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International evidence on fiscal solvency: Is fiscal policy "responsible"? ☆

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ABSTRACT

We conduct a cross-country empirical analysis of fiscal solvency based on dynamic stochastic general equilibrium conditions. The results show evidence of fiscal solvency, in the form of a robust positive conditional response of the primary balance to changes in public debt, in panels for emerging and industrial economies and in a combined panel. Emerging economies show a stronger response and hence converge to lower mean debt–output ratios, as observed in the data. The results are weaker for countries with debt ratios exceeding panel means and medians. Hence, we can separate countries where fiscal solvency holds from those where it remains in doubt.

1. Introduction

The degree to which fiscal policy is consistent with intertemporal solvency—the requirement that public debt not explode or is "sustainable" in the long run—is a key issue for both industrial and emerging market countries. In the former, the ongoing/looming demographic transition is raising concerns about the need to avoid a large buildup of public debt, while in emerging economies with unstable access to capital markets, the painful economic adjustments associated with financial crises are an important incentive to keep public debt within sustainable bounds.

At one level, intertemporal solvency can be seen as an extremely weak criterion—since it requires only that adjustments to bring policy back on track occur at some point in the future. And given the sovereign's right to tax and (not) spend, credible changes in these variables can be assumed to make the problem of insolvency disappear. But markets are not impressed by promises that are unsupported by the track record of policy makers, and hence it is very important to

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examine this track record and assess whether it is consistent with behavior that satisfies an intertemporal budget constraint, or not.

Fiscal policy, however, is subject to a whole host of heterogeneous, often transitory, influences that make it difficult to disentangle the systematic effect of the government's efforts to adhere to its intertemporal budget constraint. For example, according to Barro's (1986) classic tax-smoothing model, temporary increases in government spending (for example due to wars) should be financed by a higher fiscal deficit, and business cycle fluctuations should be accommodated in a similar way. Hence, there is keen interest in understanding whether movements in fiscal balances that occur alongside these various "shocks" are nevertheless operating in a systematic way to offset the impact of transitory factors, and thereby preventing public debt from getting on to a divergent path.

The "model-based sustainability" (MBS) approach proposed by Bohn (1998, 2005) provides a tractable and powerful framework in which to examine whether government policy is in line with fiscal solvency. The essence of the MBS test is to determine whether increases in public debt elicit increases in the government's primary fiscal balance (i.e., the balance net of interest payments on the debt), controlling for other determinants of the primary balance. The intuition is that a positive conditional response of the primary surplus/GDP ratio to increases in the debt/GDP ratio means that, given the shocks occurring in the background, the fiscal authority reacts to positive changes in public debt by systematically raising the primary surplus.

Bohn proved that in a regression of the primary surplus against public debt, the cyclical position of the economy, and the transitory component of government spending, a positive regression coefficient on debt is *sufficient* to establish that fiscal policy is responsible, i.e., it satisfies the government's intertemporal budget constraint. Moreover, he showed that this test is valid regardless of whether debt and the primary balance are measured at constant or current prices, and in levels or as shares of GDP; it does not require explicit knowledge of fiscal policy rules or the portfolio of public debt instruments (i.e., indexed bonds, nominal bonds, foreign currency bonds, etc.); and it applies whether debt is held by domestic or foreign residents.

Applications of Bohn's MBS test have focused almost exclusively on data for the United States (see Bohn, 1998, 2005).[1] The issue, however, is of much broader interest given the greater systemic importance of a number of industrial and emerging market countries than even a few years ago, and the need to view progress in addressing high levels of public debt in some countries against the backdrop of the buoyant conditions prevailing in financial markets in recent years and the robust growth of the world economy. Indeed, whether countries have been in fact acting in ways that will make debt crises less likely in the future, or merely riding a wave of benign growth and financing conditions, is a key question that the MBS framework can address.

A further issue central to fiscal solvency debates is the degree to which the responsiveness of fiscal policy to debt varies with the level of the debt. Does responsiveness diminish as the debt ratio rises? At what levels of debt does the response change, perhaps reflecting the limits of political tolerance for fiscal stringency in the face of mounting debt? Does evidence of "tipping points" in fiscal responsibility vary between industrial and emerging market countries?

This paper looks at these issues for a large panel of both industrial and emerging market countries. We use a dataset that generally covers the broad public sector (as opposed to the central government) for 34 emerging market and 22 industrial countries (IC) over the period 1990–2005. Robustness of the positive conditional relationship between primary surpluses and debt is established across a broad range of specifications of the MBS test that allow for non-linearities in the relation, transitory effects of government purchases and the business cycle, effects of inflation and external deficits, as well as country fixed effects and country-specific serial autocorrelation of error terms. Moreover, the key homogeneity assumption of the panel regressions imposing a common response coefficient of primary balances to debt in all countries cannot be rejected for 42 out of the 56 countries in our sample.

We conclude from these findings that there is indeed strong empirical evidence of a robust positive conditional relationship between primary surpluses and public debt for both emerging market and advanced economies (as well as in a panel that combines the two). This relationship is encouraging from a policy perspective, since it suggests that, far from being prone to default, government policy is consistent with fiscal solvency in many countries.

The results also indicate that the response of the primary balance to debt is stronger in emerging economies. The MBS framework predicts that, because of this stronger response, emerging countries converge to lower mean debt ratios. We compute estimates of the mean debt ratios predicted by the model, and find that they are in line with the data for the last two decades (which show higher average public debt ratios for IC).

Our empirical analysis also shows that the MBS test is a useful tool for separating countries where fiscal solvency holds from those where it is in doubt. In particular, we find that the positive response of the primary balance to debt is much weaker in emerging market countries with debt–GDP ratios in excess of 50 percent. Moreover, we sort the countries in each of our panels of industrial, emerging market, and combined set of countries into high- and low-debt countries relative to the mean and median of each panel, and find that the MBS test fails in high-debt countries. However, the test passes even in

[1] An exception is IMF (2003) that applies Bohn's test to a panel of advanced and emerging economies. However, this analysis used ad-hoc country exclusion restrictions and did not correct for significant serial autocorrelation in the data. In contrast, we use a sample that is larger in country and time coverage without exclusions and we control for serial autocorrelation. These adjustments reverse the result in IMF (2003) suggesting that industrial countries with high debt respond with larger increases in the primary balance. In addition, we obtain new results showing that Bohn's test fails for high-debt countries in general.

these high-debt groups if we allow for non-linear terms that detect a weaker primary balance response as the debt ratio rises above 50 percent (except in industrial economies).

The remainder of this paper is organized as follows. The next section summarizes the analytical framework behind Bohn's MBS test. Section 3 presents the results of our empirical analysis. The final section presents the main conclusions.

2. Model-based sustainability analysis

This section reviews the main elements of Bohn's (2005) MBS framework. Many empirical studies of fiscal solvency (or public debt sustainability) are based on what he defines as "ad-hoc sustainability:" testing whether the time-series properties of fiscal data are consistent with the hypothesis that the expected present value of primary balances, *discounted at the interest rate on public debt*, equals initial debt.[2] In contrast, MBS requires sustainable fiscal policies to be consistent with the general equilibrium conditions that link the government and the private sector. Seen from this perspective, ad-hoc sustainability turns out to be a mistaken definition of fiscal solvency because the interest rates on public debt are *not* the correct discount factor for evaluating the expected present value of primary balances.

Following Ljungqvist and Sargent (2004), the above arguments can be illustrated as follows: Consider an economy where output (y) and government purchases (g) follow a well-behaved stochastic process such that the state s_t at date t is given by $s_t = (y_t, g_t)$ and the probability of going from s_t to s_{t+1} is given by a Markov transition density function $f(s_{t+1}, s_t)$. This economy features complete asset markets. The equilibrium prices of these assets are given by the j-periods-ahead pricing kernel $Q_j(s_{t+j}|s_t)$ that satisfies a standard optimal asset demand condition:

$$Q_j(s_{t+j}|s_t) = \frac{\beta^j u'(y(s_{t+j}) - g(s_{t+j}))}{u'(y(s_t) - g(s_t))} f^j(s_{t+j}, s_t) \tag{1}$$

where $u'(\cdot)$ is the marginal utility of consumption, with consumption given by the economy's resource constraint $c(s_{t+j}) = y(s_{t+j}) - g(s_{t+j})$. Similarly, the interest rate on risk-free public debt that matures j-periods ahead of t, R_{jt}, satisfies the following optimality condition:

$$[R_{jt}]^{-1} = \beta^j E_t \left[\frac{u'(y_{t+j} - g_{t+j})}{u'(y_t - g_t)} \right] \tag{2}$$

The government budget constraint at each date t is

$$g(s_t) = \tau(s_t) + \int Q_1(s_{t+1}|s_t) b_t(s_{t+1}|s^t)\, ds_{t+1} - b_{t-1}(s_t) \tag{3}$$

Government revenue is denoted by $\tau(s_t)$, and $b_t(s_{t+1}|s^t)$ represents securities by which the government commits at date t to deliver an amount of goods at t+1 in state s_{t+1} after a history of states s^t. No restrictive assumptions about the types of securities included in $b_t(s_{t+1}|s^t)$ are needed. The government can issue all kinds of state-contingent bonds (e.g., indexed to inflation, foreign currencies or GDP and in multiple maturities), or just one-period, non-state contingent bonds (in which case $b_t(s_{t+1}|s^t) = b_t(s_t)$ for all s_{t+1}). Assumptions about the residence of the holders of these assets are also not needed. Government securities may be traded with domestic residents only, or also with foreign agents. What is critical is that there are complete markets of contingent claims where the prices of all assets issued by the private and public sectors are determined (even if the government issues only non-state-contingent debt).

Using (1) and (3), it follows that the government's intertemporal budget constraint is[3]

$$b_{t-1}(s_t) = \tau_t - g_t + \sum_{j=1}^{\infty} E_t \left[\frac{\beta^j u'(y_{t+j} - g_{t+j})}{u'(y_t - g_t)} (\tau_{t+j} - g_{t+j}) \right] \tag{4}$$

where the notation has been simplified to use time subscripts only, instead of functions of s. Using (2), the solvency condition (4) can be rewritten as

$$b_{t-1}(s_t) = \tau_t - g_t + \sum_{j=1}^{\infty} \left\{ R_{jt}^{-1} E_t[\tau_{t+j} - g_{t+j}] + \mathrm{cov}_t \left[\frac{\beta^j u'(y_{t+j} - g_{t+j})}{u'(y_t - g_t)}, \tau_{t+j} - g_{t+j} \right] \right\} \tag{5}$$

Condition (5) makes it clear that ad-hoc sustainability tests are valid only if all the covariance terms in the right-hand side of (5) are zero. This requires at least one of the following assumptions: (a) no uncertainty; (b) private agents are risk neutral or (c) future government surpluses are uncorrelated with future marginal utilities of consumption. Assumptions (a) and (b) are unrealistic, and (c) is sharply at odds with empirical evidence showing that primary balances are procyclical in IC, and range from acyclical to countercyclical in developing countries (e.g., Alesina and Tabellini, 2005; Catao and Sutton, 2002; Gavin and Perotti, 1997; Kaminsky et al., 2004; Talvi and Vegh, 2005).

[2] Several studies have tested for fiscal solvency following this approach by examining the unit-root and co-integration features of fiscal data. Bohn (2005) reviews the literature on this class of fiscal solvency tests.

[3] This result also requires that the transversality conditions for private agents' holdings of government bonds hold.

Ignoring the result in (5) can lead to serious errors in evaluating fiscal sustainability. For instance, Bohn (1995) shows that, in a balanced-growth economy where output growth is *i.i.d.*, a rule that maintains g/y and b/y constant violates ad-hoc sustainability if mean output growth is greater than or equal to the interest rate on public debt, and yet it satisfies condition (4).

Proposition 1 in Bohn (2005) provides the basis for the MBS test: if the primary balance–GDP ratio (pb) is an increasing, linear function of the initial debt–GDP ratio (b), after controlling for other determinants (μ) of the primary balance-output ratio, and if these other determinants measured as GDP ratios are bounded and the present value of output is finite, then the solvency condition (4) holds. Hence, the MBS test consists of estimating the relationship

$$pb_t = \rho b_{t-1} + \mu_t + \varepsilon_t \tag{6}$$

where ε is a zero-mean error. The finding that ρ is positive and statistically significant is *sufficient* to guarantee that condition (4) is satisfied. In most of his tests, Bohn sets the other determinants of the primary balance as $\mu_t = \beta_0 + \beta_1\tilde{g}_t + \beta_2\tilde{y}_t$, where $\tilde{g}_t$ and $\tilde{y}_t$ are measures of temporary fluctuations in government outlays and GDP, respectively.[4]

The intuition behind the MBS test is that, if condition (6) holds, the government budget constraint implies that debt grows between t and t+1 to a level that is $(1-\rho)$ of the level that implies a Ponzi scheme, so j-periods ahead the debt is $(1-\rho)^j$ the size of a Ponzi scheme. If $0<\rho<1$, there is no Ponzi game because $E_t[q^t_{t+j+1}(s^{t+j+1})b_{t+j}(s_{t+j+1}|s^{t+j})] \approx (1-\rho)^j b_t \to 0$ as $j\to\infty$, where $q^t_{t+j+1}(s^{t+j+1}) = (\beta^j u'(y_{t+j}-g_{t+j})/u'(y_t-g_t))f(s_{t+j},s_{t+j-1})f(s_{t+j-1},s_{t+j-2})\ldots f(s_{t+1},s_t)$ is the discount factor implied by equilibrium asset prices. If $\rho>1$, this expected value diverges to $-\infty$ as j grows, so the government would be accumulating infinite assets (instead of debt).

The MBS test also yields a condition for computing sustainable debt ratios, defined as the mean debt–GDP ratio to which the economy converges in the long run. In particular, if the "other" determinants of the primary balance and the growth-adjusted real interest rate on public debt are stationary, with means $\bar{\mu}$ and $\bar{r}$, respectively, the linear response set in (6) and the budget constraint (3) yield the following long-run expected value for the public debt–GDP ratio:

$$E[b_t] = \frac{-\bar{\mu} + (1-\rho)\,\mathrm{cov}(1+r_t, b_{t-1})}{\rho(1+\bar{r}) - \bar{r}} \tag{7}$$

Note that if $\bar{\mu}\leqslant 0$ (as is the case in the empirical applications of this setup) and if cov$(1+r_t,\ b_{t-1})\geqslant 0$, $E[b]$ is a *negative* function of ρ. Thus, all else constant, a higher ρ indicates *reduced* average debt in the long run because the government responds with larger primary balances, instead of further borrowing, as past debt rises. Without additional information we cannot say that higher ρ indicates more fiscal discipline or more sustainable fiscal policies. All we can say is that, as long as ρ is positive and significant, the data indicate that fiscal solvency holds. The situation changes if we can document other features of the fiscal environment that distinguish countries, such as differences in average revenues, their volatility, or the cyclical behavior of primary balances (see IMF, 2003; Mendoza and Oviedo, 2006).

It is important to emphasize three key features of the MBS test: (1) As noted earlier, the test does not require assumptions about debt management, the maturity and/or denomination structure of debt, or the residence of debt holders.[5] (2) The linear, conditional response of the primary balance to debt in Eq. (6) is *sufficient* but not *necessary*. A non-linear and/or time varying response can also support fiscal solvency as long as the response is strictly positive above a certain threshold debt–output ratio, or almost surely in the long run. (3) The test does not require knowledge of the specific set of government policies on debt, taxes and expenditures. The MBS test determines whether the *outcome* of those policies implicit in past primary balances and debt data are in line with the solvency condition (4).

There are also two important caveats. First, the test assumes complete markets. If instead one assumes an incomplete-markets economy where the possible realizations of shocks are known but there are not sufficient state-contingent claims to fully hedge against them, the debt dynamics consistent with fiscal solvency are difficult to analyze because of precautionary saving behavior (see Aiyagari et al., 2002; Mendoza and Oviedo, 2006). Still, our estimates of long-run mean debt ratios for emerging economies in Section 3 are similar to those obtained by Mendoza and Oviedo. This is reasonable because the linear rule specified in (6) is a sufficiency condition that yields a well-defined long-run average (see Eq. (7)) which can be consistent either with the complete-markets solvency condition or with the tighter debt limits implied by incomplete markets. Intuitively, a government with positive ρ remains solvent, but it could afford higher indebtedness if markets were complete.[6]

The second important caveat of the MBS test relates to how to read results showing that the conditional response of the primary balance to debt is negative or statistically insignificant. Bohn (2005) argues that as long as there is an active market for the debt instruments of a government for which the test fails, and if investors are rational, failures of the test are evidence that either the intertemporal budget constraint of infinitely lived agents is not the relevant one (e.g., holders of

[4] As Bohn (1998) explained, these controls are required when pb and b are stationary. Pool unit root tests with common or country-specific unit roots, and with or without linear trends, rejected unit roots in pb in all the panels we studied, but the results for b were less conclusive.

[5] Bohn (2005) also shows that the test is valid for nominal debt, real debt or the debt–GDP ratio as long as conditions (1)–(5) use the correct "propagation factor" (the nominal, real, or growth-adjusted real interest rates, respectively).

[6] This intuition does not apply if insurance markets are incomplete because of large shocks outside the set used to price contingent claims (e.g., an unexpected shutdown of credit markets or a surprisingly large negative shock to the primary balance). These shocks can make the government insolvent, and hence results showing a positive ρ in past data cannot guarantee future fiscal solvency.

public debt could have finite lives) or that the failures themselves signal future policy changes that the market anticipates. The alternative is of course that failures of the test do indicate that the prevailing fiscal policies are unsustainable and that the government is insolvent.

3. Cross-country empirical analysis of fiscal solvency

Fig. 1 plots the evolution of public debt for industrial and emerging market countries over the period 1992–2005. One feature stands out: IC have generally higher debt–GDP ratios than emerging market countries. The average for the former is about 10 percentage points higher. We will show later that this key stylized fact is consistent with the debt ratios predicted by our empirical analysis.

Our cross-country application of the MBS test is based on annual data for 22 IC over 1970–2005 and 34 developing countries over 1990–2005. Within each group, country-specific samples vary with data availability. The data include total public debt and primary fiscal balances as shares of GDP at current prices, real GDP, real government purchases, average CPI inflation and the current account as a share of GDP.

Fiscal data for IC correspond to gross general government debt and the primary balance of the general government as shares of GDP from the OECD's *Analytical Database*. For emerging economies, we use an IMF dataset produced following the methodology used in IMF (2003) and Celasun et al. (2006). These data reflect information from IMF country desk and fiscal economists for the most comprehensive coverage of the public sector available, which was either the general government or the overall public sector (i.e., the consolidated general government plus public enterprises). The debt data pertain mainly to gross debt and are adjusted to include, where appropriate, debt issued by development banks and debt used to recapitalize domestic banks in the aftermath of banking crises. Output and government purchases data are from the IMF's *World Economic Outlook*, and inflation and the current account are from the IMF's *International Financial Statistics*. Since we detrend GDP and government expenditures using the Hodrick–Prescott filter, we retrieved the longest time series available for these variables, which for the majority of countries start in 1960.

We estimate a cross-country panel version of the MBS test that allows for variation across countries (indexed by i) and over time (indexed by t):

$$pb_{i,t} = \beta_{0,i} + \beta_1 \tilde{g}_{i,t} + \beta_2 \tilde{y}_{i,t} + \rho b_{i,t} + \varepsilon_{i,t} \tag{8}$$

We allow for country-specific fixed effects, so the intercept varies across i. In addition, since within-country first-order autocorrelation of the error term is likely given the annual macroeconomic time series used in the regressions, we correct for country-specific serial autocorrelation in error terms such that $\varepsilon_{i,t} = \delta_i \varepsilon_{i,t-1} + \eta_{i,t}$, where $\eta_{i,t}$ is *i.i.d.* All the regressions use White cross-section standard errors and covariances to adjust for heteroskedasticity.

The regressions use two alternative measures of temporary fluctuations in government outlays and GDP. One set uses simply the cyclical components of those variables obtained by detrending the data using the Hodrick–Prescott filter with the smoothing parameter set at 100. The resulting detrended series are labeled "*output gap*" and "*government expenditures*

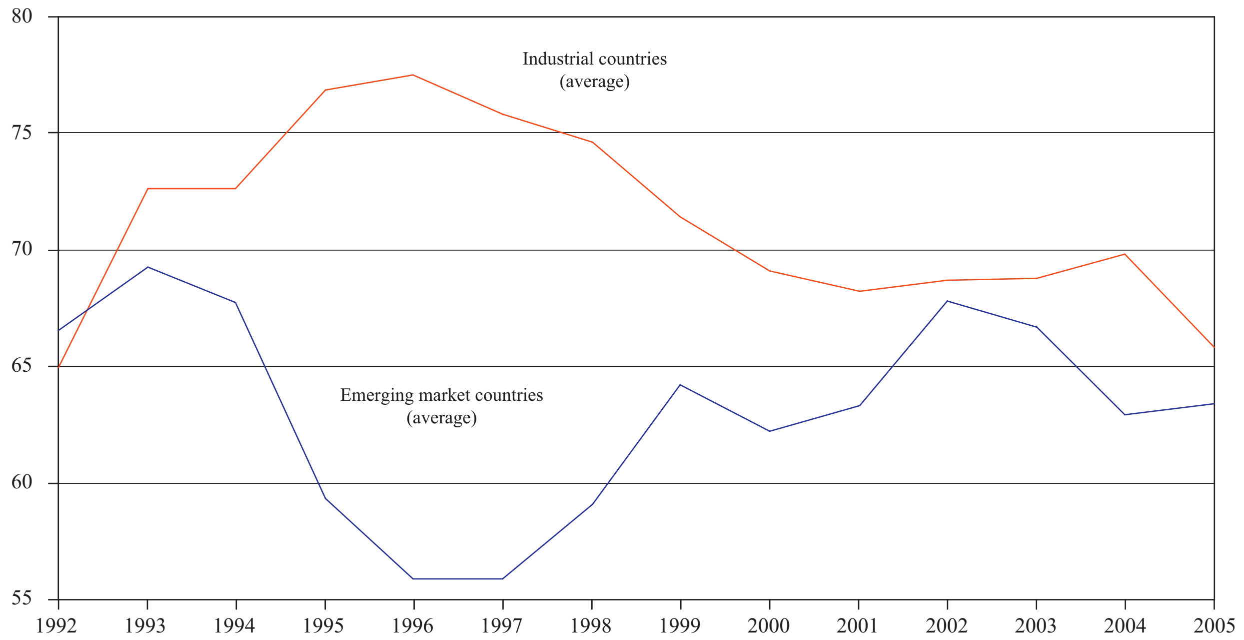

Fig. 1. Public debt (in percent of GDP).

gap.'' The second set follows Bohn (1998) to construct the measures of temporary fluctuations in output and government purchases that enter in the closed-form solution of Barro's (1986) tax-smoothing model. These measures are defined as *GVAR* and *YVAR* for government purchases and output, respectively, and the corresponding formulae are

$$\mathrm{GVAR}_t = \frac{g_t - g_t^T}{g_t^T}\frac{g_t^T}{y_t}, \quad \mathrm{YVAR}_t = \frac{y_t^T - y_t}{y_t^T}\frac{g_t^T}{y_t} \tag{9}$$

In these expressions, a superscript T denotes the trend value of the corresponding variable. Note that the sign of β_2 obtained in specifications that use *YVAR* should be the opposite of that produced by specifications that use *output gap*.

Bohn applied the MBS test to long samples of US time series (1916–1995 and 1792–2003 in his (1998) and (2005) articles, respectively), and he measured temporary government purchases as the difference between actual and estimated permanent *military* expenditures. This was done because non-military expenditures are a random walk in long US time series (so they have no transitory component) and because big transitory shifts in military spending during wars are the dominant force driving temporary government spending. Since these two features of the US data cannot be established in our cross-country sample, we use a standard definition of temporary government purchases as the cyclical component of such purchases.[7]

3.1. Results for Industrial Countries

Table 1 presents the results of panel regressions for the IC panel. Column I shows the results of a univariate regression that uses the debt ratio as the only explanatory variable (other than country fixed effects and autocorrelation coefficients). Columns II and III add the output and government expenditures gaps in specifications without correcting for serial autocorrelation (column II) and with serial autocorrelation corrections (column III). Columns IV to VI replace the output and government purchases gaps with *YVAR* and *GVAR*, respectively (column IV), add inflation (column V) or add the current account–GDP ratio (column VI). Due to space constraints, estimates of the β_i and δ_i coefficients are not listed in Table 1 and all the tables that follow. The full set of results is available from the authors.

The univariate regression in column I yields a positive value for ρ that predicts that increases of 100 basis points in the debt–GDP ratio lead to an increase in the primary balance–GDP ratio of 3.8 basis points. This response is statistically significant at the 95 percent confidence level. Fluctuations in output and government purchases enter significantly and with the expected sign in columns II and III, and adding them reduces the estimate of ρ to 0.02, which is still significant (albeit only at the 90 percent level in column III). Columns III and IV show that changing the measures of temporary output and government spending does not affect the estimate of ρ or its standard error. Interestingly, these results are similar to those obtained by Bohn (1998, 2005).[8]

Columns V and VI of Table 1 illustrate the robustness of the results to the inclusion of two potentially important determinants of the primary balance: CPI inflation (to control for inflation tax effects) and the current account–GDP ratio (to control for ''twin deficits'' effects—a positive association between external deficits and fiscal deficits). These variables are not statistically significant, and they do not affect the coefficient estimates for output and government purchases and their standard errors. The standard error of ρ is also unaffected, but the coefficient estimate is slightly higher (reaching 0.024 in column VI).

We conducted two sets of tests to study whether the response of the primary balance to debt varies at different levels of debt. First we added non-linear coefficients by introducing as explanatory variables splines that test for changes in the response of *pb* to *b* above a threshold level of debt, or terms in the square or cube of deviations of debt from within-country means. The coefficients of these non-linear variables were not statistically significant, however, in contrast to Bohn's (1998, 2005) findings for the United States.[9] He identified a stronger and statistically significant response of the primary balance to debt at high-debt ratios. Second, we split the IC panel into high-debt (HDIC) and low-debt (LDIC) countries (columns VII and VIII of Table 1). The LDIC (HDIC) subgroup is defined as the IC with mean *and* median debt ratios in their country time series that are less or equal (greater) than the mean and median for the full IC panel (i.e., the mean and median calculated using the data for all 22 IC over the entire sample period).[10] The mean and median debt ratios in the IC panel are 59 and 57.8 percent, respectively. The HDIC (LDIC) group has 9 (13) countries.

Columns VII of Table 1 shows that the estimate of ρ in the HDIC group is not statistically significant, and the point estimate is in fact negative. In contrast, column VIII shows that the debt coefficient is positive and significant at the 90 percent confidence level for the LDIC group, and the estimated ρ (0.022) is close to the estimate for the full IC group in

[7] We conducted sensitivity analysis by comparing the results obtained in this way with those produced by measuring temporary government spending as excess government spending above thresholds set in units of standard deviations of the cyclical component of government purchases. These thresholds are a proxy that captures large spikes in government spending due to wars or natural disasters. The results were largely unaffected by this change.

[8] The estimates of ρ obtained using 1916–1995 data in Bohn (1998) range from 0.028 to 0.054. The estimates based on 1792–2003 data in Bohn (2005) are somewhat higher, ranging from 0.028 to 0.147.

[9] As in Bohn (1998), the spline variables are of the form $\max(0, b - \bar{b})$. We tried $\bar{b}$ ranging from 0.45 to 0.90.

[10] If the mean and median for a particular country give conflicting results (i.e., one above the full IC panel moment and the other below), we let the median set the country's designation. This occurred only in the case of Sweden.

Table 1
Debt sustainability regressions: industrial countries (dependent variable: primary balance as a share of GDP)

	All industrial countries						High-debt group	Low-debt group
	I	II	III	IV	V	VI	VII	VIII
Debt–GDP ratio	0.038	0.023	0.020	0.020	0.021	0.024	−0.013	0.022
	(0.018)**	(0.012)**	(0.012)***	(0.012)***	(0.012)***	(0.013)***	(0.026)	(0.014)***
Output gap		0.339	0.309		0.311	0.300		
		(0.091)*	(0.055)*		(0.054)*	(0.055)*		
Gov. expenditures gap		−0.347	−0.209		−0.215	−0.213		
		(0.081)*	(0.041)*		(0.042)*	(0.042)*		
YVAR				−1.239			−1.414	−1.135
				(0.211)*			(0.356)*	(0.237)*
GVAR				−0.946			−1.672	−0.533
				(0.186)*			(0.352)*	(0.277)**
Inflation					0.026			
					(0.018)			
Current account–GDP ratio						−0.029		
						(0.037)		
Country AR(1) coeffs.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.739	0.283	0.769	0.767	0.770	0.768	0.794	0.662
s.e.	1.648	2.763	1.558	1.564	1.557	1.566	1.958	1.278
No. of countries	22	22	22	22	22	22	9	13
No. of observations	514	524	504	504	502	496	196	286

Note: All regressions include country fixed effects and White cross-section standard errors and covariances. Standard errors shown in parenthesis. "*," "**" and "***" denote that the corresponding coefficient is statistically significant at the 99, 95 and 90 percent confidence levels, respectively. Output and government expenditures gaps are percent deviations from Hodrick–Prescott trends. YVAR and GVAR are transitory components of output and government purchases as defined in Barro (1986). YVAR is the percent deviation of trend GDP from actual GDP times the ratio of trend government purchases to actual GDP. GVAR is the percent deviation of actual government purchases from their trend times the ratio of trend government purchases to actual GDP. Low-debt countries are those with mean and median debt ratios at or below the mean and median of all industrial countries (which are 59 and 57.8 percent, respectively), and they include Austria, Australia, Germany, Finland, France, Great Britain, Greece, Norway, New Zealand, Sweden, United States, Iceland and Luxemburg. The high-debt countries are Canada, Denmark, Spain, Ireland, Italy, Japan, The Netherlands, Portugal and Belgium. The panel is unbalanced with samples that cover mainly the 1980–2005 period.

column IV. Thus, these results suggest that fiscal solvency cannot be verified in IC with a history of high debt such that the median (mean) debt ratio exceeds 57.8 (59) percent.

3.2. Results for emerging economies

Table 2 presents results for the emerging markets (EM) panel. The results show that the response of primary balances to debt is generally positive and statistically significant in all the regressions. The estimated response without spline adjustments (columns I–IV and VII, VIII) is about 0.036. As in the case of IC, whether we use *output gap* and *government expenditures gap* or *YVAR* and *GVAR* makes virtually no difference for the estimate of ρ (compare columns III and IV).

A comparison of the results in Tables 1 and 2 yields two important differences in the results of the solvency tests for the IC and EM groups:

(1) The estimate of ρ is higher in the EM group. Comparing column III in Tables 1 and 2, ρ is estimated at 0.02 in the IC group vs. 0.036 in the EM group. The ρ coefficients are also estimated with more precision in the EM group (with the majority significant at the 0.99 confidence level).

(2) The absolute values of the coefficients on *output gap* and *gov. expenditures gap* in the IC group are significantly higher than in the EM group. Looking at column III in Tables 1 and 2, an increase of 1 percentage point in *output gap* (*gov. expenditures gap*) increases (reduces) the primary balance–GDP ratio by nearly 1/3 (1/5) of a percentage point in the IC group, compared to 0.09 (0.08) of a percentage point in the EM group. These differences reflect the sharp contrast between countercyclical fiscal policies in IC and the procyclical/acyclical fiscal policies of emerging economies. The median unconditional correlation between the primary balance–GDP ratio and *output gap* is 0.25 in the IC group vs. only 0.03 in the EM group (see Table 4 in Mendoza and Ostry (2007) for a listing of each country's correlation coefficient).

The differences in the IC and EM results have important implications. On one hand, the solvency condition (5) implies that, if asset markets are complete, fiscal solvency is compatible with higher debt ratios for countries with acyclical or countercyclical primary balances (i.e., procyclical fiscal policy) than for countries with procyclical primary balances (i.e., countercyclical fiscal policy). Hence, the lower primary balance-output gap correlations of EM countries would suggest that they should make more use of debt markets than they seem to make. On the other hand, the result in (7) predicts that the higher ρ in the EM group implies that these countries converge to *lower* mean debt ratios in the long run than countries in the IC group. Thus, the higher ρ in the EM group is not an indicator of "more sustainable" fiscal policies. Instead it indicates that an increase in debt of a given magnitude requires a stronger conditional response of the primary balance than in the IC group. This may reflect asset market frictions that are more pervasive for EM countries (see IMF (2008)) and the riskier fiscal environment they face—their primary balances are acyclical or countercyclical, their revenues are lower and more volatile, and they have limited access to state-contingent claims.

The results with the 50-percent spline (columns V and VI in Table 2) show that the response of primary balances to debt in the EM group weakens considerably when the debt ratio is above 50 percent.[11] However, the net effect (i.e., the sum of the coefficients on the debt–GDP ratio and the 50 percent spline) remains positive at 0.023 and is statistically significant. Thus, the spline does not provide evidence against fiscal solvency in EM countries.

Columns VII and VIII in Table 2 show that the estimate of ρ for the EM group is robust to the addition of inflation and the current account–GDP ratio as explanatory variables. The estimate of ρ is always about 0.036. Inflation is not statistically significant, but the current account–GDP ratio is significant and positive with a coefficient of 0.19 (suggesting a "twin deficits" effect).

Columns IX and XI present the results obtained by dividing the EM group into high-debt (HDEM) and low-debt (LDEM) subgroups, splitting the sample again by assigning countries to the LDEM group if both their mean and median debt ratios are less or equal than the mean and median of the full EM panel (64.5 and 58.2 percent, respectively). HDEM and LDEM include 15 and 19 countries, respectively. The results are in line with the findings derived from splitting the IC group into high- and low-debt groups: The estimate of ρ in the high-debt group is not statistically significant, while the estimate of ρ in the low-debt group at 0.041 is significant at the 99 percent confidence level. Moreover, comparing the results for low-debt groups in Tables 1 and 2, the estimate of ρ for emerging economies is again higher than for IC (0.041 vs. 0.022 in the LDEM and LDIC groups, respectively).

Columns X and XII add a 50-percent spline to the HDEM and LDEM panels. The estimate of ρ is similar (around 0.063), and positive and significant. Thus, when debt ratios are below 50 percent, the response of the primary balance to debt is about the same in the two groups. The spline term weakens this response in both HDEM and LDEM, but much more in the former.

[11] The 50-percent spline was chosen by comparing results with splines ranging from 40 to 90 percent, choosing the one with the lowest standard error from those that were statistically significant.

Table 2
Debt sustainability regressions: emerging economies (dependent variable: primary balance as a share of GDP)

	All emerging economies								High-debt group		Low-debt group	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Debt–GDP ratio	0.037	0.035	0.036	0.035	0.106	0.107	0.036	0.036	0.018	0.064	0.041	0.063
	(0.011)*	(0.008)*	(0.008)*	(0.008)*	(0.019)*	(0.019)*	(0.008)*	(0.007)*	(0.018)	(0.017)*	(0.006)*	(0.013)*
50% Spline of debt ratio					−0.084	−0.085				−0.057		−0.033
					(0.020)*	(0.021)*				(0.018)*		(0.019)***
Wald test P value (H0: spline = debt coefficient)					0.032	0.046						
Output gap		0.109	0.090		0.096		0.090	0.148				
		(0.012)*	(0.019)*		(0.016)*		(0.019)*	(0.031)*				
Gov. expenditures gap		−0.079	−0.076		−0.073		−0.076	−0.063				
		(0.032)**	(0.036)**		(0.034)**		(0.036)**	(0.027)**				
YVAR				−0.651		−0.730			−0.920	−0.431	−0.726	−0.509
				(0.140)*		(0.146)*			(0.330)*	(0.309)	(0.231)*	(0.337)
GVAR				−0.508		−0.487			−0.450	−0.366	−0.833	−1.194
				(0.222)**		(0.216)**			(0.254)	(0.270)	(0.313)*	(0.314)*
Inflation							0.000					
							(0.0005)					
Current account–GDP ratio								0.190				
								(0.037)*				
Country AR(1) coeffs.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes	yes
Adj. R^2	0.526	0.413	0.548	0.552	0.552	0.556	0.547	0.604	0.551	0.584	0.543	0.576
s.e.	2.227	2.518	2.154	2.145	2.144	2.135	2.157	2.009	2.480	2.324	1.815	1.735
No. of countries	34	34	34	34	34	34	34	34	15	15	19	19
No. of observations	459	477	443	443	443	443	443	441	198	195	245	238

Note: All regressions include country fixed effects and White cross-section standard errors and covariances. Standard errors shown in parenthesis. "*", "**" and "***" denote that the corresponding coefficient is statistically significant at the 99, 95, and 90 percent confidence levels, respectively. YVAR and GVAR are transitory components of output and government purchases as defined in Barro (1986). The panel is unbalanced with country samples that cover mainly the 1990–2005 period. Low-debt countries are those with mean and median debt ratios at or below the mean and median of all emerging countries in the sample (which are 64.5 and 58.2 percent, respectively). Low-debt countries are Argentina, Brasil, Mexico, Peru, Turkey, Uruguay, Venezuela, Chile, Korea, Russia, South Africa, Thailand, Colombia, Poland, Ukraine, Costa Rica, China, Croatia and India. High-debt countries are Malaysia, Hungary, Ecuador, Morocco, Panama, Philippines, Indonesia, Bulgaria, Cote d'Ivoire, Egypt, Israel, Jordan, Lebanon, Nigeria and Pakistan.

3.3. Results for the combined panel of industrial and emerging economies

Table 3 presents results using the combined panel of industrial and emerging economies. This panel has the advantage that it includes 56 countries and about 1000 observations, which is a significantly larger sample than for the EM and IC panels separately. The disadvantage, however, is that the combined panel can hide important differences in fiscal variables and macroeconomic volatility across countries (particularly industrial vs. emerging economies).

In general, the results from the combined IC–EM panel show that the qualitative findings derived from examining the two groups separately still hold. Quantitatively, the results of the combined panel are similar to those of the EM panel. The estimates of ρ are similar in regressions without splines (at about 0.033–0.037), and using *output gap* and *gov. expenditures gap* vs. *YVAR* and *GVAR* makes again no difference. Inflation is not statistically significant, and the current account–GDP ratio is significant with a coefficient of 0.14 (evidence again of a "twin deficits" effect). Regarding results with splines, there is a range of splines that are statistically significant, and the one with the lowest standard error is the 48-percent spline for which results are reported in columns V and VI of Table 3. The net response is again statistically significant and a little higher than in the case of the EM group (about 0.03 instead of 0.023).

Columns IX and XI of Table 3 show results dividing the combined panel into high- and low-debt groups, defining again low-debt countries as those with mean and median debt ratios below the mean and median for the full panel (which are 61.6 and 57.8 percent, respectively). The results are similar to those obtained with the EM and IC panels: the estimate of ρ is not statistically significant for the high-debt group while the estimated value of ρ is 0.04 for the low-debt countries (similar to the value obtained for low-debt countries in the EM group) and this estimate is significant at the 99 percent confidence level.

Columns X and XII add a 48-percent spline to columns IX and XI. The effects are similar to those noted in the case of emerging economies: The estimate of ρ is now positive and significant for the high-debt group, and the spline term weakens the response of the primary balance to debt considerably more in the high-debt group than in the low-debt group (with the spline in the latter not being statistically significant). The ρ estimates are different for the two groups, however, so unlike in the case of the EM panel, the debt coefficient is not about the same in the high- and low-debt groups when debt is below the spline threshold.

Table 3
Debt sustainability regressions: industrial and emerging economies (dependent variable: primary balance as a share of GDP)

	All countries								High-debt group		Low-debt group	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Debt–GDP ratio	0.037 (0.011)*	0.033 (0.008)*	0.036 (0.008)*	0.035 (0.008)*	0.071 (0.021)*	0.072 (0.021)*	0.036 (0.008)*	0.035 (0.006)*	0.021 (0.015)	0.065 (0.014)*	0.040 (0.005)*	0.053 (0.010)*
48% Spline of debt ratio					−0.041 (0.020)**	−0.044 (0.021)**				−0.056 (0.015)*		−0.021 (0.014)
Wald test P value (H0: spline = debt coefficient)					0.001	0.004						
Output gap		0.155 (0.026)*	0.138 (0.019)*		0.145 (0.018)*		0.138 (0.019)*	0.179 (0.026)*				
Gov. expenditures gap		−0.099 (0.027)*	−0.089 (0.030)*		−0.088 (0.030)*		−0.089 (0.030)*	−0.082 (0.025)*				
YVAR				−0.925 (0.137)*		−0.957 (0.138)*			−1.232 (0.242)*	−0.847 (0.238)*	−0.828 (0.174)*	−0.695 (0.195)*
GVAR				−0.570 (0.188)*		−0.563 (0.182)*			−0.525 (0.230)**	−0.452 (0.235)**	−0.771 (0.231)*	−0.984 (0.172)*
Inflation							0.000 (0.0005)					
Current account–GDP ratio								0.141 (0.028)*				
Country AR(1) coeffs.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.649	0.340	0.673	0.669	0.664	0.669	0.673	0.728	0.699	0.714	0.593	0.611
s.e.	1.921	2.672	1.854	1.871	1.889	1.874	1.856	1.803	2.111	2.035	1.567	1.523
No. of countries	56	56	56	56	56	56	56	56	28	28	28	28
No. of observations	988	1015	961	925	920	920	959	950	475	471	450	442

Note: All regressions include country fixed effects and White cross-section standard errors and covariances. Standard errors shown in parenthesis. "*" and "**" denote that the corresponding coefficient is statistically significant at the 99 and 95 percent confidence levels, respectively. YVAR and GVAR are transitory components of output and government purchases as defined in Barro (1986). Low-debt countries are those with mean and median debt ratios at or below the mean and median of all countries in the sample (which are 61.6 and 57.8 percent, respectively). Low-debt countries are Austria, Australia, Finland, France, Great Britain, Norway, New Zealand, Iceland, Luxembourg, Argentina, Brasil, Mexico, Peru, Turkey, Uruguay, Venezuela, Chile, Korea, Russia, South Africa, Thailand, Colombia, Poland, Ukraine, Costa Rica, China, Croatia and India. High-debt countries are Canada, Germany, Denmark, Spain, Greece, Ireland, Italy, Japan, the Netherlands, Portugal, Sweden, United States, Belgium, Malaysia, Hungary, Ecuador, Morrocco, Panama, Philippines, Indonesia, Bulgaria, Cote d'Ivoire, Egypt, Israel, Jordan, Lebanon, Nigeria and Pakistan. The panel is unbalanced.

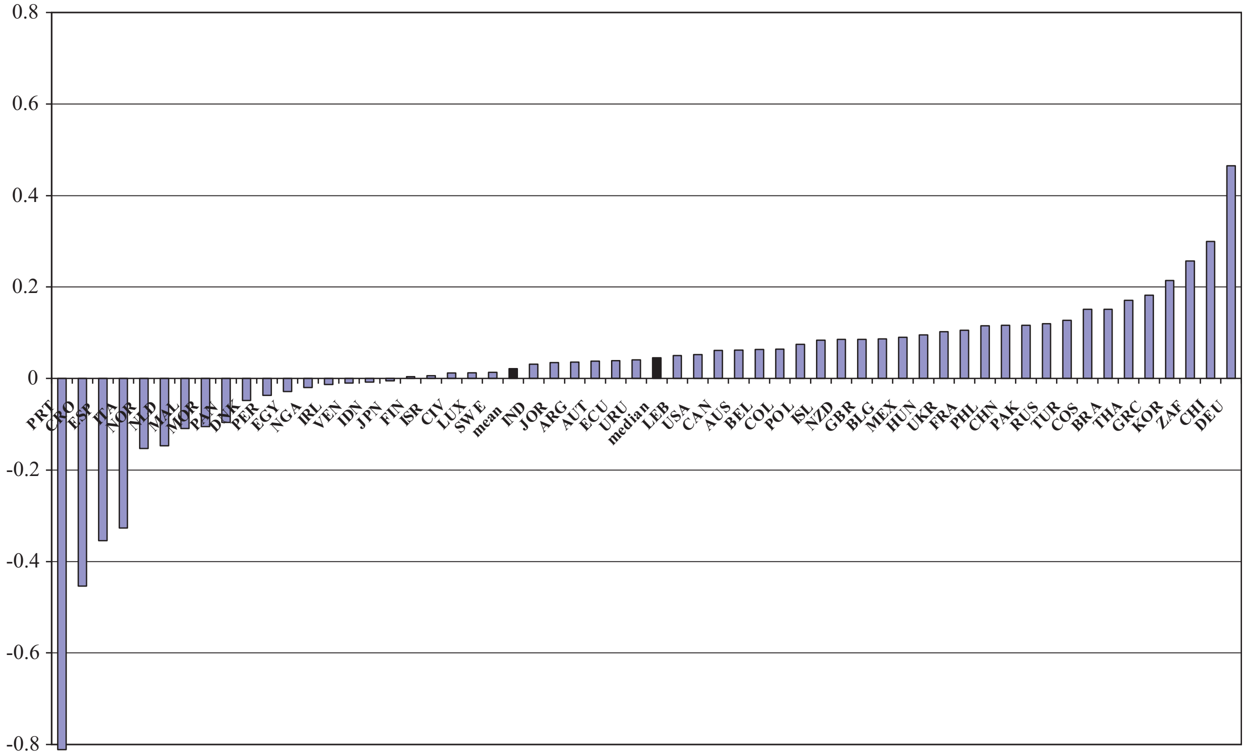

Fig. 2. Country-specific debt coefficients.

An important assumption implicit in all these panel regressions is that the coefficient ρ is common across countries. This can be a strong assumption inasmuch as the countries in our sample differ widely in the history of their economic policies, the macroeconomic volatility they display, the financial markets they have access to, and their institutional characteristics. Unfortunately, our data does not provide enough time-series coverage to produce robust country-specific estimates of the primary balance-debt relationship. In this context, the fact that our IC results are in line with Bohn's (1998, 2005) estimates for historical US data is reassuring. It is still worthwhile, however, to examine the distribution of country-specific debt coefficients implied by our data, and use conventional Wald tests to study whether the data can reject the hypothesis that ρ is the same across countries.

Fig. 2 shows the distribution of the 56 country-specific estimates of ρ from regressions that also include country-specific terms for output and government expenditures gaps, and AR(1) error terms. The coefficients range from -0.81 to 0.46, and only 10 of them are statistically significant. Wald tests easily reject the hypothesis of a common coefficient. The figure also shows, however, that excluding the 14 countries for which $|\rho|\geqslant 0.15$, the coefficients of the remaining 42 countries (3/4 s of the combined panel) are clustered together. Panel estimation for this group yields an estimate of $\rho = 0.038$, significant at the 99 percent confidence level. Moreover, joint Wald tests of the null hypotheses that the country-specific ρ coefficients for these 42 countries are equal to each other or equal to the panel estimate cannot be rejected.[12] Thus, despite the limited time-series coverage of our data and structural differences across countries, the data still produce a fairly robust panel estimate of the conditional response of the primary balance to public debt.

3.4. Long-run mean debt ratios

The MBS setup yields an estimate of the sustainable debt ratio defined as the long-run expected value of the debt–output ratio implied by Eq. (7). For simplicity, we use Bohn's (1998) approximation to Eq. (7), $E[b] \approx -\bar{\mu}/[\rho(1+\bar{r})-\bar{r}]$, which ignores the long-run covariance between the real interest rate and debt.

Table 4 shows estimates of long-run means of the debt–GDP ratio for industrial and emerging economies based on the results of the MBS tests for low-debt countries (column VIII of Table 1 and column XI of Table 2). This approach uses more precise estimates of ρ and $\bar{\mu}$ because it sets aside the high-debt countries for which ρ was not statistically significant. Computing $E[b]$ also requires estimates of $\bar{r}$ (the difference in the long-run averages of the real interest rate and the

[12] The F and χ^2 statistics for the former are $F(41, 498) = 1.219$ and $\chi^2(41) = 49.964$, and for the latter the statistics are $F(42, 498) = 1.206$ and $\chi^2(42) = 50.64$.

Table 4
Long-run expected values of debt– GDP ratios

Debt–GDP ratio		Growth-adjusted interest rate	Real interest rate	Growth rate	Stationarity condition	
Industrial countries ($\rho = 0.022$)	Emerging economies ($\rho = 0.041$)				Industrial countries	Emerging economies
A. Exogenous 2.5% growth rate						
38.640	20.641	−0.500	2.000	2.500	0.973	0.954
60.105	26.108	0.500	3.000	2.500	0.982	0.964
135.215	35.515	1.500	4.000	2.500	0.992	0.973
NA	55.521	2.500	5.000	2.500	1.002	0.983
NA	127.134	3.500	6.000	2.500	1.012	0.993
B. Exogenous 5% growth rate						
20.415	13.548	−3.000	2.000	5.000	0.948	0.930
25.162	15.707	−2.000	3.000	5.000	0.958	0.940
32.786	18.684	−1.000	4.000	5.000	0.968	0.949
47.040	23.055	0.000	5.000	5.000	0.978	0.959
83.218	30.094	1.000	6.000	5.000	0.987	0.969

Note: Debt–GDP ratios estimated using Eq. (7) assuming zero long-run covariance between the growth-adjusted interest rate and the debt ratio. These estimates use values of ρ equal to 0.022 and 0.041 for industrial countries and emerging economies, respectively, which are the values estimated for the low-debt groups in the IC and EM panel regressions shown in Tables 2 and 3. The averages of μ are −1.058 and −0.945 for industrial and developing countries, respectively.

per-capita growth rate of real GDP). Panel A (B) of Table 4 shows results assuming a growth rate of 2.5 (5) percent and real interest rates varying from 2 to 6 percent.[13] The last two columns of the table show the product $(1+\bar{r})(1-\rho)$, which must be less than 1 for the debt ratio to be stationary. When this condition is violated, the table shows "NA" for the mean debt ratio.

The results show that the predictions of our empirical analysis are consistent with the empirical observation shown in Fig. 1 indicating that average debt ratios are higher in IC than in emerging economies. We find that the former can sustain significantly higher mean debt ratios than the latter under common assumptions about growth and interest rates. Assuming the same growth rate for industrial and emerging economies, the differences are larger at lower growth rates, and for a given growth rate they widen as the interest rate rises. At the 5 percent growth rate, the difference in the debt ratio of IC relative to emerging economies increases from 7 to 53 percentage points as the interest rate rises from 2 to 6 percent. Note that IC attains higher mean debt ratios because the regressions produce both a lower ρ and a higher absolute value of $\bar{\mu}$ in the LDIC group.

The gap in mean debt ratios between industrial and developing countries widens even more if emerging economies grow *faster* than IC. At a 2 percent interest rate, IC growing at 2.5 percent converge to a debt–GDP ratio of about 39 percent, while emerging economies growing at 5 percent converge to a 14 percent debt ratio. If emerging economies do reach higher long-run growth rates, however, one would expect that the fundamentals behind ρ and $\bar{\mu}$ would change, and the estimates in Table 4 would not apply. On the other hand, emerging economies may be riskier and hence pay higher interest rates, and if so their growth-adjusted real interest rates will be closer to those of IC.

The fact that the mean debt ratios in Table 4 rise with $\bar{r}$ may seem odd because it is the opposite of the prediction derived from the traditional formula used to calculate long-run debt as the deterministic steady-state debt (i.e., the annuity value of the steady-state primary balance $b = pb/r$). This deterministic formula predicts that the debt ratio *falls* as r rises. The two debt ratios have, however, very different meaning. The mean debt ratio of the MBS framework shows the ratio to which the economy converges on average given estimates of ρ, $\bar{r}$ and $\bar{\mu}$ (and the underlying structural assumptions of the framework). If we increase $\bar{r}$, keeping everything else unchanged (as is the case moving down the rows of panels A and B in Table 4), the mean debt ratio rises because with $0<\rho<1$ and $\bar{\mu}<0$, $\partial E[b]/\partial \bar{r} > 0$. Intuitively, this occurs because $E[b]$ has implicit the feedback structure driving the stochastic dynamics of the primary balance (Eq. (6)), and a mapping from these dynamics into debt via the government budget constraint (3). In contrast, the deterministic steady-state debt ratio simply evaluates the government budget constraint at steady-state for arbitrary values of pb and r. This steady-state debt ratio cannot tell whether the particular value of pb it uses is a relevant one. Only when there is no feedback ($\rho = 0$) and no covariance, the mean debt ratio implied by Eq. (7) collapses to $(-\bar{\mu})/(-\bar{r}) = E[pb]/\bar{r}$, which is equal to the deterministic steady-state debt ratio.

[13] Assuming exogenous growth and interest rates is a limitation. In Mendoza and Ostry (2007) we show a straightforward way to endogenize the connection between these two rates that preserves the estimates in Table 4 by borrowing standard results from the balanced-growth class of endogenous growth models.

4. Conclusions

This paper examined fiscal solvency in industrial and emerging economies. The main finding is that in both groups of countries, the data are consistent with the key requirement of the model-based fiscal sustainability test, namely that the conditional response of the primary fiscal balance to changes in government debt be positive and statistically significant. We showed that this result is robust across a broad range of panel regression specifications that allow for non-linearities, transitory effects of government purchases and the business cycle, effects of inflation and external deficits, country fixed effects, and country-specific serial autocorrelation of error terms. In addition, the data cannot reject the main homogeneity assumption of the panel regressions imposing a common response coefficient of primary balances to debt in 42 out of the 56 countries in our sample.

In contrast to the previous literature, we do not find that the response of the primary balance to public debt increases above t