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Volatility, External Debt, and Fiscal Risk: Simulations of the Impact of Shocks on Fiscal Adjustment for Thirteen Latin American Countries

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Executive Summary

This paper examines how the combination of indebtedness and exogenous shocks induce volatility for the countries of Latin America. An exogenous shock, such as a shock to world real rates of interest, petroleum prices or terms of trade, changes the present value of external debt as a proportion of GDP and affects the capacity of the government and the private sector to service external debt obligations. A technique for simulating the impact of shocks on the costs of external indebtedness and the response of fiscal policies in adjustment to such shocks is presented and applied to thirteen indebted Latin American countries.

The paper first extends the theoretical analysis of sustainable debt to allow for volatility. The criterion adopted for sustainability is based on the conventional solvency condition. For public debt, this is that the change in the expectation of the present value of future primary (that is, interest-exclusive) surpluses must equal or exceed the change in the expectation of the present value of public debt service. Both expectations are conditional to the current shock. The conditional expectation and present value calculations take account of the future dynamics of the debt servicing costs and the fiscal balance following shocks, whether the shocks are transitory or permanent.

An econometric model is used to calculate back-of-the-envelope simulations of the importance of volatility and debt for the sample countries. The expectation of the present value of the shock to debt servicing costs conditional on a shock to world interest rates, oil prices or the non-oil terms of trade are calculated for

each country. This calculation is performed separately for total external debt and public external debt, both as fractions of GDP and of public sector revenues. The same is done for the response of the primary surplus under past policies. This is one way to simulate the endogenous adjustment of a given fiscal stance, but it is unreliable as a measure of the adjustment of current fiscal stances for the Latin American countries because the historical response to shocks includes significant changes of fiscal stance.

The simulations demonstrate the effect of indebtedness on the vulnerability of fiscal policies to macroeconomic volatility. They show that for several countries, current debt levels imply that past patterns of fiscal policy responses cannot sustain public external debt in the face of interest rate and oil price shocks. The implication is that eventual fiscal contractions will be necessary to sustain external public debt against a standard deviation shock to these variables.

The impact of a 10% increase in the external debt-to-GDP ratio for each of the thirteen countries on the expected present value of future debt service as a percentage of GDP is shown in Table I. It shows, for example, that Chile is the least sensitive country to the impact of world interest rate shocks on the cost of external indebtedness, and for only six of the thirteen countries does a terms of trade improvement reduce the cost of external indebtedness as a proportion of GDP.

The net effect of exogenous shocks on the expected present value of external debt less the expected present value of the simulated historical primary surplus response is shown in Table II (Table 7 of the text). This table shows the expected present value conditional on a shock of the adjustment that must be met by changes in fiscal policies inclusive of inflation tax increases. It shows that a number of governments need to undertake significant eventual changes in fiscal stance in response to exogenous shocks. The first column for each shock shows the net impact for total external debt of the country for the latest available year (1994) as a percentage of GDP. The second column shows the net impact for public external debt only (1994 level) as a percentage of public sector revenues (1994).

Table I

Type of Shock:	Interest rate	Petroleum Price	Terms of Trade
Argentina	0.25	0.56	-0.07
Bolivia	0.29	1.15	-0.02
Brazil	0.02	0.33	-0.10
Chile	0.52	0.92	0.23
Colombia	0.27	0.58	-0.10
Costa Rica	0.29	0.88	-0.21
Ecuador	0.25	0.69	0.02
Mexico	0.25	0.28	0.11
Panama	0.89	0.59	0.27
Paraguay	0.31	0.36	0.03
Peru	0.44	0.23	0.28
Uruguay	0.20	0.67	-0.05
Venezuela	0.27	0.66	0.02

Table II

Type of Shock:	Interest Rate		Petroleum Price		Terms of Trade	
	Total %GDP	Public %Revenues	Total %GDP	Public %Revenues	Total %GDP	Public %Revenues
Argentina	2.76	15.84	1.54	6.44	0.76	5.16
Brazil	-0.55	-2.00	2.44	7.36	-0.04	-1.11
Chile	4.07	12.19	8.37	26.81	2.78	9.88
Colombia	1.65	8.58	6.28	34.83	-0.93	-5.09
Costa Rica	0.92	2.44	5.41	18.06	-0.90	-2.70
Ecuador	1.31	2.95	8.07	27.03	0.08	-0.10
Mexico	0.12	-1.15	3.14	16.86	0.88	4.50
Panama	10.64	21.28	2.13	-2.94	2.20	2.81
Paraguay	0.20	0.12	2.54	15.76	-0.01	-0.06
Peru	2.33	13.62	2.16	14.88	2.40	16.25
Uruguay	-1.63	-6.21	5.79	16.40	6.92	23.10
Venezuela	2.47	9.57	2.98	8.57	-0.59	-3.03

The sensitivity of the estimates to changes in model specification and, especially, to changes in the base growth rates of real GDP and interest rate spreads for each country were examined. These estimates are very insensitive to changes in the growth rate and interest rate for all countries to a tenth of one percent. The paper does not perform a complete econometric analysis of the dynamics of past fiscal policy responses to shocks for each country (notably, model specification has not been investigated). Since policies have changed, often significantly, for several of these countries, this is an interesting topic for further research.

Introduction

An important consideration in the evaluation of the viability of a current set of policies or the need for policy reforms is whether the projected path for public sector debt or for external national debt is sustainable. Standard back-of-the-envelope calculations of the sustainability of public sector deficit-finance focus on the difference between the long-run expectation of the primary surplus and expectation of the debt service required to maintain a constant outstanding public debt to output ratio. Buiter [1983] labels this measure of the sustainability of a particular set of fiscal, financial and monetary policies, the "permanent primary gap." Blanchard [1990] and Blanchard, et al [1990] propose a similar measure, the "primary gap," as a measure of fiscal stance over an arbitrary horizon. Similar calculations are applied to the evaluation of the sustainability of current account deficits and external debt.

While these simple long-run calculations are often very informative about the consequences of current policies, the variables used are all subject to shocks that cause significant disturbances to real economic performance. Under a given set of fiscal policies, outstanding public debt and the debt-servicing capacity of the public sector will respond to these shocks. For example, foreign macroeconomic shocks that increase world real interest rates or cause a deterioration of a country's terms of trade tend to raise the cost of servicing external national debt (or both external and internal public debt) and the socioeconomic costs of generating a given primary surplus. When the volatility of national incomes and present values of debt obligations are taken into account, the primary gap measures implicitly assume that any macroeconomic disturbance is met by an adjustment of the sequence of primary surpluses to maintain the given long-run debt-to-GDP ratio. That is, a given debt ratio is sustainable by those measures only if the present value of future public sector primary surpluses rises to match the increase in the present value of the impact of the disturbance on the debt. Without a compensating increase in the long-run expectation of the primary surplus, expected outstanding debt will grow in response to a transitory negative macroeconomic shock and, therefore, become unsustainable in the long run.

The problem of assessing the sustainability of a given set of fiscal-financial policies of the public sector in the presence of disturbances to real economic activity is especially important for the Latin American countries where real growth rates have been much more volatile over cycles than in the industrialized countries.¹ This suggests that measurements of the sustainability of fiscal policies and the public debt paths they generate should take account of the magnitude of shocks to real debt-service obligations and to the capacity of the public sector to generate the net resource transfers necessary to meet debt-service obligations. A fiscal stance estimated to be sustainable in expectation may not be when volatility in real economic activity and the response of the fiscal policies to shocks are taken into account.

This paper proposes an approach for evaluating the riskiness of public debt for fiscal policies for a country in an uncertain world economy. The standard long-run debt-sustainability criterion is first used to motivate a measure of how responsive fiscal policies must be to sustain debt levels against the historical impact of external macroeconomic shocks on the domestic economy. This measure gives an estimate of the present value of amount by which the government must increase its domestic revenues net of expenditures over time following a shock. The shocks can be either transitory or permanent. The required adjustment for a given level of debt can then be compared to the predicted cumulative (in discounted present value) adjustment of the primary surplus to the same shock based on historical estimates. To the extent that past fiscal policy responses capture the current fiscal stance, this comparison can be used to determine if the current debt level can be sustained against shocks without changing the tax and expenditure policies. The procedure gives an estimate of the volatility of the present value of the primary surplus needed to maintain external debt, or more generally, public debt, that can be used along with the standard primary gap criterion to determine the debt ratio that is sustainable using current fiscal policies.

An approach for estimating the riskiness of public debt is demonstrated. A straight-forward econometric technique is used to form back-of-the-envelope estimates of the impact of world real interest rate, oil price and terms of trade shocks on the real GDP growth rate and primary public sector surplus for thirteen Latin American countries.² For each country, the measure of riskiness of debt exposure is applied to foreign debt, rather than the total of all public debt, to compare the volatility of external debt-service obligations to the response of public sector revenues. Because fluctuations in foreign debt-service obligations due to external shocks can be met by increasing seignorage revenues or domestic public borrowing instead of increasing the primary surplus, another measure of the historical response of domestic fiscal policies is also demonstrated. This combines the primary surplus with seignorage revenues and domestic borrowing by the government and endogenizes the entire policy response other

than the accumulation of additional foreign debt. Because of difficulties constructing such measures well, estimates are only done for three countries as examples, Colombia, Ecuador and Mexico. These three countries also illustrate the problem that past policy responses include changes in fiscal stance during times of crisis due to external indebtedness and economic volatility.

The plan of the paper is as follows. Section 1 reviews the conventional solvency criterion and definition of debt sustainability as background for the proposed measurements and analysis that follow. In Section 2, the approach for assessing the sustainability of fiscal policies against volatile real economic performance is explained and discussed. Section 3 describes the estimation and calculation procedure for making back-of-the-envelope estimates of the riskiness of debt exposure and response of the fiscal balance to shocks. Section 4 reports the results for the thirteen Latin American countries. The alternative calculations of the policy response to external debt are also reported in Section 4 for Colombia, Ecuador and Mexico. Section 5 concludes.

Government Solvency and Sustainable Debt

The public sector is said to be solvent if the face value of its outstanding debt does not exceed the present discounted value of its anticipated future revenues net of expenditures. The single-period budget identity for the combined public sector expressed in domestic currency units is given by:

$$(1) \quad e_t D_{t+1}^f + D_{t+1}^d - e_{t+1} D_t^f (1+i_t^f) (1+\pi_t^*) - D_t^d (1+i_t) - (T_t + G_t) = (H_{t+1} - H_t)$$

where D_{t+1}^f and D_{t+1}^d are foreign and domestic currency denominated debt outstanding at the beginning of period $t+1$, respectively. e_t is the exchange rate (expressed in units of domestic currency per unit of foreign currency), i_t^f is the foreign nominal interest rate, π_t^* is the proportional rate of depreciation of the domestic currency, i_t is the domestic nominal interest rate, T_t is total taxes and fees net of transfers and subsidies of the public sector, G_t is nominal government non-interest expenditure and H_t is base money outstanding at the beginning of period t . Rewriting this in terms of ratios to nominal GDP gives

$$(2) \quad d_{t+1} - \frac{(1+i_t^f)(1+\pi_t^*)}{(1+g_t)(1+B_t)} d_t - \frac{(1+i_t^f)(1+\pi_t^*) + (1+i_t)}{(1+g_t)(1+B_t)} d_t^d + s_t + F_t,$$

where d_t is the total debt-to-GDP ratio, d_t^d is the ratio of domestic currency denominated debt to GDP, g_t is the growth rate of real GDP, B_t is the domestic inflation rate. s_t is the ratio of the primary surplus, the difference between non-interest public sector revenues and non-interest public sector expenditures, to GDP, and F_t is seignorage defined as the change in base money divided by nominal GDP. The term,

$$(3) \quad \frac{(1+i_t^f)(1+\pi_t^*) + (1+i_t)}{(1+g_t)(1+B_t)} d_t^d,$$

allows for departures from uncovered interest parity.

The solvency condition is obtained by solving the single-period budget identity for the public sector forward over an infinite horizon. Requiring that the face value of debt is no greater than the present discounted value of planned future primary surpluses plus seignorage revenues gives an upper bound on the long-run growth rate of the debt-to-GDP ratio. This growth rate is given by $(r-g)/(1+g)$, where r is the long-run domestic real rate of interest and g is the long-run growth rate of real GDP. To see this, we rewrite the single-period budget identity assuming that uncovered interest parity holds ex post. That is,

$$(1+i_t^f)(1+\pi_t^*) = (1+i_t),$$

so that

$$(4) \quad d_{t+1} = \frac{(1+r_t)}{(1+g_t)} d_t + s_t + F_t$$

Solvency requires that the long-run debt-to-GDP ratio must satisfy the following condition:

$$(5) \quad \lim_{t \rightarrow \infty} (d_t - \frac{1+g_j}{1+r_j}) = 0$$

Note that if the real exchange rate does not change in the long run, then r equals the foreign real rate of interest.

For a long-run real interest rate that exceeds the long-run growth rate of real GDP, this implies that the debt-to-GDP ratio can be growing as part of a sustainable fiscal policy. However, such a policy necessarily implies that the ratio of the public sector primary surplus to GDP is growing. A stronger, sufficient but not necessary, condition for public sector solvency is that the debt-to-GDP ratio converge to a constant. This is a useful benchmark for assessing the sustainability of a public sector borrowing plan because it imposes the restriction that public sector non-interest revenues cannot grow as a percentage of GDP without bound so that private consumption, investment and government expenditures can remain positive fractions of GDP in the long run.

The long-run condition for sustainability of a debt-to-GDP ratio, d , is given by

$$(6) \quad s_t + F_t = \left[\frac{(1+i_t^f)(1+\pi_t^*)}{(1+g_t)(1+B_t)} + 1 \right] d_t = \left[\frac{r_t + g_t}{1+g_t} \right] d_t$$

If long-run values are substituted for each of the parameters in equation (6), then the constant long-run ratio of the sum of the primary surplus and seignorage revenues to GDP that sustains the given level of the debt-to-GDP ratio is derived.

This formula can be used to make a quick assessment of the implications of a projected debt-to-GDP ratio for the average primary surplus if the public sector is to remain solvent. For these purposes, the government is the consolidated non-financial public sector and the central bank, and the debt is its non-monetary debt. The primary surplus-to-GDP ratio is the sum of the primary surplus of the non-financial consolidated public sector and the quasi-primary surplus-to-GDP ratio of the central bank.

In the presence of international relative price and interest rate uncertainty, the cost to the domestic economy of servicing outstanding public debt is also uncertain. Public debt can increase the impact of macroeconomic volatility on domestic consumption and investment as the repayment stream necessary to maintain solvency will fluctuate with shocks in proportion to the present value of the debt.

The conventional solvency constraint can be written to allow for volatility. The public sector is always solvent if the conditional expectation of the present discounted value of future primary surpluses, inclusive of seignorage revenues, equals the face value of the debt at every date. This can be written as

$$(7) \quad d_t = E_t \sum_{j=0}^{\infty} \left[s_{t+j} + F_{t+j} \right] \left(\frac{1+g_j}{1+r_j} \right)^j$$

where

$$\left(\frac{1+g_j}{1+r_j} \right)^j = \left(\frac{(1+n_j)(1+B_j)}{(1+i_j^f)(1+\pi_j^*)} \right)^j = \left(\frac{1+g_j}{1+r_j} \right)^j$$

is the discount factor applied to the primary surplus-to-GDP ratio generated at date j discounted to date t and is a random variable. This relationship implies that solvency is maintained if an increase in the debt ratio is matched by an equal rise in the expectation of the present value of future primary surpluses.

Volatility and Sustainable Policies

Solvency implies that adverse shocks to real interest rates or to real economic performance require adjustments of the path of the augmented (inclusive of seignorage) primary surpluses of the public sector if there is outstanding public debt. The increase in the real debt-service obligations must eventually be repaid by generating larger primary surpluses or more seignorage revenues. Using the single-period budget identity, equation (4), and imposing solvency yields the relationship:

$$(8) \quad E_t \left[\sum_{j=t}^{\infty} d_t \right] \left(\frac{(r_j g_j)}{(1 g_j)} \right) \left(\sum_{i=t}^j \frac{(1 g_i)}{(1 r_i)} \right) \neq E_t \left[\sum_{j=t}^{\infty} [s_j F_j] \right] \left(\sum_{i=t}^j \frac{(1 g_i)}{(1 r_i)} \right)$$

where

$$\left(\sum_{i=t}^j \frac{(1 g_i)}{(1 r_i)} \right)$$

is the discount factor between periods t and j . This simply says that the expectation of the present value of the increase in debt-service as a ratio of GDP that must be financed after a shock occurs in period t must be less than or equal to the expected present value of the changes in the augmented primary surplus following the shock.

An adverse shock to the real rate of interest or GDP growth rate, either transitory or permanent, at date t raises the present value of the debt as a ratio of GDP. Sustainability implies that the expectation of the present value of the augmented primary surpluses conditional on the shock at date t must rise to match this increase. This holds whether the long-run debt ratio remains constant or permanently rises in response to the shock. It is true whether the augmented primary surplus rises each period following a shock to match the increase in debt-service period-by-period (as for a debt-constrained government) or if the government borrows more to smooth the increase in the augmented primary surplus over time. The left-hand side of inequality (8) is a measure of how much domestic absorption must adjust, in present value, to a macroeconomic disturbance for the public sector remain solvent in all future dates.³

The effect of volatility on the sustainability of public sector debt paths under a given set of fiscal policies can be estimated by using this inequality. A dynamic empirical model of how exogenous macroeconomic shocks affect real interest rates, real growth rates, primary surpluses and seignorage revenues can be used to generate the effects of disturbances to the present values of the change in the augmented primary surplus and debt-servicing requirement, the two sides of this inequality. If fiscal surpluses do not adjust enough under the simulated policies to offset the increase in the present value of public debt obligations, d_t , then the fiscal policy and outstanding public debt are not sustainable against that shock. That is, the fiscal policies will need to change in response to the given shock to sustain debt repayment. This interpretation does not include contingent outright default as part of a given fiscal stance.

The response of the primary surplus to world macroeconomic shocks combines two effects. Public sector revenues and expenditures respond passively to fluctuations in real economic variables, for example, through the effects of shocks on the tax base. The capacity of the government to transfer resources from the private sector for the purpose of servicing public debt is effected by world interest rate, terms of trade and other shocks, and under given tax and spending policies, the primary surplus will be endogenous to economic activity. The primary surplus can also respond because tax and spending policies are revised in the face of disturbances. Similar statements hold for monetary policies. That is, any historical response to macroeconomic disturbances includes both endogenous changes in the primary surplus under given policies and policy changes that are necessary when the previous policies provide insufficient adjustments to shocks.

If a sequence of augmented primary surplus responses to exogenous shocks are produced under a simulated policy using a structural model of the domestic economy, then an excess of the left-hand over the right-hand side of equation (8) in response to a potential shock indicates that the fiscal policy is not sustainable under that shock. If, instead as in the analysis below, the response is taken from historical responses to exogenous shocks, then the right-hand side measures the present value of the augmented primary surpluses that would be generated under past policies. If the past responsiveness of public revenues and expenditures to a simulated shock are too small,

in present value, to offset the increase in debt service, then the analysis shows that the current stock of public debt cannot be sustained in the face of volatility by pursuing past fiscal policies without resorting to monetization.

The solvency analysis can be applied to estimating the impact of economic volatility on fiscal policies in a number of ways. The estimated consequences of disturbances to debt-service obligations (the left-hand side of (8)) for the current outstanding stock of public debt can be compared to the responsiveness of the primary surplus or its components, revenues and spending. Alternatively, an informative comparison can be made between public sector revenues and the volatility of debt obligations by calculating the volatility of debt servicing as a ratio of public sector revenue rather than GDP. This number gives the percentage increase in tax revenues necessary to sustain public expenditures and solvency after a shock.

Different types of public debt may carry different explicit or implicit terms of payment, complicating the calculation of the volatility of public debt service. Even if the total level of public debt is a properly calculated present value discounted at the real interest rate faced by the government for issuing additional debt, the change in the interest rate charged on different types of debt in response to a shock can differ. For example, domestic debt may be nominally-indexed to the domestic currency, so that the inflation tax on outstanding public debt should be taken into account if the monetary policy response to a shock is included endogenously. External debt can carry fixed or variable interest terms (this problem is discussed in the next section).

This approach for estimating the interaction between indebtedness and volatility is applied to external debt separately below. The response of the present value of the primary surplus to macroeconomic shocks is estimated. This number gives the effect of the shock on public sector revenues net of expenditures under past policies. Possible policy responses to shocks to real external debt-servicing obligations also include additional domestic borrowing and inflation taxation. The difference between the impact of the shock to the burden of external debt and the primary surplus, exclusive of seignorage, equals the increase in seignorage revenues or additional domestic public borrowing that must occur to sustain current external indebtedness under the simulated tax and spending policies. An alternative way to study past policy responses is to calculate an “external primary surplus” which includes seignorage and domestic borrowing. This is illustrated at the end of Section 4. These calculations endogenize all ways in which domestic resources have been used to finance external debt obligations in the face of volatility, so that they include revisions of fiscal and monetary policies.

Estimating the Impact of Volatility on the Sustainability of Public Debt

A simple dynamic econometric model is used to estimate the impact of volatility on debt and fiscal balances. The procedure begins by estimating the stochastic process for world real interest rates and oil prices, variables that are exogenous to the country, using a vector autoregressive model. The world real rate of interest is calculated from the nominal 3-month LIBOR using average U.S. CPI inflation for the previous 12 months as a measure of expected inflation. Real interest rates are correlated with both lagged real interest rates and lagged world oil prices. Lagged values of the real interest rate are also included in the regressions for the oil price.

Three variables are used to characterize the domestic economy's response to shocks: the terms of trade, the real GDP growth rate and the primary surplus as a fraction of GDP. The primary surplus and growth rate are used in the calculations of sustainability, while the terms of trade serve as one source of shocks. The terms of trade are estimated as functions of lagged values of world real interest rates, oil prices and the terms of trade, but not on other country-specific variables, such as the domestic growth rate, to be consistent with a small open-economy assumption. The impact of the terms of trade on real GDP growth and the public sector primary surplus, therefore, is the impact holding constant the deflated world oil price, so that the separate terms of trade shock is only the portion of terms of trade shocks unexplained by world oil price shocks.

Two approaches can be taken for specifying the dynamics of the growth rate of real GDP and the primary surplus. In one, real GDP depends on lagged values of world real interest rates, oil prices, the terms of trade, itself and the primary surplus to reflect the potential effects of fiscal policies on output. In the other, real GDP growth is taken as exogenous to the primary surplus. This is done because past fiscal policies may depart significantly from current or desirable policies for the countries studied. Including the impact of past policy choices on the left-hand

side of equation (8) endogenizes the estimation of the impact of exogenous shocks on fiscal adjustment to these past policy responses. Neither approach is fully satisfactory. The actual regressions are set up to demonstrate a simple “back-of-the-envelope” procedure, so that the real GDP growth rate is used directly in place of real GDP. A time trend is included for the terms of trade, GDP growth rate and primary surplus in the primary version of the model, which excludes feedbacks of the primary surplus on real GDP growth. This model is estimated as an autoregression (restricted VAR) in the five variables with coefficient restrictions imposed to reflect the exogeneity assumptions just described.

The real interest rate is calculated by averaging the monthly real interest rate over each year. The oil price is the US dollar price reported in the IMF International Financial Statistics, deflated by the US consumer price index. Real GDP growth is taken from the IDB data base, the terms of trade index from the World Tables of the World Bank, and the primary surplus of the non-financial consolidated public sector series was constructed by the IDB (Gavin, et al [1996]). The quasi-fiscal surplus for the central bank is not included due to data unavailability. Annual data from 1970 to 1995, inclusive, are used as availability permitted. Debt data are taken from the World Bank World Debt Tables.

Interest rates and the price of oil are modelled by the following pair of equations:

$$r_t = \alpha_r + \beta_1^r r_{t-1} + \beta_2^r r_{t-2} + \gamma_1^r p_{t-1} + \gamma_2^r p_{t-2} + \epsilon_t^r \quad (9)$$

$$p_t = \alpha_p + \beta_1^p p_{t-1} + \beta_2^p p_{t-2} + \gamma_1^p r_{t-1} + \gamma_2^p r_{t-2} + \epsilon_t^p \quad (10)$$

The presence of a unit root is rejected for the real interest rate series, while the estimated equations for the deflated world oil price and terms of trade for the individual countries are mean regressive but unit roots are not necessarily rejected for all.

Estimation of equations (9) and (10) using OLS for observations on the dependent variable from 1970 to 1995 yield:

$$r_t = 0.326 + 0.652 r_{t-1} - 0.224 r_{t-2} - 0.096 p_{t-1} + 0.140 p_{t-2}$$

$$(0.804) (0.137) (0.170) (0.039) (0.038)$$

Standard error of estimate = 1.638

$$R^2 = 0.8393$$

$$R\text{-bar}^2 = 0.5792$$

$$p_t = 8.455 + 1.357 r_{t-1} - 1.838 r_{t-2} + 0.888 p_{t-1} - 0.120 p_{t-2}$$

$$(4.228) (0.902) (0.894) (0.205) (0.202)$$

Standard error of estimate = 8.611

$$R^2 = 0.9461$$

$$R\text{-bar}^2 = 0.6508$$

(standard errors in parentheses)

The sample mean of the real interest rate is 2.66% with a standard deviation of 2.53%. The real 3-month Eurodollar rate of interest is graphed in Figure 1. The sample mean deflated oil price was \$29.75 with a standard deviation of \$14.57.

The rest of the basic system for each country is given by

$$q_t = \alpha_1^q r_{t+1} + \alpha_2^q r_{t+2} + (\beta_1^q p_{t+1} + \beta_2^q p_{t+2} + \gamma_1^q q_{t+1} + \gamma_2^q q_{t+2} + \delta_1^q g_{t+1} + \delta_2^q g_{t+2} + \epsilon_t^q)$$

$$g_t = \alpha_1^g r_{t+1} + \alpha_2^g r_{t+2} + (\beta_1^g p_{t+1} + \beta_2^g p_{t+2} + \gamma_1^g q_{t+1} + \gamma_2^g q_{t+2} + \delta_1^g g_{t+1} + \delta_2^g g_{t+2} + \epsilon_t^g)$$

$$s_t = \alpha_1^s r_{t+1} + \alpha_2^s r_{t+2} + (\beta_1^s p_{t+1} + \beta_2^s p_{t+2} + \gamma_1^s q_{t+1} + \gamma_2^s q_{t+2} + \delta_1^s g_{t+1} + \delta_2^s g_{t+2} + \epsilon_t^s)$$

where q is the terms of trade for the country. The model equation for the public sector primary surplus is just a basic specification. Alternative specifications might allow for possible policy reactions by including variables such as the operational budget surplus to allow for endogenous increases in taxes or reductions in expenditures as debt-servicing costs rise.

The regression results for the individual country equations are reported in the Appendix.

The impact of exogenous shocks to the world real interest rate, petroleum price and terms of trade on the debt-service requirement and the primary surplus are calculated using the simulated impulse response for each of the five variables⁴. The impulse response calculates the predicted value for each dependent variable using the estimated equation system when the initial value of one of the variables is increased by one standard deviation of its estimate. For each shock, the present values of the change in debt-service and the primary surplus as fractions of GDP are calculated as follows:

$$(11) \quad PV_d = d_t + \sum_{j=1}^4 \left(\beta_j^d \left[\frac{r_j \& g_j}{1\% g_j} \right] + \gamma_j^d \left[\frac{1\% g_j}{1\% r_i} \right] \right),$$

$$(12) \quad PV_s = \sum_{j=1}^4 \left(\beta_j^s \left[\frac{1\% g_j}{1\% r_i} \right] \right)$$

where

$$) \left[\frac{r_j \& g_j}{1\%g_j} \right] + \frac{(r_0\%)r_j \& (g_0\%)g_j}{1\%(g_0\%)g_j} \& \frac{r_0 \& g_0}{1\%g_0}$$

and r_0 (g_0) is the base interest rate (growth rate) and r_j (g_j) is the change in the real interest rate (growth rate) at date $t+j$ for the date t impulse. Equations (11) and (12) approximate the two sides of equation (8) since the simulated expected values for the interest and growth rates appear in denominators. Because the variation in $(1+r)$ and $(1+g)$ is small, the difference is negligible for these data.

Equation (11) gives the expected present value of the increase in the primary surplus necessary to sustain the current level of debt, d_t , in response to a one standard deviation exogenous shock at date t . It does not just give the first period effect, but accounts for subsequent dynamics. The effects of shocks to the foreign real interest rate, oil price and terms of trade diminish over time in the data sample, so that the calculated present value is an estimate of the conditional expectation of the full discounted cost of adjustment to the shock. That is, a shock to the real interest rate is transitory but persists so that the calculation takes into account the expected deviation of future interest rates from the long-run rate conditioned on the disturbance at date t . Equation (12) gives the expected present value of the simulated response of the primary surplus under past policies to a shock. The primary surplus may respond permanently to a transitory shock, as in a neoclassical model of tax-smoothing.

The calculation of the impact of exogenous shocks on fiscal adjustment requires values of the base growth rate, interest rate and debt level. The interest rate must include the premium on national borrowing on international financial markets over the real interest rate simulated. This is calculated as an average over five years using the most recent available values for average interest rate on all new commitments from the World Bank World Debt Tables minus nominal 3-month LIBOR. The average difference is used as the expected interest differential for each country. This is smaller for countries with large shares of official creditor and concessional debt. The base growth rate for each country is also calculated as a five-year average using the latest available dates, as is the base world real interest rate.⁵ The five-year average world real interest rate is 2.6%, while the steady-state interest rate for the estimated interest rate and oil price VAR is 2.9%; this difference has a very small effect on the present value calculations. The robustness of the calculations to different base growth and interest rates is discussed below.

Both total external debt and public external debt as reported in the World Debt Tables are used. Because private external debt carries explicit and implicit public guarantees, it is unclear where between these two values to place the present value of debt burden of the public sector so calculations for both are simply reported.⁶

Treatment of Fixed Rate Debt

The treatment of floating and fixed rate debt also matters. Suppose that an equal share of fixed rate debt is refinanced each year with maturity constant and equal to T . At date t , $1/T$ of the outstanding fixed rate debt is refinanced at the interest rate r_t for T periods. The change in the present value of the debt service for this new fixed rate debt is given by

$$d_t^f(1/T) = \sum_{k=t}^{k=t+T-1} \left(\sum_{j=0}^{j=4} \left(\sum_{k'=j}^{k'=j+T-1} \right) \left[\frac{r_{t\%j} \& g_{t\%k}}{1\%g_{t\%k}} \right] \sum_{i=0}^{i=k} \left[\frac{1\%g_{t\%i}}{1\%r_{t\%i}} \right] \right)$$

Similarly, the shock at date t affects the interest rate at date $t+1$ which is incorporated into the fixed rate contract for the $1/T$ fraction of the outstanding total fixed rate debt refinanced at date $t+1$. The present discounted value of a shock to fixed rate debt service is given by discounting all of these contributions to date t and summing:

$$PV_d = d_t^f(1/T) = \sum_{j=0}^{j=4} \left(\sum_{k'=j}^{k'=j+T-1} \right) \left[\frac{r_{t\%j} \& g_{t\%k}}{1\%g_{t\%k}} \right] \sum_{i=0}^{i=k} \left[\frac{1\%g_{t\%i}}{1\%r_{t\%i}} \right]$$

This expression is a bit difficult to untangle but can be simplified by rearranging the summations, discounting over the life of each portion of the fixed rate debt at the base interest and growth rates and approximating

$$\frac{r_{t\%j}}{1\%g_{t\%k}} \cdot \frac{r_{t\%j}}{1\%g_{t\%j}},$$

for each $k = j, \dots, j+T-1$. That is, deflate the interest shock for each portion of the fixed-rate debt at just one growth rate; this is a very minor approximation for the estimated shocks. This gives

$$PV_d \cdot d_t^f \cdot \sum_{j=0}^{j=4} \left(\frac{r_{t\%j} \& g_{t\%j}}{1\%g_{t\%j}} \right) \cdot \sum_{i=0}^{i=j} \left[\frac{1\%g_{t\%i}}{1\%r_{t\%i}} \right] \cdot \left(\sum_{k=0}^{k=T-1} \left[\frac{1\%g_0}{1\%r_0} \right]^k \right) / T$$

This expression is just the present value of the effect of the shock for variable rate debt multiplied by the factor

$$\left(\sum_{k=0}^{k=T-1} \left[\frac{1\%g_0}{1\%r_0} \right]^k \right) / T$$

which equals one for $T=1$ and declines as T grows for $r_0 > g_0$. For an initial maturity on fixed rate debt of 7 years this equals 94% for a difference between the real rate of interest and real GDP growth rate of 2% and 97% for a difference of 1%. As the maturity rises to 10 years, these fall to 92% and 96%, respectively. That is, the present value of the full impact of a shock at date t to fixed rate debt is approximately 95% or more of what it would be for an equal present value amount of variable rate debt for the Latin American countries.

Fixed rate and variable rate debt interest terms may also differ. The World Debt Tables does not report separate average interest rates on new commitments by maturity, so that the average interest spread for each country applies to the sum of fixed and variable rate debt.

An approximate correction for fixed versus floating rate debt would reduce the debt-to-GDP ratio used by the fraction of fixed rate debt in the total times 0.05. This difference is certainly smaller than the error of the estimated shock for all countries. In the calculations of the expectation of the impact of shocks on debt-servicing costs, fixed rate and variable rate debt are treated the same.

Adjustment Costs of External and Public Debt for 13 Latin American Countries

Table 1 gives the debt, public sector revenue, interest rate spread and real growth rate data used in the calculations.

Table 1

	Total External	Public External	Public Revenues	Real GDP	
Interest	Debt (%GDP)	Debt (%GDP)	(%GDP)	Growth Rate	Rate
Spread					
Argentina	33.50	24.45	16.02	6.16	2.26
Bolivia	88.22	76.54	14.00	4.23	-1.20
Brazil	31.24	21.29	28.69	0.90	2.60
Chile	52.36	25.76	22.09	6.38	1.18
Colombia	38.06	30.02	16.69	4.24	1.86
Costa Rica	60.76	49.50	24.49	4.87	1.54
Ecuador	107.08	82.03	23.50	3.59	1.10
Mexico	37.44	24.80	16.55	3.20	2.04
Panama	118.56	68.00	28.97	6.33	1.36
Paraguay	29.06	23.07	14.73	2.91	0.14
Peru	61.80	46.47	12.12	2.90	1.18
Uruguay	41.34	28.88	30.24	4.31	1.72
Venezuela	65.72	47.71	20.79	3.94	1.90

Table 2 compares the present values of the expectation of the impact of exogenous world interest rate shocks on the cost of maintaining solvency across the thirteen countries. It shows the expected adjustment necessary for a one-standard deviation shock to the US real rate of interest for a common debt-to-GDP ratio equal to one hundred percent. These values can be used to compare how much a given increase in outstanding debt, for example, an increase in the debt-to-GDP ratio of 1%, increases the risk of having to adjust future fiscal policies to shocks across countries.

Table 2

	model 1	model 2	model 3
Argentina	3.37	2.47	3.85
Bolivia	3.05	2.88	NR
Brazil	-5.46	0.21	-0.12
Chile	5.20	5.19	5.15
Colombia	3.04	2.72	3.04
Costa Rica	2.27	2.88	2.09
Ecuador	3.07	2.45	2.36
Mexico	1.69	2.48	2.26
Panama	8.03	8.85	8.87
Paraguay	2.84	3.11	2.32
Peru	-2.11	4.43	2.97
Uruguay	2.31	1.99	1.04
Venezuela	2.84	2.70	1.31

The table displays the results for three models. The first is the base model described above. In the second, time trends are included in the equations for the terms of trade, growth rate and primary surplus. The trends may improve the fit of the equations to the data in the absence of adding more lagged dependent variables because of the short data sample, but are not included on the basis of tests for stochastic trends. The third series is for a model in which two lagged values of the primary surplus are included in the regression equation for the real growth rate of GDP. The estimate for Bolivia is not reported because the value of the Bolivian primary surplus in the data set for one year appears to be grossly distorted by the effect of the hyperinflation of the early 1980's on national accounts.

The estimated impact of an interest rate shock on the present value of debt payments for a debt-to-GDP ratio equal to one shows sizable differences under the alternative models for two countries, Brazil and Peru. After multiplying by actual debt-to-GDP ratios, the differences for most countries diminish. The version with trends included is used for the remainder of the comparisons.

Robustness with respect to changes in the base growth rate of real GDP is illustrated in Table 3; results for changes in the interest spread over LIBOR are very similar. Table 3 compares the expected present value adjustment cost for all external debt due to an interest rate shock for each country for a common interest spread equal to 2% (real interest rate of 4.6%) for different rates of growth (g) with the calculated simulation value.

Table 3

	g=2	g=3	g=4	g=5	simulation
Argentina	0.91	0.90	0.88	0.85	0.83
Bolivia	2.68	2.68	2.69	2.69	2.54
Brazil	0.05	0.03	0.01	-0.01	0.06
Chile	2.86	2.84	2.80	2.77	2.72
Colombia	1.03	1.03	1.04	1.04	1.04
Costa Rica	1.75	1.75	1.75	1.75	1.75
Ecuador	2.66	2.64	2.61	2.59	2.62
Mexico	0.94	0.93	0.92	0.91	0.93
Panama	9.95	10.07	10.20	10.32	10.50
Paraguay	0.91	0.90	0.90	0.89	0.90
Peru	2.76	2.73	2.71	2.68	2.74
Uruguay	0.89	0.86	0.83	0.80	0.82
Venezuela	1.87	1.82	1.77	1.72	1.77

The simulated impact of a world interest rate shock for each country is reported in Table 4. The table first shows the total expected present value cost of the shock attributable to foreign debt exposure as a percentage of GDP for both total external debt and public sector external debt. It next shows the same costs as percentages of public sector revenues. The last column shows the expected present value of the simulated response of the primary surplus to the same shock.

Table 4 allows a comparison of the adjustment of public sector revenues and expenditures to an interest rate shock under past policies to the adjustment required to maintain solvency. An excess of the amount shown in column 1 (column 2, depending on the nature of public sector liabilities associated with private foreign

borrowing) over that shown in column 5 implies that further policy adjustment will be necessary in the event of a shock. This can take the form of monetization, domestic public borrowing, eventual default or a change of fiscal stance.

Table 4

Surplus	Total External Debt		Public External Debt		Primary
	%GDP	%Revenue	%GDP	%Revenue	
%GDP					
Argentina	0.83	5.17	0.60	3.77	-1.93
Bolivia	2.54	18.13	2.20	15.73	NR ⁷
Brazil	0.06	0.22	0.04	0.15	0.62
Chile	2.72	12.30	1.34	6.05	-1.36
Colombia	1.04	6.21	0.82	4.90	-0.62
Costa Rica	1.75	7.14	1.42	5.81	0.82
Ecuador	2.62	11.17	2.01	8.55	1.32
Mexico	0.93	5.61	0.61	3.71	0.81
Panama	10.50	36.23	6.02	20.78	-0.14
Paraguay	0.90	6.13	0.72	4.87	0.70
Peru	2.74	22.57	2.06	16.97	0.41
Uruguay	0.82	2.72	0.57	1.90	2.45
Venezuela	1.77	8.53	1.29	6.19	-0.70

The table shows that an adverse interest rate shock leads to an increase in the present value of outstanding debt for Mexico, for example, of 0.9% of GDP and a present value increase in the primary surplus of 0.8%. This leaves a point estimate gap of 0.1% of GDP which is equivalent to a small rise in annual seignorage revenues. Negative estimates of the response of the primary surplus in present value indicate that the primary deficit rises in response to an adverse interest rate shock and decreases with a favorable shock. Both Tables 2 and 4 show that Panama is particularly sensitive to shocks. Table 2 shows this controlling for the outstanding debt level. The rate of real GDP growth for Panama is comparably volatile.⁸

Most of the countries display an increase in primary surpluses in response to world interest rate shocks that increase the present value of outstanding debt. At a glance this appears to be consistent with countercyclical fiscal policy. However, positive interest rate shocks are correlated with transitory reductions in real GDP growth, so that these fiscal policy stances are actually contractionary and therefore, procyclical.

Table 5 displays similar estimates for world petroleum price shocks.

Table 5

Surplus	Total External Debt		Public External Debt		Primary
	%GDP	%Revenue	%GDP	%Revenue	
	%GDP	%Revenue	%GDP	%Revenue	
Argentina	1.89	11.79	1.38	8.61	0.35
Bolivia	10.16	72.60	8.82	62.99	NR
Brazil	1.03	3.60	0.70	2.45	-1.41
Chile	4.83	21.86	2.38	10.76	-3.55
Colombia	2.20	13.17	1.73	10.39	-4.08
Costa Rica	5.33	21.77	4.34	17.74	-0.08
Ecuador	7.35	31.28	5.63	23.96	-0.72
Mexico	1.04	6.30	0.69	4.17	-2.10
Panama	6.99	24.13	4.01	13.84	4.86
Paraguay	1.05	7.10	0.83	5.64	-1.49
Peru	1.45	11.94	1.09	8.98	-0.72
Uruguay	2.77	9.17	1.94	6.41	-3.02
Venezuela	4.37	21.01	3.17	15.25	1.39

This table shows that world oil price shocks have greater effects on the costs of current indebtedness than do world interest rate shocks. The impact of a shock on the present value of external public debt as a fraction of public sector revenues for seven of the thirteen countries exceeds 10 percent. For Bolivia, a world oil price shock raises the present value of public external debt by 63 percent of revenues; for Ecuador, it is estimated to be 24 percent. For the majority of the countries, without a pattern with respect to oil importing or exporting countries, a positive shock in the real US price of oil raises the primary deficit of the public sector.

Table 6 displays the response to terms of trade shocks, holding constant the deflated world oil price for each country. A terms of trade shock is an improvement in the country's terms of trade. A favorable shock leads to a net present value increase in the public sector primary deficit of between 0.5 and 5 percent of GDP for five of twelve countries. It also leads to increases in the present value of outstanding debt for six of thirteen countries.

Table 6

Surplus	Total External Debt		Public External Debt		Primary
	%GDP	%Revenue	%GDP	%Revenue	
	%GDP	%Revenue	%GDP	%Revenue	
Argentina	-0.23	-1.46	-0.17	-1.06	-1.00
Bolivia	-0.21	-1.49	-0.18	-1.29	NR
Brazil	-0.31	-1.06	-0.21	-0.72	0.11
Chile	1.18	5.35	0.58	2.63	-1.60
Colombia	-0.38	-2.30	-0.30	-1.81	0.55
Costa Rica	-1.29	-5.29	-1.05	-4.31	-0.39
Ecuador	0.24	1.04	0.19	0.79	0.16
Mexico	0.41	2.49	0.27	1.65	-0.47
Panama	3.26	11.24	1.87	6.45	1.05
Paraguay	0.08	0.56	0.06	0.44	0.07
Peru	1.74	14.37	1.31	10.81	-0.66
Uruguay	-0.22	-0.72	-0.15	-0.50	-7.14

Venezuela	0.16	0.75	0.11	0.54	0.74
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Net Adjustment to Shocks

Each of the simulations of the expected cost of a shock provides an estimate of the net amount of adjustment to each shock that would be necessary under past fiscal policy responses to shocks in present value after taking account of changes in public sector taxes net of transfers and expenditures. Table 7 presents these estimates which are calculated by subtracting the present value change in the primary surplus from the present value change in debt-servicing costs. The first column for each type of shock gives the required adjustment net of the primary surplus response for the total of external debt as a percentage of GDP, and the second gives the net adjustment for public external debt alone as a percentage of public sector revenues.

Several interesting observations can be made from Table 7. The simulations imply that six countries, Argentina, Chile, Colombia, Panama, Peru and Venezuela, would require significant adjustments of their past fiscal stances in response to a world interest rate shock as shares of public sector revenues. However, for Argentina, Chile, Colombia, Peru and Venezuela, increases in inflation tax revenues of up to 2 percent of GDP could provide the increase in public sector revenues needed to sustain current levels of public external debt. For Panama, the shortfall is very large and changes in seignorage revenues are restricted by the peg of the balboa to the US dollar. The simulations imply that Brazil and Uruguay can more than sustain their current external debt using past fiscal policy responses without resort to inflation taxes.

Table 7

Type of Shock:	Interest Rate		Petroleum Price		Terms of Trade	
	Total %GDP	Public %Revenues	Total %GDP	Public %Revenues	Total %GDP	Public
%Revenues						
Argentina	2.76	15.84	1.54	6.44	0.76	5.16
Brazil	-0.55	-2.00	2.44	7.36	-0.04	-1.11
Chile	4.07	12.19	8.37	26.81	2.78	9.88
Colombia	1.65	8.58	6.28	34.83	-0.93	-5.09
Costa Rica	0.92	2.44	5.41	18.06	-0.90	-2.70
Ecuador	1.31	2.95	8.07	27.03	0.08	-0.10
Mexico	0.12	-1.15	3.14	16.86	0.88	4.50
Panama	10.64	21.28	2.13	-2.94	2.20	2.81
Paraguay	0.20	0.12	2.54	15.76	-0.01	-0.06
Peru	2.33	13.62	2.16	14.88	2.40	16.25
Uruguay	-1.63	-6.21	5.79	16.40	6.92	23.10
Venezuela	2.47	9.57	2.98	8.57	-0.59	-3.03

World oil price shocks have a small impact on Argentina, but fiscal policies would need to adjust, under the simulation, for Chile, Colombia, Costa Rica, Ecuador and Uruguay even allowing for significant seignorage revenue increases. Oil price shocks have a small effect on Panama, while for most countries they are a greater source of fiscal concern than foreign interest rate shocks.

Adverse terms of trade shocks other than petroleum price shocks do not appear to require significant fiscal adjustments for all countries. Positive non-oil terms of trade shocks do increase the net adjustment for the public

sector (public debt-servicing impact as a share of revenues) for Argentina, Chile, Mexico, Panama, Peru and Uruguay.

Simulating Other Fiscal Policy Responses

In addition to increasing taxes or reducing expenditures to meet positive shocks to external debt service, governments can increase inflation taxes or borrow domestically. The behavior of the sum of the primary surplus, seignorage revenues and domestic public borrowing is a broader measure of the historical fiscal response to the impact of exogenous shocks on debt-servicing. The model was re-estimated and the simulations calculated for three countries that have pursued rather different fiscal policies and for which this model performs well. These are Colombia, Ecuador and Mexico. Seignorage was calculated using the change in reserve money reported by the IMF International Financial Statistics, and domestic borrowing the difference between the interest-inclusive public sector budget deficit (IFS) minus foreign interest payments (World Bank World Debt Tables). Table 8 reports the present value of the response of this invented “external augmented surplus” and compares it to the response of the primary surplus for these countries, both as percentages of GDP.

Table 8

Surplus: “External” Primary						
Type of Shock:		Interest Rate		Petroleum Price		Terms of
Trade						
Colombia	-2.50	-0.62	-4.69	-4.08	1.03	0.55
Ecuador	0.74	1.32	-7.40	-0.72	-0.28	0.16
Mexico	-3.57	0.81	-6.38	-2.10	1.91	-0.47

This table reveals that the addition of the simulated responses of seignorage and domestic public borrowing exacerbates the insufficiency of the response of fiscal policies to exogenous shocks to the present real value of external debt except for the case of the Colombian and Mexican responses to terms of trade shocks. The separate time series behavior of seignorage revenues, tax revenues and public sector expenditures to these shocks would make an interesting extension of the study of the fiscal adjustment of indebted countries.

Comparison with Primary Gaps Estimates

The empirical model in the version without time trends can be used to compare the expected long-run present value of the primary surplus for each country. This is done by finding the steady-state solution of the estimated model and calculating the sustainable level of external debt as

$$d^* = \left(\frac{1\%g^*}{r^* + g^*} \right) s^*,$$

where * indicate the model steady-state values for the growth rate, interest rate and primary surplus. For example, the implied debt-to-GDP ratio that is sustainable is 22% for Argentina, 95% for Mexico and 98% for Colombia. However, these simulations are very sensitive to changes in the growth rate. For example, lowering the growth rate for each of these countries by 1% reduces the estimated long-run sustainable debt level to 17%, 36% and 60%, respectively. The estimates of the volatility of external debt obligations and the expected change in the present value of the primary surplus are much less sensitive to changes in the assumed base growth rate of GDP as shown in

Table 3.

Conclusion

The results reported in Tables 4 through 7 indicate the importance of exogenous shocks combined with external debt exposure for fiscal policies in Latin America. For most countries (with the exceptions of Panama and Peru), oil price shocks have larger impacts on the expected present value of external debt as a proportion of GDP, than do world interest rate shocks. Non-oil terms of trade shocks tend to have smaller effects than either interest rate or oil price shocks.

At current debt levels, three countries, Bolivia, Panama and Peru face a potential increase in the real present value of external public debt of at least 15% of public sector revenues for interest rate shocks. For oil price shocks, the potential fiscal adjustment necessary, in present value, for Bolivia exceeds 60% of public revenues. For six other countries, Chile, Colombia, Costa Rica, Ecuador, Panama and Venezuela, the impact of an oil price shock due to public debt exceeds 10% of public revenues. These estimates indicate that exogenous shocks have significant impacts on fiscal policy adjustment and viability. The country with the highest external debt-to-GDP ratio, Panama, also faces a potential interest rate shock to the present value of debt as a fraction of GDP of 10% of GDP. This is a dramatic measure of the riskiness of high indebtedness.

Table 7 adjusts these volatility estimates for simulated historical responses of fiscal policies to the same shocks. It reveals that for most of the countries adverse shocks to world interest rates and oil prices will require a change in fiscal stance or sizable increases in inflation taxes. The estimates also show that the oil shocks tend to increase public sector primary deficits for all but Panama and Venezuela (the impact for Costa Rica is negligible) in addition to increasing the costs of debt-service for all. For most countries, non-oil terms of trade improvements increase deficits so that adverse terms of trade shocks create the least concern for fiscal policy adjustment.

The sensitivity of the simulated estimates to the assumed base rates of real GDP growth and interest rate spreads is shown in Table 3. The simulations are very insensitive to these changes, which is comforting and contrasts sharply with the primary gaps procedure for the sustainability of public debt in long-run expectation.

Endnotes

1. Gavin, et al [1996] find that the average cumulative change in real GDP during major recessions of the past 25 years has been -10.7% for Latin American compared to -3.3% for the OECD countries.

2. These are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Panama, Paraguay, Peru, Uruguay and Venezuela. The time period for the estimation is 1970-1996, although the data series for some countries are shorter.

3. That is, if the public debt is sustainable before the shock in expectation, then the expression measures the required adjustment for the public sector to remain solvent in expectation after the shock.

4. The simulated primary surplus reported in this paper is calculated over an infinite horizon using long-run averages for the growth rate and interest rate. Because the growth rates and terms of trade for each country and the interest rate converge rapidly, the shock to debt-service reported in the tables is calculated from a ten-period simulation (adding more years and discounting using historical long-run growth and interest rates does not affect the simulated values to the reported number of decimal places).

5. The recent average value of each country's real growth rate is used for ten-periods to capture short-run dynamics due to a contemporary shock. However, a common average long-run rate of 3% is used for discounting beyond the first ten-periods of the simulation. The calculations are robust to changes in this growth rate between 2 and 4 percent as reported.

6. The external public debt of several Latin American countries includes a portion that is grant. This component does not affect the calculations performed in this paper, since even if debt carries a concessionary interest-rate spread, the cost of debt servicing as a fraction of GDP is subject to the same size shock to world interest rates or international prices. The grant element would affect a "primary gaps" estimation, but not the riskiness estimation.

7. The simulated value for the Bolivian primary surplus is not reported because the estimated model is explosive. This is attributable to a value for the primary surplus in the data set available to the author that is not credible for 1984 followed by unavailable data for 1985. Reestimation deleting the 1984 data will eliminate the unstable dynamics.

8. A hypothesis is that the US invasion of Panama on December 20, 1989 could contribute to this estimate and a dummy variable should be introduced to account for this event. However, the GDP growth rate drops dramatically in 1988 (it is -16%) not 1990.

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Appendix

Estimated Equations for Each Country

Table A.1

Dependent variable: Terms of Trade

Variable	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Ecuador
Constant	108.4131 <i>48.8154</i>	71.2053 <i>34.6366</i>	133.4054 <i>69.4799</i>	132.3814 <i>39.2251</i>	268.8094 <i>108.7344</i>	217.8650 <i>68.5433</i>	70.2786 <i>13.4604</i>
Trend	-1.5507 <i>0.8627</i>	-1.2011 <i>0.7494</i>	-2.1337 <i>0.9667</i>	-1.5877 <i>0.6986</i>	-5.0801 <i>2.2696</i>	-2.6875 <i>1.0399</i>	0.2096 <i>0.4801</i>
Interest rate(-1)	-0.6600 <i>1.3207</i>	1.9742 <i>2.3591</i>	-0.3521 <i>1.1070</i>	-0.6456 <i>1.2665</i>	3.5102 <i>3.5446</i>	1.2437 <i>1.6181</i>	3.1608 <i>1.0819</i>
Interest rate(-2)	0.4527 <i>1.1083</i>	-2.0324 <i>2.5475</i>	2.1048 <i>1.0976</i>	0.3903 <i>1.0489</i>	-1.2788 <i>2.3846</i>	-2.3438 <i>1.4069</i>	-0.3145 <i>1.1864</i>
Oil price(-1)	0.0196 <i>0.2611</i>	1.2551 <i>0.8293</i>	-0.2067 <i>0.2269</i>	-0.5522 <i>0.2196</i>	-0.0295 <i>0.6671</i>	-0.0496 <i>0.3509</i>	1.6967 <i>0.4397</i>
Oil price(-2)	-0.4576 <i>0.2682</i>	-0.4571 <i>0.8144</i>	-0.2010 <i>0.2354</i>	-0.1328 <i>0.2709</i>	-0.2001 <i>0.6368</i>	-0.1335 <i>0.2833</i>	0.8953 <i>0.5169</i>
Terms of Trade(-1)	0.9827 <i>0.2120</i>	0.1679 <i>0.3704</i>	0.0073 <i>0.2645</i>	0.5693 <i>0.1873</i>	0.1616 <i>0.2954</i>	-0.0204 <i>0.2600</i>	-0.5520 <i>0.2824</i>
Terms of trade(-2)	-0.3944 <i>0.2416</i>	0.2362 <i>0.3749</i>	0.3170 <i>0.2669</i>	-0.1932 <i>0.1676</i>	-0.3500 <i>0.3155</i>	-0.2786 <i>0.2775</i>	0.0055 <i>0.2182</i>
R-squared	0.9965	0.9800	0.9968	0.9969	0.9825	0.9937	0.9950

Standard errors in italics

Table A.1 (continued)

Variable	Mexico	Panama	Paraguay	Peru	Uruguay	Venezuela
Constant	90.9052 <i>25.4069</i>	111.6184 <i>36.2279</i>	176.7156 <i>47.6748</i>	197.6419 <i>52.9689</i>	95.6310 <i>20.3829</i>	41.1655 <i>18.0566</i>
Trend	-0.6586 <i>0.4152</i>	-1.0016 <i>0.4045</i>	-1.7540 <i>0.5630</i>	-3.4642 <i>0.9415</i>	-0.0161 <i>0.3529</i>	-0.1190 <i>0.7092</i>
Interest rate(-1)	2.2938 <i>1.3724</i>	-0.0336 <i>0.7607</i>	-2.1021 <i>1.0002</i>	-1.4576 <i>1.5322</i>	-1.3896 <i>0.9314</i>	4.4737 <i>2.1397</i>
Interest rate(-2)	-1.8053 <i>1.3799</i>	0.4611 <i>0.6818</i>	0.4647 <i>1.0453</i>	0.7794 <i>1.0950</i>	-0.2102 <i>0.9224</i>	-2.5764 <i>2.2131</i>
Oil price(-1)	1.1060 <i>0.4652</i>	0.6092 <i>0.1759</i>	-0.2259 <i>0.2247</i>	-0.3789 <i>0.2466</i>	-0.0243 <i>0.1707</i>	2.0495 <i>0.7528</i>
Oil price(-2)	0.3914 <i>0.5674</i>	0.0332 <i>0.2560</i>	-0.1165 <i>0.2434</i>	-0.0758 <i>0.2682</i>	-0.2643 <i>0.1799</i>	1.0396 <i>0.9068</i>
Terms of Trade(-1)	0.0369 <i>0.3044</i>	0.1851 <i>0.2596</i>	0.4597 <i>0.2335</i>	0.8420 <i>0.2210</i>	0.4999 <i>0.0970</i>	-0.0809 <i>0.3267</i>
Terms of trade(-2)	-0.0913 <i>0.2716</i>	-0.2287 <i>0.2121</i>	-0.4133 <i>0.2061</i>	-0.6098 <i>0.2817</i>	-0.2696 <i>0.0997</i>	-0.1115 <i>0.2646</i>
R-squared	0.9917	0.9987	0.9967	0.9968	0.9981	0.9826

Table A. 2

Dependent variable: Real GDP Growth Rate

Variable	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Ecuador
Constant	-0.0022 <i>0.2489</i>	0.0462 <i>0.0508</i>	0.1545 <i>0.4373</i>	0.6369 <i>0.1961</i>	-0.1330 <i>0.0710</i>	-0.2756 <i>0.2950</i>	0.2894 <i>0.0891</i>
Trend	0.0019 <i>0.0044</i>	0.0005 <i>0.0008</i>	-0.0057 <i>0.0056</i>	-0.0080 <i>0.0037</i>	0.0040 <i>0.0016</i>	0.0052 <i>0.0045</i>	-0.0049 <i>0.0017</i>
Interest rate(-1)	-0.0057 <i>0.0071</i>	-0.0052 <i>0.0026</i>	0.0013 <i>0.0068</i>	-0.0276 <i>0.0065</i>	-0.0060 <i>0.0024</i>	-0.0102 <i>0.0062</i>	-0.0001 <i>0.0031</i>
Interest rate(-2)	0.0004 <i>0.0058</i>	0.0030 <i>0.0025</i>	0.0026 <i>0.0062</i>	0.0115 <i>0.0060</i>	0.0003 <i>0.0015</i>	0.0063 <i>0.0050</i>	-0.0027 <i>0.0032</i>
Oil price(-1)	-0.0009 <i>0.0013</i>	-0.0010 <i>0.0008</i>	-0.0005 <i>0.0013</i>	-0.0008 <i>0.0012</i>	0.0004 <i>0.0005</i>	-0.0004 <i>0.0012</i>	-0.0013 <i>0.0013</i>
Oil price(-2)	-0.0002 <i>0.0014</i>	-0.0011 <i>0.0008</i>	-0.0003 <i>0.0013</i>	-0.0014 <i>0.0015</i>	-0.0010 <i>0.0005</i>	-0.0018 <i>0.0015</i>	-0.0011 <i>0.0017</i>
Terms of Trade(-1)	-0.0000 <i>0.0012</i>	0.0006 <i>0.0004</i>	0.0007 <i>0.0017</i>	0.0016 <i>0.0009</i>	0.0007 <i>0.0002</i>	0.0016 <i>0.0011</i>	0.0014 <i>0.0008</i>
Terms of trade(-2)	0.0002 <i>0.0013</i>	-0.0003 <i>0.0004</i>	-0.0004 <i>0.0016</i>	-0.0039 <i>0.0008</i>	0.0004 <i>0.0003</i>	0.0011 <i>0.0011</i>	-0.0015 <i>0.0007</i>
GDP Growth(-1)	-0.1296 <i>0.2756</i>	0.1008 <i>0.2686</i>	-0.0495 <i>0.3064</i>	0.1891 <i>0.1914</i>	-0.2740 <i>0.2648</i>	-0.0972 <i>0.3604</i>	-0.3496 <i>0.1888</i>
GDP Growth(-2)	-0.3866 <i>0.3014</i>	0.0280 <i>0.2179</i>	-0.1211 <i>0.3298</i>	-0.0524 <i>0.1518</i>	-0.1780 <i>0.2033</i>	-0.8217 <i>0.3858</i>	-0.4478 <i>0.1637</i>
R-squared	0.3459	0.9000	0.7370	0.8490	0.9702	0.8381	0.8685

Table A. 2 (continued)

Variable	Mexico	Panama	Paraguay	Peru	Uruguay	Venezuela
Constant	0.3129 <i>0.0900</i>	1.1343 <i>0.4041</i>	0.1530 <i>0.1396</i>	0.4289 <i>0.4558</i>	0.1605 <i>0.1270</i>	0.1172 <i>0.0592</i>
Trend	-0.0042 <i>0.0013</i>	-0.0041 <i>0.0042</i>	-0.0020 <i>0.0016</i>	-0.0092 <i>0.0084</i>	-0.0012 <i>0.0023</i>	-0.0010 <i>0.0017</i>
Interest rate(-1)	-0.0017 <i>0.0037</i>	-0.0003 <i>0.0082</i>	-0.0012 <i>0.0029</i>	-0.0141 <i>0.0141</i>	-0.0119 <i>0.0060</i>	-0.0070 <i>0.0060</i>
Interest rate(-2)	-0.0002 <i>0.0037</i>	-0.0145 <i>0.0074</i>	-0.0050 <i>0.0032</i>	0.0051 <i>0.0086</i>	0.0103 <i>0.0059</i>	0.0018 <i>0.0055</i>
Oil price(-1)	0.0023 <i>0.0012</i>	0.0032 <i>0.0020</i>	0.0006 <i>0.0008</i>	-0.0014 <i>0.0019</i>	0.0004 <i>0.0011</i>	-0.0020 <i>0.0018</i>
Oil price(-2)	0.0008 <i>0.0015</i>	0.0075 <i>0.0029</i>	-0.0010 <i>0.0008</i>	0.0014 <i>0.0021</i>	-0.0018 <i>0.0011</i>	-0.0008 <i>0.0022</i>
Terms of Trade(-1)	-0.0016 <i>0.0008</i>	-0.0060 <i>0.0029</i>	-0.0003 <i>0.0007</i>	0.0009 <i>0.0017</i>	0.0004 <i>0.0006</i>	0.0008 <i>0.0008</i>
Terms of trade(-2)	-0.0006 <i>0.0008</i>	-0.0062 <i>0.0024</i>	0.0000 <i>0.0006</i>	-0.0021 <i>0.0024</i>	-0.0009 <i>0.0006</i>	-0.0004 <i>0.0006</i>
GDP Growth(-1)	-0.1055 <i>0.3141</i>	-0.3782 <i>0.2763</i>	0.5583 <i>0.2480</i>	0.3024 <i>0.2823</i>	0.4125 <i>0.2318</i>	0.0782 <i>0.2862</i>
GDP Growth(-2)	-0.2697 <i>0.2593</i>	-0.2274 <i>0.2431</i>	-0.3432 <i>0.2270</i>	-0.5638 <i>0.3564</i>	-0.3554 <i>0.2325</i>	-0.4469 <i>0.3290</i>
R-squared	0.7911	0.7293	0.9105	0.3192	0.7433	0.5482

Table A. 3

Dependent variable: Primary Surplus of the Public Sector

Variable	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Ecuador
Constant	0.0580 <i>0.0523</i>	-0.1331 <i>0.1115</i>	-0.2243 <i>0.2577</i>	0.1958 <i>0.0925</i>	-0.0241 <i>0.0736</i>	0.1567 <i>0.1442</i>	0.0911 <i>0.0738</i>
Trend	0.0003 <i>0.0009</i>	0.0001 <i>0.0021</i>	0.0157 <i>0.0041</i>	-0.0032 <i>0.0019</i>	0.0012 <i>0.0018</i>	0.0008 <i>0.0021</i>	0.0010 <i>0.0015</i>
Interest rate(-1)	-0.0019 <i>0.0016</i>	0.0083 <i>0.0080</i>	0.0028 <i>0.0042</i>	-0.0073 <i>0.0043</i>	-0.0047 <i>0.0024</i>	0.0012 <i>0.0031</i>	0.0032 <i>0.0023</i>
Interest rate(-2)	-0.0033 <i>0.0014</i>	-0.0057 <i>0.0064</i>	0.0030 <i>0.0040</i>	0.0054 <i>0.0032</i>	0.0032 <i>0.0019</i>	0.0013 <i>0.0024</i>	0.0020 <i>0.0023</i>
Oil price(-1)	-0.0003 <i>0.0003</i>	0.0048 <i>0.0021</i>	-0.0019 <i>0.0008</i>	0.0005 <i>0.0007</i>	-0.0002 <i>0.0005</i>	-0.0010 <i>0.0007</i>	-0.0027 <i>0.0008</i>
Oil price(-2)	0.0002 <i>0.0003</i>	0.0013 <i>0.0022</i>	0.0007 <i>0.0008</i>	-0.0016 <i>0.0007</i>	-0.0007 <i>0.0004</i>	0.0004 <i>0.0007</i>	0.0025 <i>0.0014</i>
Terms of Trade(-1)	0.0002 <i>0.0003</i>	-0.0008 <i>0.0007</i>	0.0021 <i>0.0011</i>	-0.0003 <i>0.0004</i>	0.0002 <i>0.0002</i>	-0.0008 <i>0.0005</i>	0.0003 <i>0.0005</i>
Terms of trade(-2)	-0.0006 <i>0.0003</i>	-0.0002 <i>0.0009</i>	-0.0014 <i>0.0010</i>	-0.0003 <i>0.0004</i>	-0.0001 <i>0.0002</i>	-0.0007 <i>0.0006</i>	-0.0010 <i>0.0005</i>
GDP Growth(-1)	-0.0626 <i>0.0634</i>	1.0887 <i>0.6856</i>	0.0125 <i>0.1854</i>	0.1511 <i>0.1054</i>	0.3419 <i>0.2610</i>	0.1851 <i>0.1727</i>	-0.0492 <i>0.1427</i>
GDP Growth(-2)	-0.0867 <i>0.0672</i>	0.9976 <i>0.4354</i>	-0.2785 <i>0.1975</i>	0.0925 <i>0.0820</i>	0.0099 <i>0.2802</i>	-0.1538 <i>0.1817</i>	-0.2777 <i>0.1053</i>
Primary Surplus(-1)	0.2405 <i>0.2382</i>	2.1698 <i>1.1659</i>	-0.5133 <i>0.2201</i>	0.2321 <i>0.3347</i>	-0.2749 <i>0.4440</i>	0.1690 <i>0.2379</i>	0.8974 <i>0.2241</i>
Primary Surplus(-2)	-0.0837 <i>0.2333</i>	0.6718 <i>1.7073</i>	-0.8454 <i>0.2462</i>	-0.0737 <i>0.2492</i>	0.1285 <i>0.3016</i>	-0.8521 <i>0.2291</i>	-0.7097 <i>0.1683</i>
R-squared	0.8296	0.8721	0.9620	0.8774	0.8642	0.8990	0.9630

Table A. 3 (continued)

Variable	Mexico	Panama	Paraguay	Peru	Uruguay	Venezuela
Constant	0.0718 <i>0.0671</i>	-0.2363 <i>0.2587</i>	-0.0318 <i>0.0599</i>	0.0765 <i>0.1264</i>	0.2678 <i>0.0937</i>	0.0970 <i>0.0600</i>
Trend	0.0030 <i>0.0014</i>	0.0060 <i>0.0042</i>	0.0011 <i>0.0010</i>	-0.0011 <i>0.0023</i>	-0.0028 <i>0.0018</i>	-0.0022 <i>0.0020</i>
Interest rate(-1)	-0.0033 <i>0.0025</i>	-0.0027 <i>0.0060</i>	0.0004 <i>0.0011</i>	0.0011 <i>0.0043</i>	-0.0051 <i>0.0027</i>	-0.0042 <i>0.0092</i>
Interest rate(-2)	0.0046 <i>0.0025</i>	0.0006 <i>0.0052</i>	0.0014 <i>0.0011</i>	-0.0021 <i>0.0026</i>	0.0049 <i>0.0026</i>	-0.0009 <i>0.0055</i>
Oil price(-1)	0.0012 <i>0.0008</i>	0.0025 <i>0.0021</i>	-0.0006 <i>0.0003</i>	0.0002 <i>0.0005</i>	0.0003 <i>0.0005</i>	-0.0015 <i>0.0020</i>
Oil price(-2)	-0.0005 <i>0.0011</i>	-0.0012 <i>0.0022</i>	0.0002 <i>0.0003</i>	-0.0005 <i>0.0006</i>	-0.0018 <i>0.0005</i>	0.0005 <i>0.0022</i>
Terms of Trade(-1)	-0.0012 <i>0.0005</i>	-0.0002 <i>0.0018</i>	0.0005 <i>0.0002</i>	-0.0002 <i>0.0005</i>	-0.0004 <i>0.0004</i>	0.0004 <i>0.0009</i>
Terms of trade(-2)	0.0001 <i>0.0006</i>	0.0008 <i>0.0016</i>	-0.0004 <i>0.0002</i>	-0.0001 <i>0.0007</i>	-0.0008 <i>0.0003</i>	-0.0000 <i>0.0006</i>
GDP Growth(-1)	-0.3339 <i>0.2261</i>	-0.0817 <i>0.2095</i>	0.2010 <i>0.0812</i>	-0.0401 <i>0.0916</i>	-0.1015 <i>0.1625</i>	0.0398 <i>0.3065</i>
GDP Growth(-2)	-0.3009 <i>0.2150</i>	-0.1216 <i>0.2135</i>	0.0331 <i>0.0892</i>	-0.1792 <i>0.1001</i>	-0.2841 <i>0.1386</i>	-0.1694 <i>0.3197</i>
Primary Surplus(-1)	-0.3855 <i>0.2636</i>	0.2546 <i>0.5532</i>	0.4678 <i>0.2312</i>	0.3506 <i>0.2888</i>	0.2598 <i>0.3011</i>	0.6948 <i>0.3571</i>
Primary Surplus(-2)	-0.0361 <i>0.2452</i>	0.1538 <i>0.5016</i>	-0.1003 <i>0.1919</i>	-0.0744 <i>0.2735</i>	0.6035 <i>0.3439</i>	-0.8747 <i>0.5672</i>
R-squared	0.8323	0.7829	0.9079	0.6693	0.8165	0.7272