annual data, 1965-2009.

Figure 4. Rolling Regression Estimates of Fiscal Reaction Function

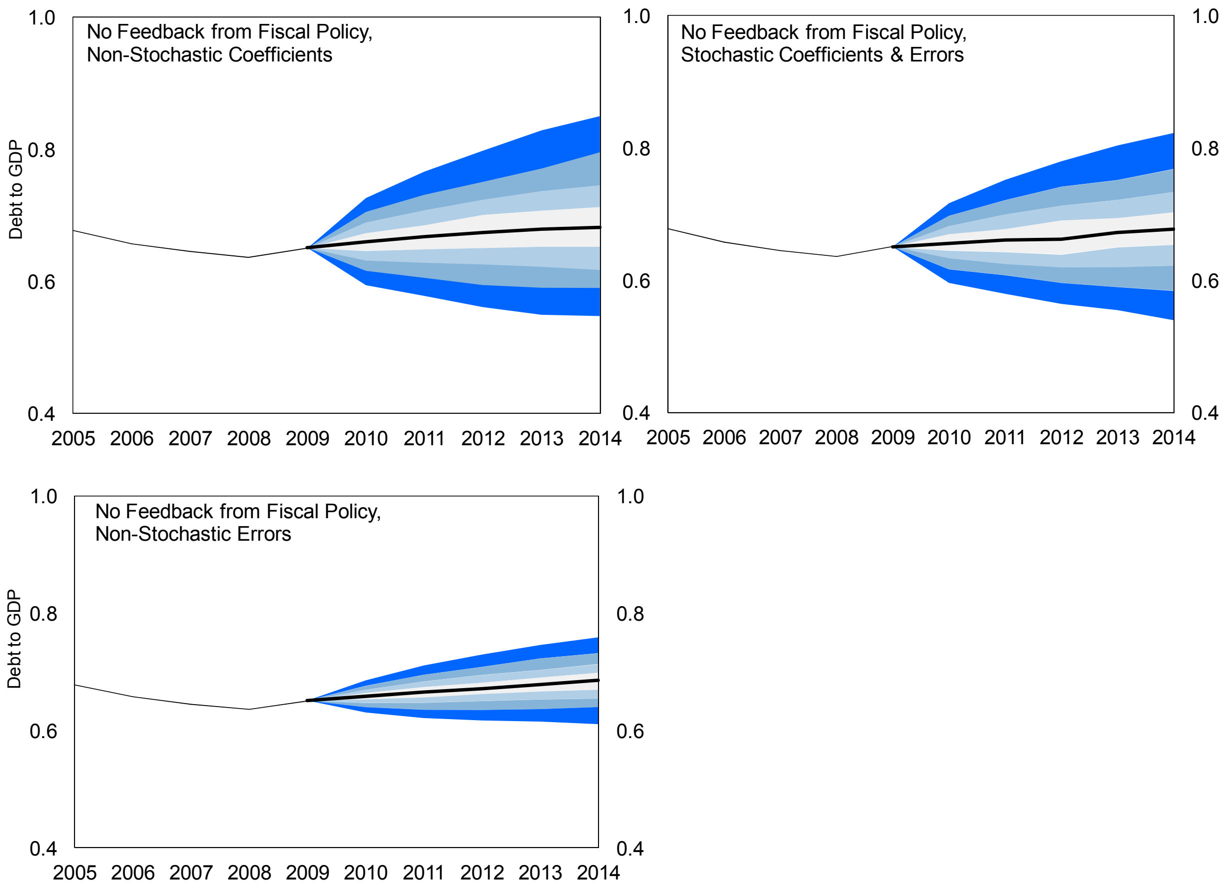


15 Year Rolling Estimate   25 Year Rolling Estimate   35 Year Rolling Estimate

Source: IFS, IPEA, Silva et al., WEO, and Authors' estimates.

Note: The panel depicts the three key estimated parameters of the fiscal reaction: real exchange rate changes (top row, intended to reflect commodity prices, easy external financial conditions, and other exogenous changes), the output gap (intended to reflect automatic stabilizers and other endogenous cyclical changes), and lagged debt (bottom row, intended to capture non-linear budgetary pressures) for Fifteen, twenty-five, and thirty-five year moving window estimation of the fiscal reaction function, annual data, 1965-2009. The shaded are reflects the 90 percent confidence interval for throughout the estimation, and the dashed line reflects the full-sample point estimate employed in the debt simulations.

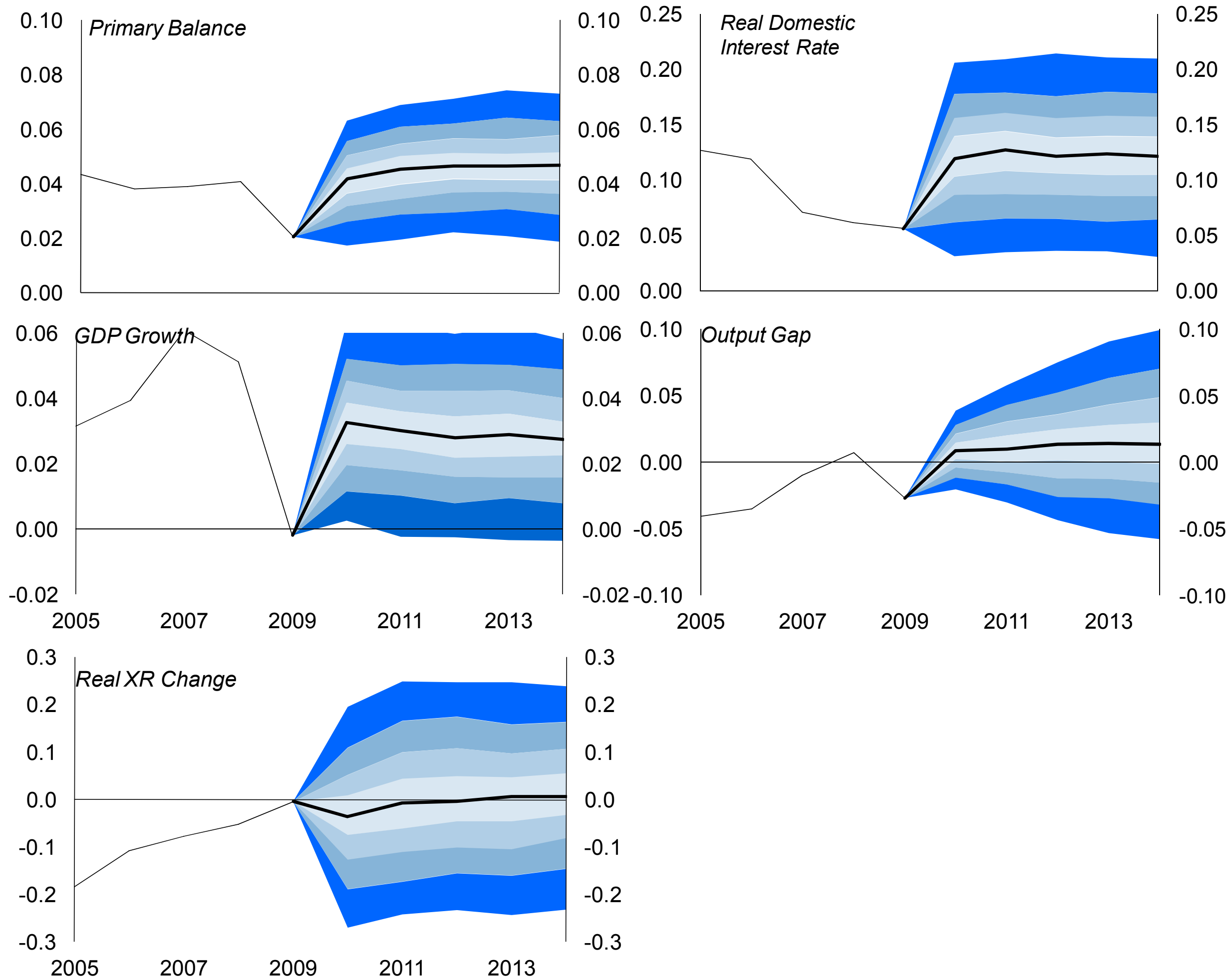
Figure 5. Baseline Debt Forecast: No Fiscal Feedback and Restricted VAR



Source: Authors' estimates.

Note: SUR estimation. Fiscal reaction function parameter distributions and shocks estimated on annual data, 1965-2009. Macroeconomic fundamentals: Monte Carlo shocks and distribution of coefficients drawn from separate estimation of restricted VAR on quarterly data, 1995Q2-2009Q4, with appropriate normalization for combining quarterly and annual data in the simulation. Forecast based on restricted VAR assuming normally distributed stochastic errors and coefficients (Monte Carlo). No feedback from fiscal policy to nonpolicy macroeconomic aggregates included in this system. Five year forecast with stochastic errors only (upper left), stochastic coefficients only (bottom), and both (upper right).

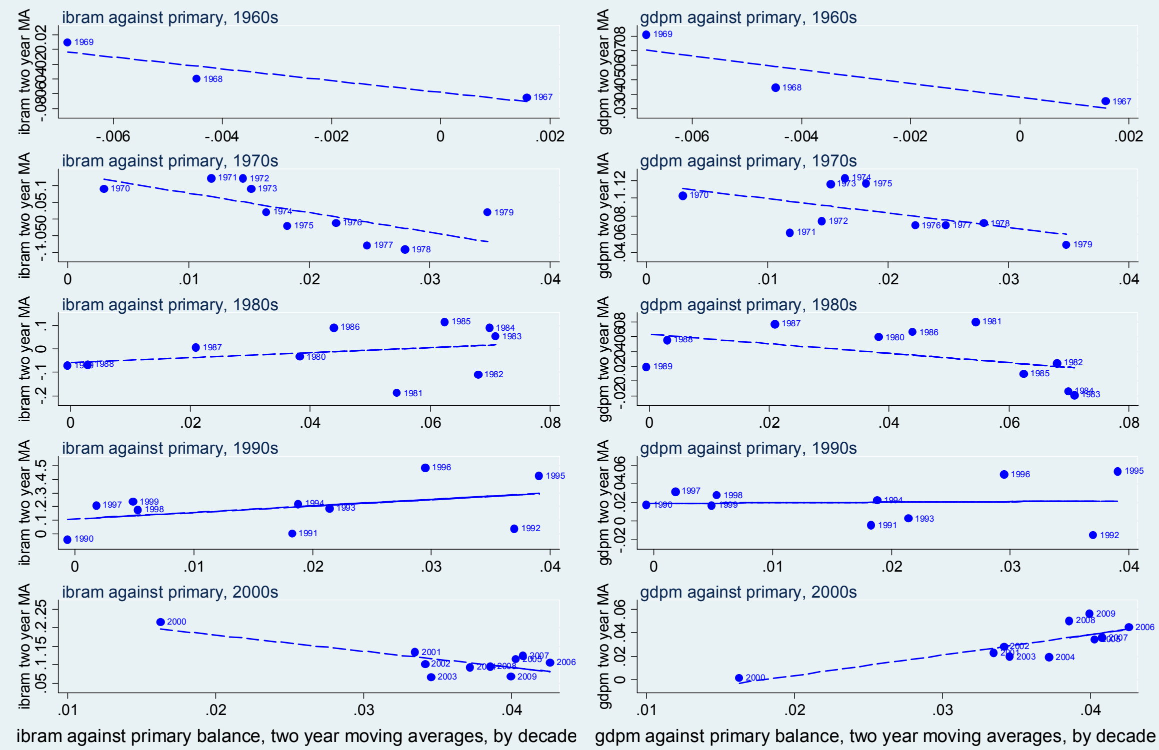
Figure 6. Baseline Debt Forecast: Underlying Fundamentals



Source: Authors' estimates.

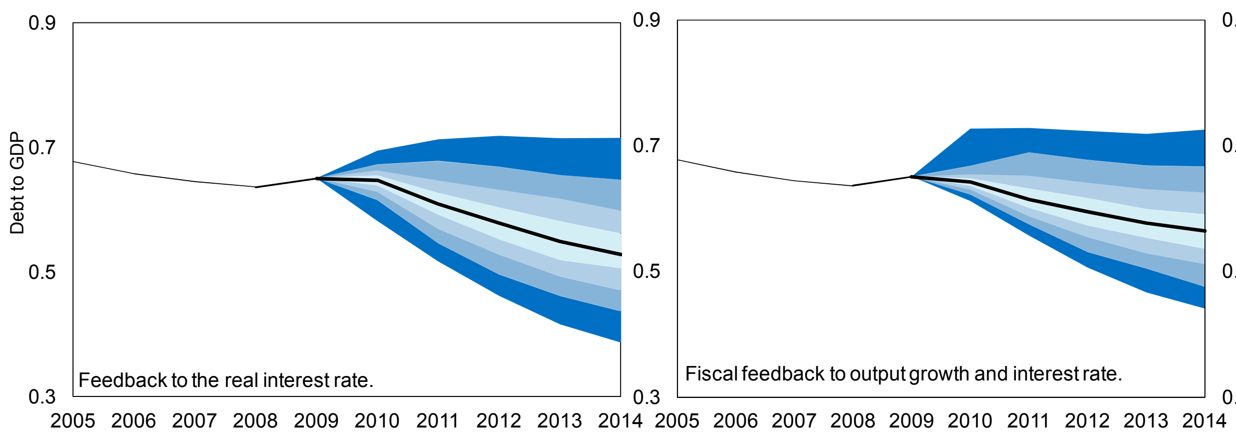
Note: The panel above gives the simulated economic fundamentals over the five year projection period. SUR estimation. Macroeconomic fundamentals: Monte Carlo shocks and distribution of coefficients drawn from separate estimation of restricted VAR on quarterly data, 1995Q2-2009Q4, with appropriate normalization for combining quarterly and annual data in the simulation. Forecast based on restricted VAR assuming normally distributed stochastic errors and coefficients (Monte Carlo). No feedback from fiscal policy to nonpolicy macroeconomic aggregates included in this system.

Figure 7. Primary Balance Against Output Growth and Domestic Real Interest Rate



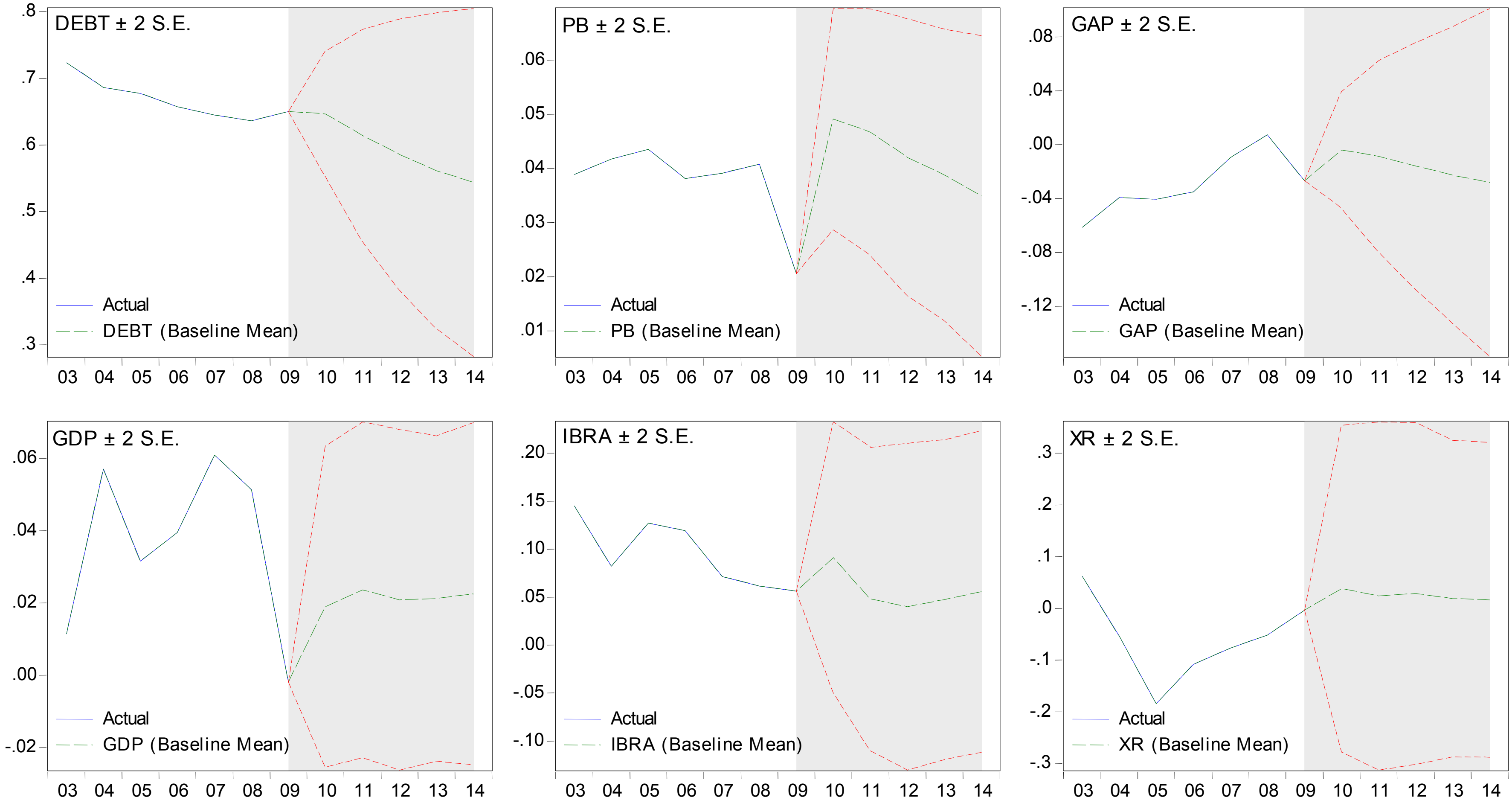
Source: IFS, IPEA, Silva et al., WEO, and Authors' estimates.
Note: Primary balance and macro variables by decade.

Figure 8. Stochastic Debt Projection with Endogenous Fiscal Policy



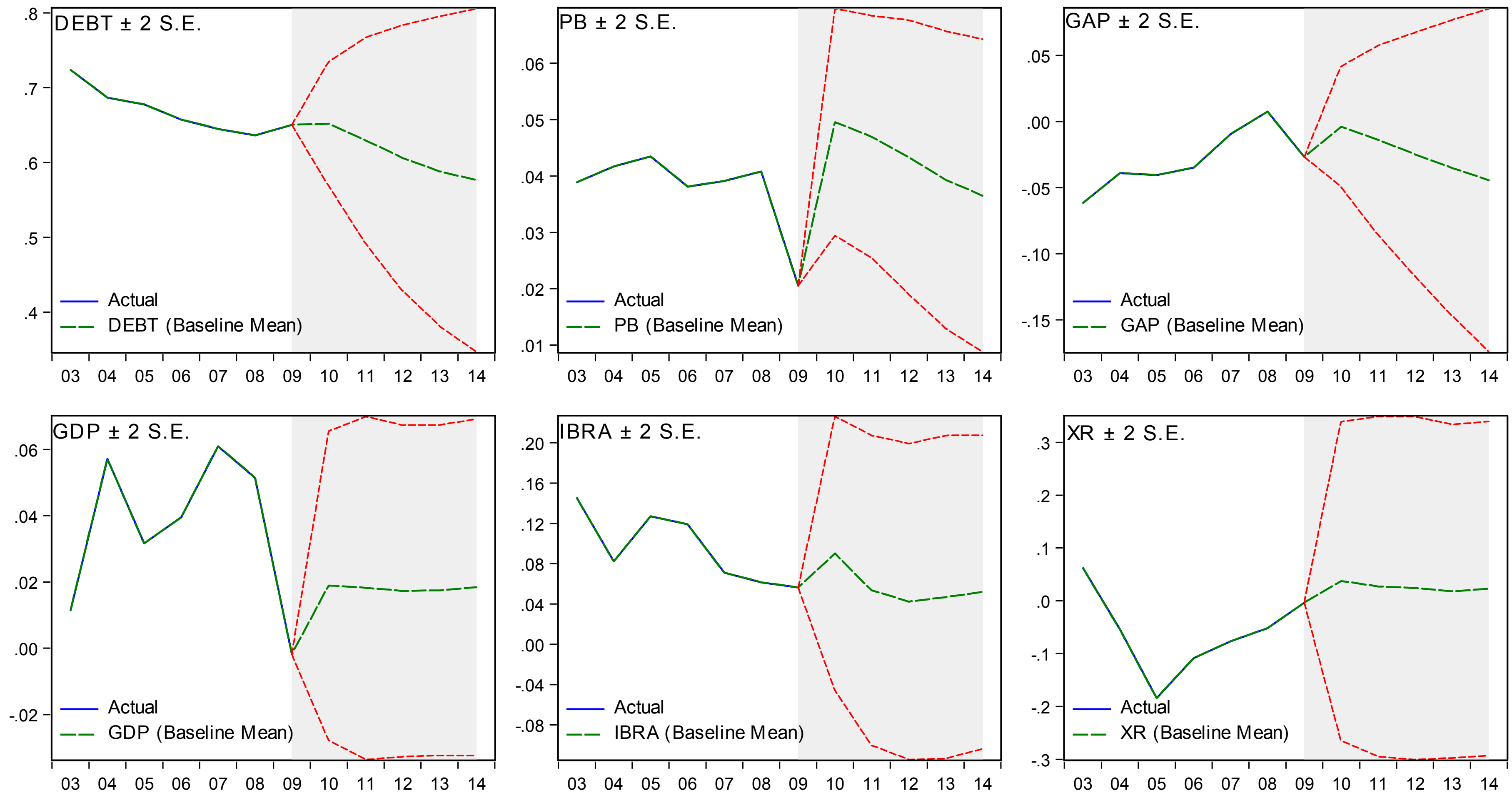
Source: Authors' estimates. Actual 1965-2009, forecast 2010-14, bootstrap errors 1996-2009. Forecast of debt-to-GDP ratio from system estimation of the restricted VAR and the fiscal reaction function with feedback from the structural fiscal shocks to non-policy aggregates. The left panel includes fiscal policy feedback to output growth and the real domestic interest rate. The right panel depicts the system with fiscal policy feedback only to the real domestic interest rate. All estimations incorporate parameter estimate uncertainty.

Figure 9. Projections with Feedback from Fiscal Policy to Interest Rates



Source: Author estimates, IFS, IPEA, Silva et. Al, WEO; Actual 1965-2009, estimated 2010-14. Bootstrap errors drawn from 1996-2009.
Notes: System estimation of the restricted VAR and the fiscal reaction function, imposing debt motion equation, and including feedback from structural fiscal policy shocks to the real domestic interest rate. The upper panel shows the forecast debt to GDP ratio, primary balance, and output gap (left to right). The lower panel shows output growth, the real domestic interest rate, and the change in the real exchange rate (left to right). Error bands reflect bootstrap forecast error and estimated coefficient uncertainty.

Figure 10. Projections with Feedback from Fiscal Policy to GDP and the Real Interest Rate



Source: Author estimates, IFS, IPEA, Silva et. Al, WEO; Actual 1965-2009, estimated 2010-14. Bootstrap errors drawn from 1996-2009.

Notes: System estimation of the restricted VAR and the fiscal reaction function, imposing debt motion equation, and including feedback from structural fiscal policy shocks to the real domestic interest rate, the real exchange rate growth, and real output growth. The upper panel shows the forecast debt to GDP ratio, primary balance, and output gap (left to right). The lower panel shows output growth, the real domestic interest rate, and the change in the real exchange rate (left to right). Error bands reflect bootstrap forecast error and estimated coefficient uncertainty.

Appendix – Data

Variable	Source	Period
Primary Balance	Estimates based on IMF Public Information Notices	1965-83
	Reported in Silva, et al.	1984-2008
	Reported in IMF Public Information Notice	2009
Gross Public Sector Debt	Estimates based on IMF Public Information Notices	1965-69
	IMF WEO Database	1970-80
	Reported in Silva, et al.	1981-99
	Reported in IMF Public Information Notice	2000-09
Interest Rate	IPEA, one-month nominal interest rate less one-month ahead inflation. Twelve-month compounded real monthly rate used for annual.	1965-2009
Real Bilateral Exchange Rate	IMF WEO Database. Bilateral U.S.-Brazil exchange rate deflated by respective CPI. Index, 1965=100, a decline in the index signals appreciation.	1965-2009
Exceptional Financing	IMF WEO Database. Dummy variable is unitiy if WEO reports positive exceptional financing other than arrears or rescheduling of existing debt.	1965-2009
GDP Growth	IMF WEO Database.	1965-2009
Inflation	IMF WEO Database.	1965-2009

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