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Public Debt, Money Supply, and Inflation: A Cross-Country Study

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This paper provides comprehensive empirical evidence that supports the predictions of Sargent and Wallace's ''unpleasant monetarist arithmetic'' that an increase in public debt is typically inflationary in countries with large public debt. Drawing on an extensive panel data set, we find that the relationship holds strongly in indebted developing countries, weakly in other developing countries, and generally does not hold in developed economies. These results are robust to the inclusion of other variables, corrections for endogeneity biases, relaxation of common-slope restrictions, and are invariant over subsample periods. We estimate a vector autoregression to trace out the transmission channel and find the impulse responses consistent with the predictions of a forward-looking model of inflation. Wealth effects of public debt could also affect inflation, as posited by the fiscal theory of the price level, but we do not find supportive evidence. The results suggest that the risk of a debt-inflation trap is significant in highly indebted countries and pure money-based stabilization is unlikely to be effective over the medium term. Our findings stress the importance of institutional and structural factors in the link between fiscal policy and inflation. [JEL E31, E62, E63, C59]
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The most widely accepted school of thought on inflation is that it is a monetary phenomenon and therefore the reduction of inflation is largely the purview of monetary policy, particularly in the initial stages of disinflation. This school of thought, based on the quantity theory of money, posits that inflation is determined solely by the change in the relative supply of money and goods. Against this background, disinflation policy in many countries is framed with the objective of constraining monetary growth to be in line with the expansion in nominal income. Hence, an increasing number of countries have granted their central banks autonomy in the hope that it will insulate them from having to accommodate imprudent fiscal policies.

However, given that current money demand should depend on expectations about future inflation, a purely monetary effort at reducing inflation may not be successful. Theoretically, once account is taken of forward-looking expectations, multiple equilibrium paths for inflation can coexist. Under such circumstances, money supply alone may not be sufficient to pin down the time path of inflation.

Against this background, attention has increasingly been given to the role of fiscal policy in determining inflation. The main result of the seminal paper by Sargent and Wallace (1981) is that the effectiveness of monetary policy in controlling inflation depends critically on its coordination with fiscal policy. In their model, tighter monetary policy could lead to higher inflation under certain circumstances, even when the traditional relationship between money and the price level holds. The rationale is that, with the demand for government bonds given and in the absence of changes in future fiscal policy, a part of government obligations has to be covered by seignorage at some point in the future.

A similar line of reasoning lies behind the fiscal theory of the price level (FTPL). Apart from seignorage financing, traditional analysis of the fiscal impact on inflation focuses mostly on Keynesian aggregate demand considerations, public wage spillovers to private sector wages, and taxes affecting marginal costs and private consumption (Elmendorf and Mankiw, 1999). The FTPL identifies the wealth effect of government debt as an additional channel of fiscal influence on inflation and, amid debates over the coherence of the theory (Buiter, 1999; Niepelt, 2004), has spawned an extensive literature (Sims, 1994; Woodford, 1994 and 2001; Loyo, 1999; Christiano and Fitzgerald, 2000; Canzoneri, Cumby, and Diba, 2001; Cochrane, 2001 and 2005; Gordon and Leeper, 2002). This theory posits that increased government debt adds to household wealth and, hence, to demand for goods and services, leading to price pressures.

This paper provides a comprehensive empirical examination of the link between fiscal policy and inflation identified by the forward-looking fiscal-monetary models of inflation. We draw on an extensive cross-country data set for 71 countries spanning up to 43 years. We think that this helps overcome, or mitigate substantially, potential biases arising from the

selection of sample countries and sample periods. In addition, given the importance of policy regimes in the forward-looking models, we rely on flexible econometric techniques allowing for cross-country heterogeneity, which is often neglected in empirical studies for the sake of stronger testing power. Our approach also differs from much of the existing empirical literature on fiscal policy and inflation (Evans, 1987a and 1987b; Elmendorf, 1993; Ardagna, Caselli, and Lane, 2004; Catao and Terrones, 2005) in that we focus on the role of public debt—instead of the budget deficit—in determining inflation and inflation expectations. In so doing, we account for the nontraditional channels of fiscal influence on inflation—namely, monetization expectations and wealth effects of public debt, which do not necessarily move in lockstep with the size of the budget deficit due to a host of technical factors including nondebt financing, debt indexation, exchange rate movements, as well as the government's assumption of accumulated quasi-fiscal liabilities (IMF, 2003; Singh and others, 2005).

The closest paper to our study is that of Castro, De Resende, and Ruge-Murcia (2003), who by estimating the degree of interdependence between monetary and fiscal policy for *developed* countries draw inferences about the relation between debt and the price level. Our empirical results are consistent with their conclusion that debt plays only a minor role in determining the price level in *developed* countries. Our contribution is to estimate the link between public debt and inflation in a generalized framework and to extend the empirical analysis to *developing* countries.

I. Conceptual Framework

There is a rich literature on forward-looking models of inflation. Aiyagari and Gertler (1985) introduced an overlapping generation model, deriving a simple, direct link between public debt and the price level. Calvo (1988) developed an alternative model based on a loss function of the authorities, which establishes a similar link between prices and public debt. Bohn (1988) also created a rational expectation model of a similar nature. The key common ingredients of these models are rational expectations, Cagan-type money demand, and a non-Ricardian regime that takes government bonds as net wealth.

In one variant of such models, a functional relationship can be derived for price, on the one hand, and money, debt, and output, on the other, as follows (see Appendix I for the derivation):

$$P_t = \frac{(M_t + \delta B_t)}{\gamma(i)w}, \quad \gamma(i) = \beta\left(\frac{1+i_t}{i_t}\right) + \alpha\delta, \tag{1}$$

where P, M, B, and w denote price, money, debt, and real income (or wealth in this simple model). α and β are functions of the structural parameters of the household's optimization problem, i is the yield on debt, and δ is a portion of government debt that is not backed by the government's current and future primary surpluses.

Equation (1) nests the quantity theory of money and the unpleasant monetary arithmetic of Sargent and Wallace (1981). The price level is proportional to the broadly defined monetary aggregate, $M_t + \delta B_t$, which is the sum of high-powered money demanded by the household for transactions and by the government for monetizing the debt, with δ reflecting the extent of monetary accommodation of the budget deficit and, more broadly, the nature of coordination between monetary and fiscal policy. Suppose the government pursues a policy of no monetization of its debt and runs a balanced budget over the long term. Then, δ, which can be taken as a monetization factor, reduces to 0 and the equation simplifies to the conventional quantity theory of money. More broadly, if fiscal policy is undertaken flexibly, for example, in ways to keep the debt-to-GDP ratio fixed all the time, then the monetization factor will remain 0 with no effect of public debt on prices. Alternatively, if the policy arrangement is full monetization of all public debt, δ becomes 1, implying that an increase in public debt would influence inflation as strongly as monetary expansion does. In reality, the parameter is likely to vary between 0 and 1, with the exact scale depending on the capacity and willingness of the government to service public debt, as often construed from the debt size, policy credibility, and institutional and political constraints.

Equation (1) is also consistent with the predictions of the FTPL. Although we do not explicitly allow for the wealth effect of government debt as advanced by some versions of the FTPL (Leeper and Yun, 2006), the equation is fully consistent with the general implications of the theory. Therefore, the establishment of a positive relationship between public debt and prices does not necessarily tell whether the link is from monetization concerns as stressed by Sargent and Wallace (1981) or the wealth effects as advanced by the FTPL. We will discuss theoretical and empirical implications of the two competing models of inflation and attempt to test them by distinguishing the residency of public debt holders in the next section.

Drawing on Equation (1), we consider the following generalized price function.

$$P_t = f(X_t) = f(M_t, B_t, w_t), \quad \text{where } f_1 > 0, f_2 > 0, \text{ and } f_3 < 0. \tag{2}$$

Equation (2) can be log-linearized around equilibrium values X^* to obtain a more tractable specification as follows:

$$\log P_t = f(X_t^*) + X_t^* f'(X_t^*)\hat{x}_t, \quad \text{where } \hat{x}_t = \log X_t - \log X_t^*,$$

$$\text{then, } \hat{p}_t = f(X_t^*) - \log P_t^* + X_t^* f'(X_t^*)\hat{x}_t, \quad \text{where } \hat{p}_t = \log P_t - \log P_t^*. \tag{3}$$

This transformation establishes a simple linear relationship between inflation and increases in money supply, public debt, and output. Equation (3) could be modified to the following dynamic form, which embodies a partial adjustment process that allows gradual restoration to the equilibrium

(Hendry, Pagan, and Sargan, 1984):

$$\hat{p}_t = \alpha\hat{p}_{t-1} + \beta_1\hat{m}_t + \beta_2\hat{b}_t - \beta_3\hat{w}_t, \quad (4)$$

where $\hat{p}$, $\hat{m}$, $\hat{b}$, and $\hat{w}$ denote deviations from equilibrium values in logarithms of price, money, debt, and real income, respectively.

II. Empirical Findings of the Cross-Country Study

Basic Stylized Facts

Our main data set is a panel dataset spanning 71 countries over up to 42 years (1963–2004). Data definitions and sources, as well as country grouping criteria are in Appendix II. Table 1 provides selected descriptive statistics of the main data set. It shows that, during the sample period, the average growth rate of money exceeded average inflation by about 4 percentage points per annum. Money supply grew at about the same pace as nominal GDP, implying a virtually unchanged level of money velocity over the long term. In contrast, public debt grew faster than both nominal GDP and money by about ½ percentage point per annum—a small but significant difference if extended over the long term. This could reflect financial deepening, which tends to expand nonmonetary financial instruments faster than monetary aggregates.

There is considerable variation across countries in the data, indicating potentially large gains from using panel data. Table 2 shows a summary of regional variations of selected macroeconomic indicators averaged over the sample period. Average inflation (geometric) is the highest in European developing countries, reflecting hyperinflation in many of these countries that transitioned to market economies in the early 1990s. With regard to public debt and inflation, public debt rose nearly twice as fast as inflation in low-inflation regions but not quite as fast in high-inflation regions. This could imply that nominal debt issuance, if excessive, is eroded quickly by inflation, pointing to the existence of a natural limit to real debt growth. A similar observation could be made with respect to the relationship between money growth and inflation but the extent is less prominent.

Our preferred form of data for regressions is first differences. Panel cointegration tests are not conclusive, as is often the case with medium-sized panels. The tests for stationarity, based on Pedroni (1999), reject the null of cointegration among the four main variables (CPI, money, public debt, and real output) in both the pooled and group mean *t*-tests at the 5 percent level but not always in the panel and group ρ tests (Table 3).[1] In light of these mixed outcomes, we proceed mainly with their first-difference terms, which are stationary, as we are keen to avoid the risk of spurious regressions arising from partially nonstationary or highly persistent data. Figure 1 shows the means of cross-country data in the first-difference logarithmic terms over the

[1]We thank Peter Pedroni for sharing his computer programs.

Table 1. Descriptive Statistics of Long-Term Average Cross-Country Data
(In percentage changes per annum, unless otherwise noted)

	Real GDP Growth	Inflation	Money Growth	Debt Growth	Debt-to-GDP Ratio
Mean	3.7	12.1	16.2	16.6	50.1
Median	3.9	6.2	11.4	12.1	40.1
Standard deviation	0.54	2.54	2.69	2.57	5.0
Number of countries	71	71	71	71	71
Underlying observations	2,963	2,854	2,689	2,243	2,302

Source: IMF, *World Economic Outlook*; Organization for Economic Cooperation and Development; IMF, *International Financial Statistics*; and IMF Western Hemisphere Department database.

Note: See Appendix II for sources and definitions.

full sample period. It also shows the means of public debt ratios, which increased sharply over about decade and half following the end of the Breton Woods era. Similar patterns are also observed in their median values.

Limitations of Long-Term Average Data

We first undertake a simple long-term cross-country regression as a quick way of examining relations among the variables. The results, presented in Table 4, confirm the findings of other empirical studies that long-term inflation is strongly positively associated with long-term money growth and negatively with long-term output growth. This is in line with the quantity theory of money and consistent with many empirical studies on this subject (Schwartz, 1973; Vogel, 1974; Lucas, 1980; Duck, 1993; Favero and Spinelli, 1999). In addition, the regression results show that flexible exchange regimes tend to be associated with higher inflation, although the causality is by no means established in this simple regression. With regard to the role of public debt, there is a positive linear relationship between inflation and public debt growth and a weak association between inflation and the size of public debt (Figure 2). However, both the levels and changes in public debt lose their explanatory power for inflation when money growth is controlled for.

It is, however, difficult to make direct inferences about the link between public debt and inflation from these long-term data. Although these results appear to reconfirm the dominant influence of money supply on long-term inflation, they do not necessarily reject the possibility that large and increasing public debt could push up inflation at some points in time. This can occur because the accumulation of public debt will either eventually increase primary surpluses or lead to monetization and inflation, depending on the policy regimes in place (Sargent, 1982). In the former case, there will

Table 2. Selected Macroeconomic Indicators, 1963–2004

(Average annual percentage changes, unless otherwise indicated)

	Real GDP Growth	Inflation	Money Growth[1]	Public Debt Growth	Debt-GDP (ratio)	M-GDP (ratio)[1]	Nominal GDP Growth	Seignorage (% GDP)	Fx Deprec	Fx Regime[2]	Years Covered[3]	Start Year	End Year
Unweighted averages	3.6	14.2	18.6	21.9	51.8	18.6	18.3	2.8	9.9	2.3	20	1973	2002
Major advanced economies (13)	2.9	5.7	9.1	12.4	54.2	39.7	8.9	4.2	0.1	2.0	32	1968	1999
Other advanced economies (10)	3.6	11.2	13.9	17.2	46.5	11.4	15.7	3.4	5.6	2.4	36	1967	2003
Developing countries (48)	3.7	17.4	22.4	25.8	52.2	14.2	21.6	2.3	13.9	2.3	28	1975	2003
Latin America and Caribbean (20)	3.0	21.7	26.6	30.9	51.7	11.9	25.2	2.1	18.5	1.9	28	1975	2003
Latin America (13)	3.3	29.1	34.9	39.4	36.5	11.2	33.1	3.0	26.0	2.4	28	1976	2003
Caribbean (7)	2.4	8.0	11.3	15.0	79.9	13.0	10.6	0.5	4.6	1.4	28	1975	2003
Asia (9)	4.9	8.2	13.9	15.8	48.9	12.1	14.0	1.8	6.0	2.0	31	1971	2002
Middle East (6)	5.1	7.1	16.0	19.2	63.7	22.0	13.9	2.5	3.0	1.9	31	1971	2002
Europe (5)	3.7	32.6	37.4	37.6	50.3	24.5	36.2	4.4	25.2	3.7	17	1986	2002
Africa (8)	3.4	13.0	15.3	20.2	49.9	11.2	16.6	1.9	9.9	2.5	29	1974	2003

Sources: IMF, *International Financial Statistics* (IFS); IMF, *World Economic Outlook* (WEO); Organization for Economic Cooperation and Development; IMF Western Hemisphere Department databases; and Reinhart and Rogoff (2004).

Note: Country groupings are based on the IMF's WEO classifications as of September 2005. Details are in Appendix I.

[1]Narrowest definitions of money available from IFS, WEO, and OECD databases.

[2]Based on *de facto* exchange regimes (scaled from 1 to 5) of Reinhart and Rogoff (2004). The higher are the indices, the more flexible the exchange rate regime.

[3]Average number of years. For each country, the coverage is adjusted for the longest time period for which data are available.

Table 3. Panel Cointegration Tests: CPI, Money, Debt, GDP

	Panel v	Panel rho	Panel t	Panel adf	Group rho	Group t	Group adf
Weighted by long-term variances							
Cross-section common-time effects subtracted							
Homogenous time trends	**7.34**	**−4.62**	**−8.08**	**−2.64**	**−4.14**	**−12.40**	**−3.66**
Heterogeneous time trends	**8.47**	−1.09	**−6.23**	−0.41	1.18	**−7.73**	0.07
No cross-section common-time effects							
Homogenous time trends	**4.96**	−1.23	**−4.32**	−0.64	−0.92	**−6.93**	−1.65
Heterogeneous time trends	**3.13**	0.22	**−4.32**	−0.19	1.23	**−6.48**	−1.19
Nonweighted							
Cross-section common-time effects subtracted							
Homogenous time trends	**6.60**	**−3.76**	**−6.32**	**−2.73**	**−4.14**	**−12.40**	**−3.66**
Heterogeneous time trends	**7.72**	0.60	**−3.05**	−1.41	1.18	**−7.73**	0.07
No cross-section common-time effects							
Homogenous time trends	**2.59**	0.45	**−2.37**	0.86	−0.92	**−6.93**	−1.65
Heterogeneous time trends	1.24	0.86	**−3.00**	0.20	1.23	**−6.48**	−1.19

Source: Authors' calculation.

Note: Based on unbalanced panel cointegration tests of Pedroni (1999) for price, money, public debt, and output. Statistics in bold note the rejection of the null of no-cointegration at the 5 percent confidence level.

be no relationship between debt growth and inflation and, in the latter, the correlation between money growth and inflation will likely be the dominant factor.

Main Results of Panel Data Regressions

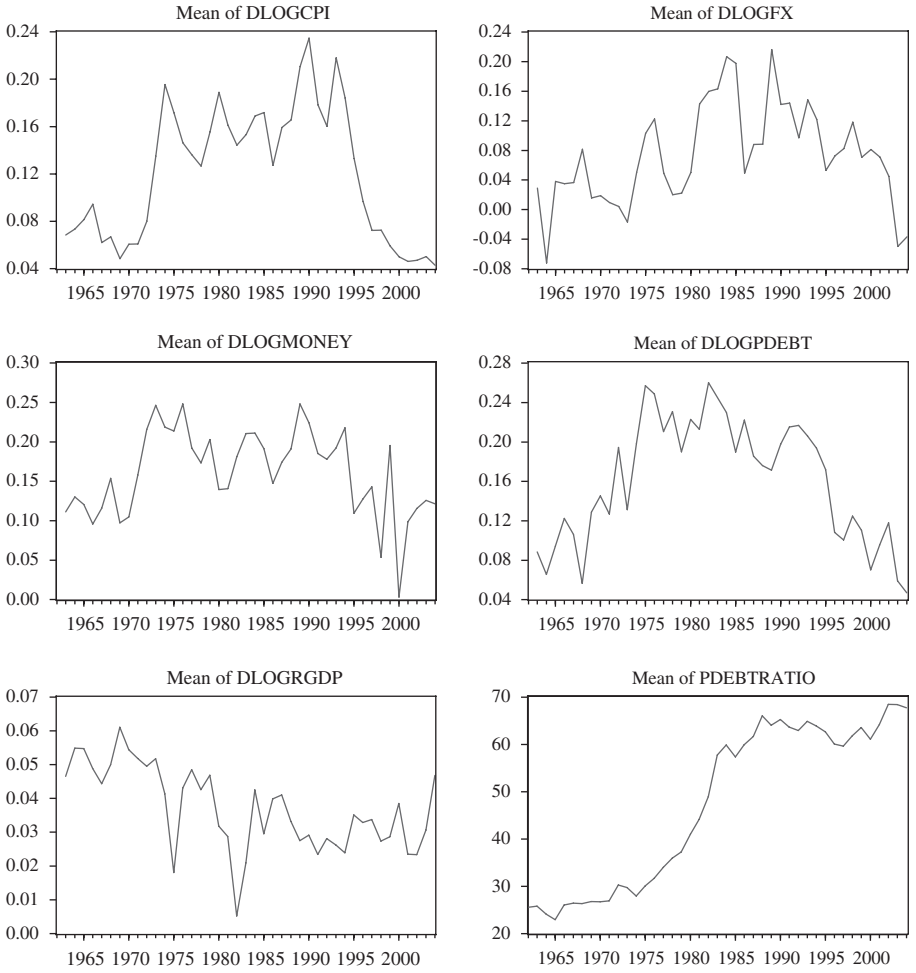
Given the limitations of long-term average data, our main modeling strategy is to use panel data, which allows for variability of individual countries while preserving the dynamics of adjustment within countries. We consider the following dynamic model, drawing on Equation (4):

$$\begin{aligned} \mathrm{d}\log cpi_{it} = {} & \alpha \mathrm{d}\log cpi_{it-1} + \beta_1 \mathrm{d}\log money_{it} + \beta_2 \mathrm{d}\log pdebt_{it} \\ & + \beta_3 \mathrm{d}\log rgdp_{it} + \eta_i + t_t + \nu_{it}, \end{aligned} \tag{5}$$

for $i = 1, \ldots, N$, and $t = 2, \ldots, t$, where η_i and ν_{it} have the standard error component structure

$$E[\eta_i] = E[\nu_{it}] = E[\eta_i \nu_{it}] = 0, \tag{6}$$

Figure 1. Mean of Cross-Country Data for Each Year



Sources: IMF, *International Financial Statistics* (IFS); IMF, *World Economic Outlook* (WEO); Organization for Economic Cooperation and Development; IMF Western Hemisphere Department databases; and Reinhart and Rogoff (2004).
Note: Country list and data sources are provided in Appendix II.

and the transient errors are serially uncorrelated:

$$E[v_{it}v_{is}] = 0 \quad \text{for } s \neq t \quad \text{for } i = 1, \ldots, N, \text{ and } t = 2, \ldots, T. \tag{7}$$

$\mathrm{d}\log cpi$ refers to inflation, and $\mathrm{d}\log money$, $\mathrm{d}\log pdebt$, and $\mathrm{d}\log rgdp$ refer to changes in money, public debt, and real GDP, respectively, all in first-difference logarithms. t_t, is a set of time dummies to control for unobserved global inflation pressures shocks such as the oil crises in the 1970s. η_i represents unobserved country-specific effects, which are meant to capture heterogeneity in the debt-inflation nexus across countries as implied by our conceptual framework. This model is designed to reflect potentially complex

Table 4. Cross-Country Ordinary Least Squares Regression Results for Inflation

Explanatory variables				
Money growth	**0.88**			**0.89**
Debt growth		**0.79**		0.03
Debt-to-GDP ratio			0.05	−0.01
Exchange rate regimes			**9.60**	**0.78**
Real GDP growth			**−2.26**	**−1.22**
R^2	0.97	0.92	0.20	0.99
Adjusted R^2	0.97	0.92	0.19	0.99
Number of observations	71	71	71	71

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. See Appendix II for country list, data sources, and definitions.

dynamics of public debt, inflation, and other macroeconomic variables within the constraints of a medium-sized panel. The existence of the fixed country effects, as opposed to the random effects, is supported by the results of the Breusch-Pagan (1980) Lagrange multiplier test. The poolability of the panel data is easily rejected by the standard Chow test.

The conceptual framework as reflected in Equations (1) and (2) suggests that the coefficients for debt and money should be positive and negative for output. In most specifications, we assume that coefficients in the vector β are constant for each country group although we relax this homogenous slope assumption in robustness tests. No other restrictions are imposed on the coefficients of the explanatory variables as the conceptual framework is ambivalent about the speed of adjustment to the equilibrium.

In addition, we assume for now that all explanatory variables in X_{it-s} ($\mathrm{d}\log cpi_{it-s-1}$, $\mathrm{d}\log money_{it-s}$, $\mathrm{d}\log pdebt_{it-s}$, $\mathrm{d}\log rgdp_{it-s}$) are predetermined such that

$$E[X_{it-s}\nu_{it}] = 0 \quad \text{for } s \geq 0. \tag{8}$$

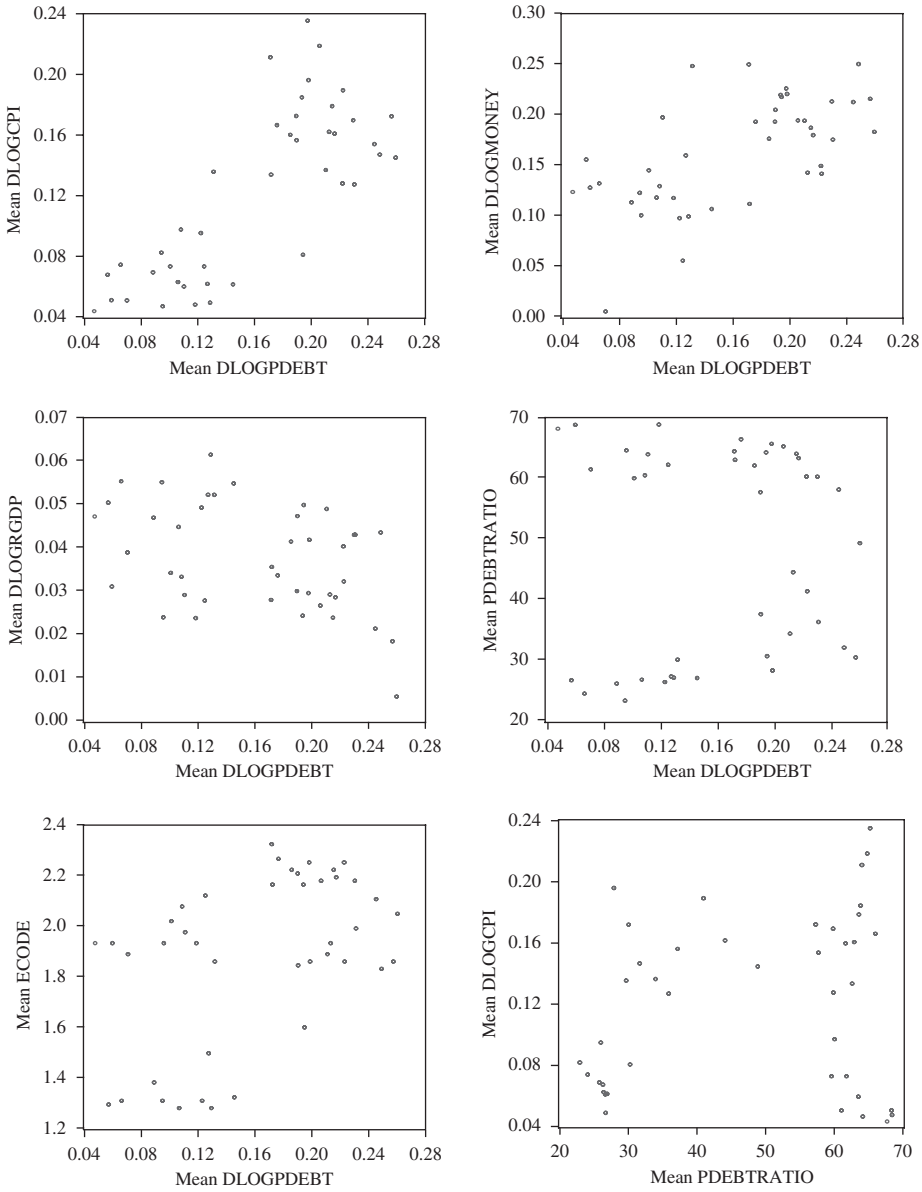
This standard set of assumptions yields the following moment conditions

$$E[X_{it-s}\Delta\nu_{it}] = 0 \quad \text{for } s \geq 1. \tag{9}$$

These two moment conditions allow the use of suitably lagged levels of the variables as instruments, after the equation has been first differenced to eliminate the country-specific effects (Arellano and Bond, 1991). Given that our regression variables are not persistent as shown in our panel unit root test (Table 3), we believe that the first-differenced instruments are adequate and do not suffer from a weak instrument problem.[2]

[2]If autocorrelation is very high in endogenous right-hand variables, their lagged variables suffer from weak instrument problems. Blundell and Bond (2000), for example, consider problems of highly persistent variables in the estimation of production functions and, more broadly, Stock, Wright, and Yogo (2002) discuss a weak instruments problem in general terms.

Figure 2. Scatter Plots of Selected Macroeconomic Indicators and Public Debt Growth
(Mean of time-series data for each country)



Sources: IMF, *International Financial Statistics* (IFS); IMF, *World Economic Outlook* (WEO); Organization for Economic Cooperation and Development; IMF Western Hemisphere Department databases; and Reinhart and Rogoff (2004).
Note: See Appendix II for country lists, data sources, and definition as well as sample periods.

The moment condition (8), based on the assumption of predetermined explanatory variables, might not necessarily hold in many countries. Macroeconomic policies, as embodied in money and debt variables in our

model, could be undertaken without any significant delays from the occurrence of shocks. Monetary policy, in particular, could be tightened at early signs of inflation but fiscal policy could be relaxed quickly in response to natural disasters. Separately, some variables, in particular interest rates and exchange rates, could change in sync with price shocks, affecting our explanatory variables—in particular the nominal value of foreign currency denominated debt—thereby invalidating the assumption of predetermination of these explanatory variables.

We will hence allow for contemporaneous feedback effects from money, debt, and output to prices, and use their lagged variables as explanatory variables as follows:

$$\log cpi_{it} = \alpha \mathrm{d}\log cpi_{it-1} + \beta_1 \mathrm{d}\log money_{it-1} + \beta_2 \mathrm{d}\log pdebt_{it-1} + \beta_3 \mathrm{d}\log rgdp_{it-1} + \eta_i + t_t + \nu_{it}. \quad (10)$$

We continue to assume that the transient errors are serially uncorrelated as before but that variables in X_{it} are endogenous with respect to the serially uncorrelated ν_{it} shocks and hence only a subset of the moment conditions (8) and (9)

$$E[X_{it-s}\nu_{it}] = 0 \quad \text{for } s \geq 1 \quad \text{and}$$

$$E[X_{it-s}\Delta\nu_{it}] = 0 \quad \text{for } s \geq 2,$$

remains valid.

We are interested in consistent estimation of the parameters. A dynamic fixed-effect estimator and a first-difference GMM estimator are used for the purpose.[3] For the GMM estimator, we prefer the one-step estimator to the two-step estimator, as the latter is prone to small sample biases, which could be considerable, in particular, in subperiod regressions. The possible existence of serial correlation of errors is handled through the use of a robust version of each estimator.

Regressions are run separately for different groups of countries in order to address a potential problem of slope heterogeneity without sacrificing efficiency gains from panel data. In line with the conceptual framework, countries are grouped according to the degree of economic development and, among subgroups, by the extent of sovereign indebtedness as classified by the most recent IMF's *World Economic Outlook* (IMF, 2005): 13 major advanced economies, 10 other advanced economies, and 48 developing economies, among which 42 countries are classified as net debtors based on balance of payment data over 1972–2005. Although there could be different groupings,

[3]A dynamic pooled model is likely to bias the coefficient of a lagged dependent variable upward due to its correlation with time-invariant country effects (Bond, 2002). In contrast, estimates from a dynamic fixed-effect model are likely to be biased downward due to the demeaning process of the fixed-effect model (Kiviet, 1995). However, the biases are not a serious concern in our main specification as T is higher than 30 for the fixed-effect estimator (Judson and Owen, 1999) and N substantially higher than 20 for the GMM estimator.

we believe that our grouping serves the purpose of our study well because the criteria are objective and broadly correspond to institutional strength and policy credibility of sample countries. Appendix II provides a detailed country list and the grouping criteria.

Below is a summary of the main findings. Our regression results show a strong and stable positive effect of debt growth on inflation in developing economies but not in major advanced economies (Tables 5 and 6). In both specifications of Equations (5) and (10), the coefficient for public debt is 0.2 in the GMM estimator for developing countries but it is insignificant in developed countries. This implies that a 1 percent increase in public debt leads to a 0.2 percentage point increase in inflation. The coefficients are lower than those of money growth but are significant at the 5 percent level and rise to 0.3 for a subset of 42 indebted developing countries. There are signs of serial correlations in the regressions of specification (5) as evidenced by the presence of second-order serial correlation in the lagged first-differenced residual (Arellano and Bond, 1991). However, in the alternative specification (10) that uses lagged variables as explanatory variables, the serial correlations disappear and the coefficients for public debt remain largely unaffected.

Our findings are consistent with other empirical studies on inflation. Many studies report the existence of a positive relationship between budget deficits and inflation mostly in developing countries but not in developed economies (Feldstein, 1986; Orr, Edey, and Kennedy, 1995; Fischer, Sahay, and Vegh, 2002; Engen and Hubbard, 2004; Catao and Terrones, 2005). In the case of developed economies, many studies find virtually no linkage even between money and inflation (Dwyer, 1982; Christiano and Fitzgerald, 2003). Supportive empirical evidence is found also in studies of fiscal reaction functions, which conclude that fiscal policies in developed economies limit the increase in the debt-to-GDP ratio (Bohn, 1998) but those in developing countries do not (IMF, 2003).

We further explore the relationship between inflation and debt in order to examine possible determinants of the strength of such a relationship. We first test whether the debt-inflation linkage is affected by the level of debt. For this exercise, we divide countries into high- and low-debt economies, with the threshold determined by the median level of debt-to-GDP ratios in each country group. We then run the dynamic panel regressions over lagged variables (Equation (10)) for each group. We also run the same regressions with debt and money expressed in percent of GDP rather than in nominal terms, in order to address possible endogeneity of the nominal explanatory variables to inflation. The results show that highly indebted developing countries tend to have significant effects of debt growth on inflation but the relationship becomes insignificant or less robust if the sample is extended to all countries (Table 7). A similar outcome is observed for high inflation countries.

We also test whether exchange rate regimes matter in the link between debt growth and inflation. For the test, we define exchange rate regime dummies, drawing on Reinhart and Rogoff (2004). Our floating rate regime

Table 5. Panel Regression Outcomes
(Dependent variable: inflation 1963–2004)

	All Countries		Major Advanced		Other Countries		Developing Countries		Of which: Debtors[1]	
	Fixed	GMM[2]	Fixed	GMM	Fixed	GMM	Fixed	GMM	Fixed	GMM
Lagged inflation	0.26	**0.21**	**1.11**	**0.68**	0.25	**0.20**	0.21	**0.18**	0.13	**0.15**
	0.14	0.10	0.45	0.24	0.13	0.09	0.13	0.08	0.10	0.06
Money growth	**0.37**	**0.27**	0.22	0.33	**0.37**	**0.26**	**0.44**	**0.33**	**0.36**	**0.33**
	0.06	0.12	0.21	0.36	0.07	0.11	0.07	0.12	0.05	0.11
Debt growth	0.09	0.13	0.01	0.02	0.12	**0.21**	0.10	**0.20**	**0.33**	**0.29**
	0.04	0.07	0.01	0.03	0.07	0.07	0.06	0.07	0.06	0.09
Real GDP growth	−0.07	−0.07	0.50	−1.37	−0.08	−0.07	**−0.32**	**−0.27**	**−0.21**	**−0.24**
	0.06	0.06	0.51	1.01	0.06	0.05	0.10	0.09	0.09	0.08
R^2	0.38		0.26		0.59		0.59		0.60	
Within	0.24		0.26		0.42		0.42		0.44	
Between	0.92		0.34		0.94		0.94		0.90	
Arellano-Bond AR (1)		−1.53		−1.43		−1.52				−1.46
Arellano-Bond AR (2)		**1.96**		−0.08		**2.39**		**2.84**		**3.09**
Number of countries	71	71	13	13	58	58	48	48	42	42
Number of observations	2,149	2,076	428	1,706	1,721	1,661	1,354	1,305	1,200	737

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. The robust standard errors are below the estimated coefficients.

[1]Indebted developing countries, based on the balance of payments data over 1972–2005.

[2]GMM based on the first-difference transformation, assuming that explanatory variables are predetermined. Standard errors are adjusted for serial correlations and heteroscadasticity. The instrument set includes up to four lags of the right-hand side and explanatory variables.

Table 6. Panel Regression Outcomes
(Dependent variable: inflation 1963–2004)

	All Countries		Major Advanced		Other Countries		Developing Countries		Of which: Debtors[1]	
	Fixed	GMM[2]	Fixed	GMM	Fixed	GMM	Fixed	GMM	Fixed	GMM
Lagged inflation	0.23	**0.10**	**1.20**	0.44	0.21	**0.10**	0.17	**0.09**	0.09	**0.06**
	0.17	0.04	0.50	0.27	0.17	0.04	0.16	0.04	0.14	0.03
Lagged money growth	**0.30**	**0.61**	−0.03	0.65	**0.31**	**0.58**	**0.35**	**0.62**	**0.32**	**0.52**
	0.10	0.10	0.18	0.56	0.09	0.10	0.11	0.08	0.09	0.11
Lagged debt growth	0.05	**0.18**	0.01	0.01	0.09	**0.22**	0.08	**0.20**	**0.27**	**0.29**
	0.04	0.07	0.01	0.02	0.05	0.06	0.05	0.05	0.07	0.08
Lagged real GDP growth	−0.03	−0.33	0.84	1.14	−0.04	−0.23	**−0.21**	**−0.43**	−0.16	−0.22
	0.04	0.08	0.67	1.07	0.05	0.19	0.10	0.17	0.09	0.16
R^2	0.32		0.27		0.51		0.49		0.52	
Within	0.18		0.40		0.32		0.31		0.33	
Between	0.92		0.27		0.94		0.93		0.90	
Arellano-Bond AR (1)		−1.87		−1.37		−1.77				−1.51
Arellano-Bond AR (2)		1.62		−0.35		**1.98**		1.8		0.96
Number of countries	71	71	13	13	58	58	48	48	42	42
Number of observations	2,131	2,076	430	415	1,701	1,661	1,334	1,305	1,181	1,157

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. The robust standard errors are below the estimated coefficients.

[1]Indebted developing countries, based on the balance of payments data over 1972–2005.

[2]GMM based on the first difference transformation, assuming that explanatory variables are predetermined. Standard errors are adjusted for serial correlations and heteroscadasticity. The instrument set includes up to four lags of the right-hand side and explanatory variables.

Table 7. Impact of Debt Growth on Inflation, 1963–2004

	Debtors[1]		All Countries	
	High debt	High inflation	High debt	High inflation
Thresholds (mean)	54.0	14.4	51.4	12.8
Thresholds (median)	46.5	8.7	47.4	7.6
Debt-inflation coefficient[2]				
Fixed-effect	**0.06**	**0.13**	0.04	0.04
First-difference GMM	**0.18**	**0.22**	0.17	**0.18**
Debt-inflation coefficient				
Debt-inflation coefficient[3]				
Fixed-effect	**0.06**	**0.15**	**0.10**	**0.11**
First-difference GMM	**0.14**	−0.12	0.11	0.02
Number of countries	21	21	35	35
Number of observations	589	559	1,008	944

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. Dynamic panel regressions on lagged variables (Equation (10)).

[1]Indebted developing countries (see Appendix II for definition).

[2]Debt and money in nominal terms as in Equation (10).

[3]Debt and money expressed in percent of GDP.

dummy, which varies by time and across countries, represents an independently floating exchange rate regime as defined by Reinhart and Rogoff (2004). Our fixed rate regime dummy covers all other exchange rate regimes (those with pegs, limited flexibility, and managed floats). We then multiply the exchange rate regime dummies by the debt growth variable to isolate the impact of the exchange rate regimes on the debt-inflation nexus. The regressions show that the sensitivity of inflation to debt is higher and significant under a floating rate regime but the sensitivity is low and often insignificant under a fixed rate regime (Table 8). The results do not change substantially if we exclude managed floats from the fixed rate regime dummy. This finding could reflect, as stressed by Ghosh and others (1997), the generally favorable commitment effect of the fixed exchange rate regime on inflation and inflation expectations.

Robustness of the Results

We test the robustness of the results from three angles. First, we test whether the inclusion of other variables affect the regression outcomes. We are particularly concerned about the possibility that some explanatory variables, in particular changes in debt values, could be affected by current or future

Table 8. Panel Regression Outcomes
(Dependent variable: inflation 1963–2004)

	All Countries			Major Advanced		Other Countries		Debtors[3]	
	Fixed	GMM[1]	GMM[2]	Fixed	GMM[1]	Fixed	GMM[1]	Fixed	GMM[1]
Lagged inflation	0.12	0.10	0.11	**1.45**	0.82	**0.11**	**0.10**	0.02	0.06
	0.14	0.05	0.07	0.07	0.45	0.13	0.05	0.10	0.04
Lagged money growth	**0.21**	**0.47**	**0.39**	−0.13	0.54	**0.23**	**0.48**	**0.24**	**0.39**
	0.06	0.11	0.09	0.19	0.49	0.07	0.10	0.07	0.10
Lagged debt growth									
Fixed rate regime	−0.00	−0.01	0.02	0.01	−0.00	0.01	0.06	**0.08**	0.08
	0.01	0.08	0.02	0.01	0.02	0.01	0.05	0.04	0.05
Floating rate regime	**0.30**	**0.32**	**0.32**	0.79	1.90	**0.31**	**0.32**	**0.46**	**0.44**
	0.09	0.08	0.09	0.73	1.10	0.09	0.08	0.09	0.08
Lagged real GDP growth	−0.02	**−0.43**	−0.13	0.79	−0.90	−0.03	−0.29	−0.15	**−0.30**
	0.04	0.18	0.10	0.65	0.72	0.04	0.17	0.08	0.14
R^2	0.34			0.26		0.53		0.53	
Within	0.20			0.27		0.36		0.36	
Between	0.85			0.09		0.89		0.87	
Arellano-Bond AR (2)		**2.31**	1.83		−0.92		**2.41**		1.4
Number of countries	71	71	71	13	13	58	58	42	42
Number of observations	2,131	2,076	2,076	430	415	1,701	1,661	1,181	1,157

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. The robust standard errors are below the estimated coefficients.

[1]GMM based on the first difference transformation, assuming that explanatory variables are predetermined. Standard errors are adjusted for serial correlations and heteroscadasticity.

[2]Three lags are used to remove autocorrelations of errors.

[3]Indebted developing countries, based on the balance of payments data over 1972–2005.

inflationary shocks through a valuation channel. For example, foreign-currency-denominated debt, which is often a sizable portion of public debt, could rise or fall depending on the exchange rate, which is in turn affected by current inflation or the inflation outlook. We hence control for the valuation channel by including exchange rate movements as another explanatory variable and test whether its inclusion affects the regression coefficient for public debt. We also include the output gap, estimated from the Hodrick-Prescott (H-P) filter, to control for cyclical factors. The results are largely unchanged with the inclusion of these additional variables.

Second, we run rolling regressions for subsample periods in order to address a potential problem of parameter instability. The main results described above are largely maintained in regressions over each rolling 20-year period of 1963–83, 1972–93, and 1983–2003 (Table 9). The sensitivity of inflation to debt growth in indebted developing countries remains significant and similar to its sensitivity to money growth. It is notable that the coefficients are larger in the later period than in the earlier period, possibly reflecting the relative dominance of flexible exchange rate regimes during the post–Bretton Woods era.

Third, we relax the common slope assumption. Pesaran and Smith (1995) illustrates that, in the case of dynamic panel data with heterogeneous slopes, pooling and aggregating produce inconsistent and potentially highly misleading estimates of the coefficients. Hence we relax the common slope assumption and calculate the mean group estimator (Pesaran and Smith, 1995) and the panel fully modified OLS estimator (Pedroni, 2000). Mean group estimates show that debt growth, both contemporaneous and lagged ones, affect inflation positively and its degree is stronger in indebted developing countries (Table 10).[4] Similar patterns are observed in fully modified OLS estimates (FMOLS), although the levels of the coefficients are not directly comparable to those from our main regressions in log difference form (Table 11). The panel FMOLS estimator is one of the least restrictive estimators for panel data, which is adjusted for endogeneity and short-run cross-country heterogeneity while exploiting long-run information contained in the panel.

Transmission Channels

We undertake a vector autoregression (VAR) to trace out the transmission channels of the fiscal influence on inflation and to cross-check the validity of the panel regressions above, particularly, with respect to a potential endogeneity problem. Our panel VAR consists of inflation and growth of public debt, money, and real GDP. Country fixed effects and time effects are controlled for through country dummies and time dummies. Impulse responses are based on the Cholesky decomposition of the structural

[4]In a similar vein, we also undertake an exclusion sensitivity analysis by removing each country sequentially from the regressions. The results remain largely unchanged.

Table 9. Panel Regression Outcomes

(Dependent variable: inflation)

	All Countries			Major Advanced			Other Countries			Of which: Debtors[1]		
	63–83	73–93	84–03	63–83	73–93	84–03	63–83	73–93	84–03	63–83	73–93	84–03
Lagged inflation	**0.59**	**0.48**	0.18	**0.58**	**0.67**	1.61	**0.58**	**0.46**	0.16	**0.47**	**0.40**	0.04
	0.09	0.15	0.17	0.07	0.07	1.04	0.09	0.16	0.16	0.11	0.19	0.12
Lagged money growth	**0.12**	**0.16**	**0.34**	**0.13**	**0.05**	−0.22	**0.11**	**0.17**	**0.35**	**0.13**	**0.17**	**0.36**
	0.03	0.04	0.11	0.04	0.02	0.24	0.03	0.05	0.11	0.05	0.06	0.10
Lagged debt growth	0.02	**0.12**	0.05	−0.02	−0.00	0.00	0.02	**0.13**	0.09	**0.08**	**0.19**	**0.29**
	0.01	0.04	0.04	0.02	0.01	0.01	0.01	0.04	0.07	0.03	0.05	0.08
Lagged real GDP growth	−0.04	0.01	−0.01	0.13	**0.16**	0.31	−0.03	0.01	−0.02	−0.04	0.00	**−0.27**
	0.03	0.02	0.05	0.10	0.06	0.60	0.03	0.02	0.05	0.03	0.05	0.14
R^2	0.78	0.82	0.30	0.80	0.85	0.26	0.78	0.82	0.49	0.72	0.83	0.52
Within	0.54	0.53	0.16	0.76	0.99	0.25	0.54	0.53	0.31	0.50	0.52	0.33
Between	0.96	0.92	0.87	0.94	0.87	0.36	0.96	0.91	0.93	0.96	0.84	0.88
Number of countries	60	67	71	13	13	13	47	54	58	33	40	42
Number of observations	819	1,187	1,312	202	263	228	617	924	1,084	402	638	779

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. Based on a dynamic fixed-effects model. Below the estimated coefficients are robust standard errors.

[1]Indebted developing countries, based on the balance of payments data over 1972–2005.

Table 10. Mean Group Estimates

(Dependent variable: inflation 1963–2003)

	Countries Other Than:								
	Whole sample			Major advanced economies			Of which: debtor countries[1]		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Lagged inflation	**0.50**	**0.55**	**0.50**	**0.44**	**0.50**	**0.43**	**0.42**	**0.49**	**0.42**
	0.04	0.03	0.05	0.04	0.03	0.05	0.05	0.04	0.08
(Lagged) money growth	**0.07**	**0.08**	**0.08**	**0.07**	**0.08**	**0.08**	**0.07**	**0.08**	**0.08**
	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04
(Lagged) debt growth	**0.08**	**0.08**	**0.11**	**0.09**	**0.10**	**0.14**	**0.11**	**0.11**	**0.16**
	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.06
(Lagged) real GDP growth	**−0.24**	0.08	0.07	**−0.26**	**−0.28**	0.03	**−0.40**	**−0.47**	−0.20
	0.10	0.09	0.12	0.12	0.11	0.14	0.18	0.18	0.03
GDP gap	0.00			0.00			0.00		
	0.00			0.00			0.00		
Number of countries	71	71	71	58	58	58	25	25	25

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. Based on country-by-country dynamic ordinary least squares (OLS) regressions. The standard errors are below the estimated coefficients.

[1]Indebted developing countries, based on the balance of payments data over 1972–2005.

(1), (2): Mean of OLS regression coefficients for each country (over contemporaneous explanatory variables).

(3): Mean of OLS regression coefficients for each country (over one-year lag explanatory variables).

Table 11. Fully Modified Ordinary Least Square (FMOLS) Estimates

	Whole Sample		Advanced Economies		Developing Countries[1]		Of which: Debtor Countries[1]			
	Coefficient	*T*-stat	Coefficient	*T*-stat	Coefficient	*T*-stat	Coefficient	*T*-stat	Coeficient[2]	*T*-stat
Money	**0.58**	78.39	**0.26**	17.31	**0.56**	87.13	**0.59**	60.83	**0.25**	13.4
Public debt	**0.13**	11.95	**0.21**	11.86	**0.05**	4.14	**0.25**	25.32	**0.19**	26.78
Real GDP	**−0.25**	−11.38	−0.09	−1.32	**−0.31**	−19.72	−0.32	−1.51	**0.08**	−2.89
Number of countries	71		23		48		25		25	

Source: Authors' calculation.
Note: Coefficients significant at the 5 percent level are in bold. Based on FMOLS regressions over the variables in the level (Pedroni, 2000).
[1]Indebted developing countries, based on the balance of payments data over 1972–2005.
[2]Common time dummies not included. Common time dummies included in all other regressions.

shocks in the order of output (R), prices (I), money (M), and public debt (D). This ordering allows possible contemporaneous feedback from inflation and money growth on debt growth but not from debt growth on inflation or money growth. This is a very conservative assumption, given that the focus of our exercise is to estimate the impact of debt growth on inflation. In the choice of the lag length, we use the Schwarz criterion which imposes a larger penalty for additional coefficients than the Akaike information criterion.

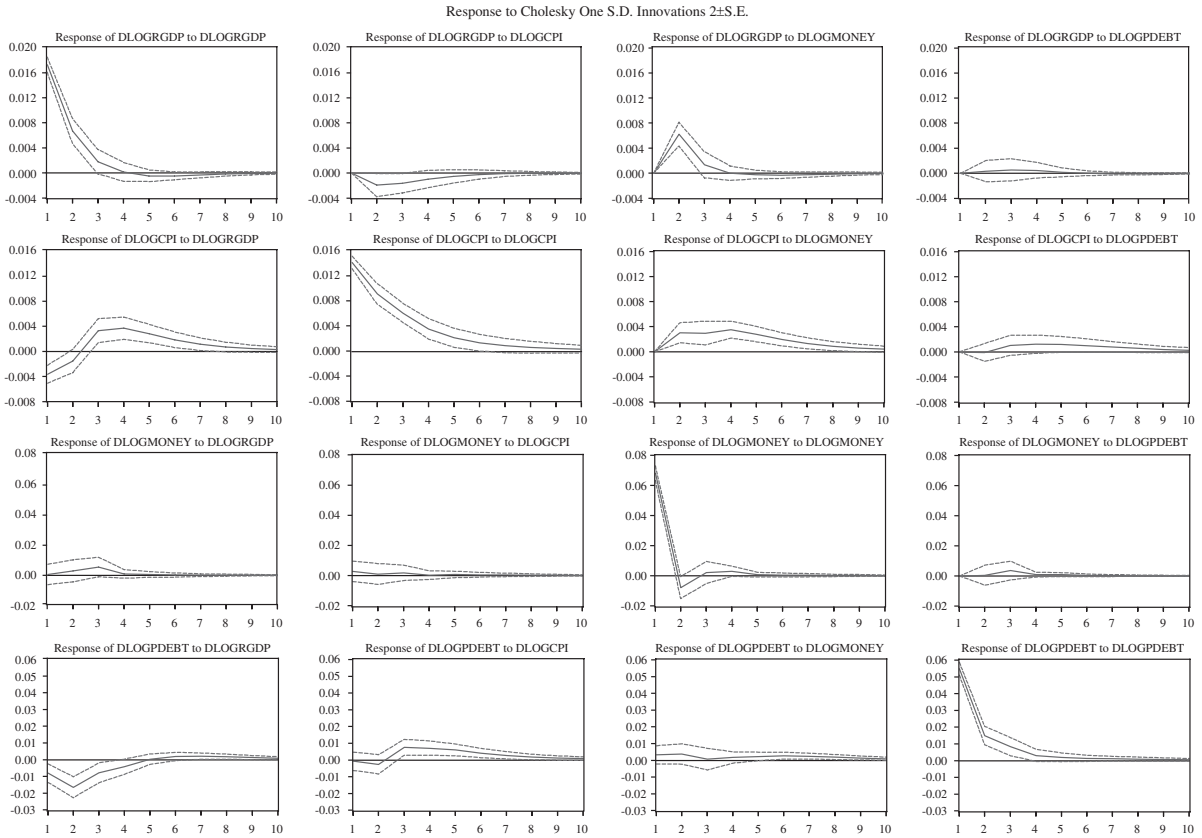
The results are largely comparable with those from our panel regressions, rendering additional support to the prediction of the fiscal-monetary model of inflation—the debt-inflation link exists and its extent is affected by institutional and structural factors. Our panel VARs show a weak or no response of inflation to fiscal shocks in major advanced economies (Figure 3a). A similar pattern is observed in the monetary response to fiscal shocks. In contrast, impulse responses for indebted developing countries (Figure 3b) show a strong and positive response of money supply and inflation to fiscal shocks. The results are largely invariant to changes in the shock ordering (Table 12).

Our findings dovetail with those of many empirical studies that document policy responses to macroeconomic shocks in developing countries (Mélitz, 1997; Akitoby and others, 2004; Kaminsky, Reinhart, and Vegh, 2004). The phenomenon of fiscal dominance in developing countries is confirmed by our VAR evidence that fiscal relaxation tends to be accommodated by monetary easing in those countries (the third chart in the right column of Figure 3b). Our VARs also show that fiscal and monetary policies in developing countries are largely insensitive to output shocks in contrast to some evidence of countercyclical fiscal policy in advanced economies (the left bottom of Figure 3a).

Implications of the Unpleasant Monetary Arithmetic and the FTPL

The implications of rising public debt for inflation are observationally similar in the Sargent-Wallace framework (1981) and the FTPL. Nonetheless, there is an important theoretical distinction between the two (Leeper and Yun, 2006). Under the FTPL, an increase in government debt raises the wealth of bond holders while not reducing the wealth of others. Hence, the increase in government debt boosts aggregate demand and pushes up the price level and in turn money demand. Money supply is endogenous in this regime and, as such, increases in response to the higher money demand. In this regime, the price level is the factor that equilibrates the nominal value of future discounted primary surplus and the nominal value of public debt. In contrast, under the Sargent-Wallace framework of the so-called unpleasant monetary arithmetic, an increase in government debt, if not fully backed by future real primary surplus, will increase concerns about monetization of public debt, which will in turn raise inflation expectations and thereby increase long-term interest rates. This will in turn reduce money demand and push up the price level even without a contemporaneous increase in money supply.

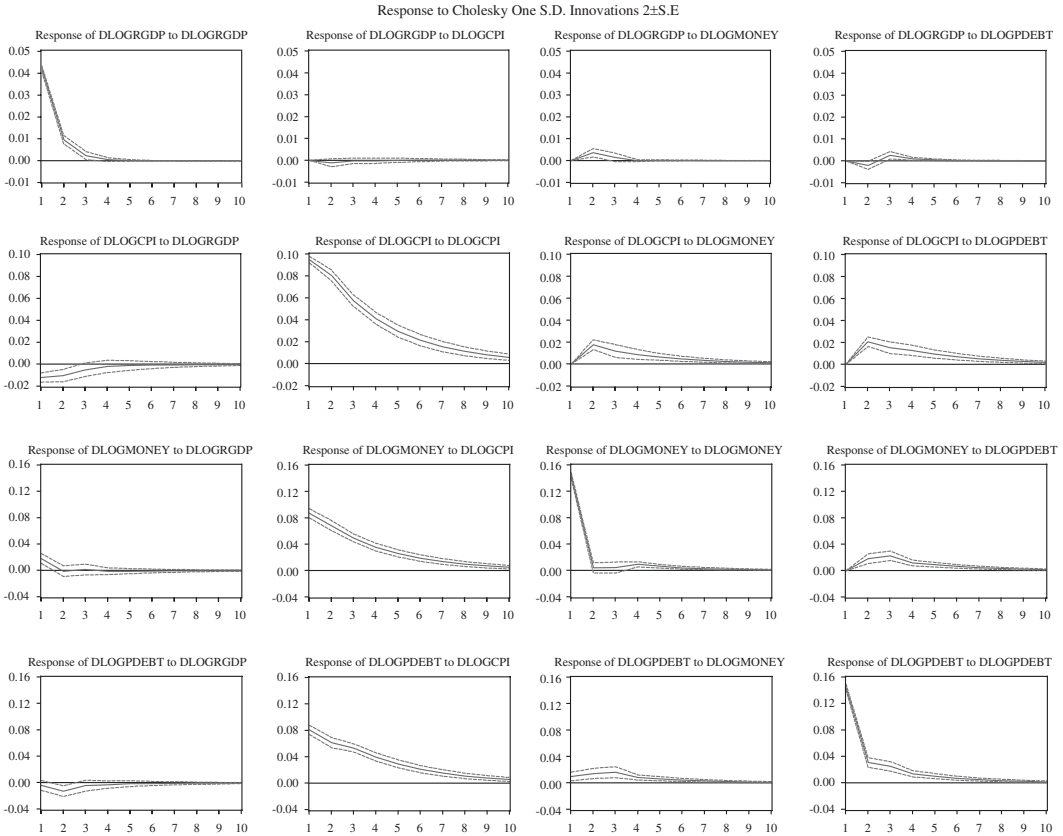
Figure 3a. Impulse Responses in Major Advanced Economies



Source: Authors' calculation.

Note: Country groupings are based on IMF, *World Economic Outlook* classifications as of September 2005. See Appendix II for details.

Figure 3b. Impulse Responses in Indebted Developing Countries



Source: Authors' calculation.
Note: These are countries whose cumulative current account balance over the period 1972–2005 (1992–2005 for transition economies) is negative. See Appendix II for details.

Table 12. Impact of Debt Growth on Inflation over four Years

	VAR	Fixed Effect	GMM
Major advanced economies			
R-I-M-D[1]	0.04	0.03	0.02
R-I-D-M	0.05	0.03	0.02
R-M-I-D	0.04	0.03	0.02
R-M-D-I[2]	0.03	0.04	0.05
Debtor developing countries			
R-I-M-D[1]	0.34	0.30	0.31
R-I-D-M	0.35	0.30	0.31
R-M-I-D	0.34	0.30	0.31
R-M-D-I[2]	0.67	0.38	0.34

Source: Authors' calculation.

Note: Cumulative percentage changes in prices over four years, following a 1 percent change in public debt. The specifications include time and country dummies.

[1]*R-I-M-D* refers to the Choleski ordering of growth of output (*R*), inflation (*I*), money (*M*), and debt (*D*). The same abbreviations are applied to other rows.

[2]This ordering allows contemporaneous impact of debt growth (*D*) on inflation (*I*). Equivalent fixed effect/GMM estimators hence place a contemporaneous debt variable in the right-hand side of the panel regression for inflation.

Notwithstanding the observational similarity, the differences in the transmission channel allow an empirical testing of the two models. The FTPL implies that the wealth effect of debt increases should materialize mainly from public debt held by residents. In contrast, monetization concerns, as stressed by the Sargent-Wallace framework, should be affected by the total size of public debt, regardless of the residency of the debt holders. Our panel regressions of a smaller data set spanning a subset of 30 Latin and Caribbean countries between 1997 and 2004 point to the dominance of monetization concerns as opposed to the wealth effects, although the lack of debt data by residency makes it difficult to extend the analysis to other countries and over a longer time span. The regression results show that the impact of total public debt growth on inflation is significantly positive but the inflation impact of an increase in domestic public debt (that is, public debt held by residents) is insignificant (Table 13).

III. Application to Jamaica

Jamaica is one of the most heavily indebted countries in the world. The public debt sharply increased to nearly 140 percent of GDP over the past decade from an already high level of 80 percent of GDP earlier. The sharp increase was due mainly to the assumption of off-budget liabilities, notably the bailout of financial institutions in the late 1990s, with accumulated budget deficits accounting for only a quarter of the surge. Debt service costs have hovered about 15 percent of GDP in recent years and to help meet these

Table 13. Latin America and Caribbean Countries: Inflation

	Total Public Debt		Of which: Domestic	
	OLS	Fixed	OLS	Fixed
Lagged inflation	**0.59**	**0.24**	**0.64**	**0.15**
	0.05	0.05	0.05	0.05
Money growth	**0.13**	**0.07**	**0.13**	**0.05**
	0.03	0.03	0.03	0.02
Debt growth	**0.04**	**0.03**	0.01	−0.00
	0.02	0.01	0.00	0.00
Real GDP growth	−0.05	−0.07	−0.04	−0.11
	0.05	0.06	0.05	0.07
R^2	0.55	0.74	0.58	0.77
D.W. statistics	2.44	2.29	2.45	2.15
Number of countries	30	30	30	30
Number of observations	270	270	210	210

Source: Authors' calculation.

Note: Coefficients significant at the 5 percent level are in bold. The standard errors are below the estimated coefficients.

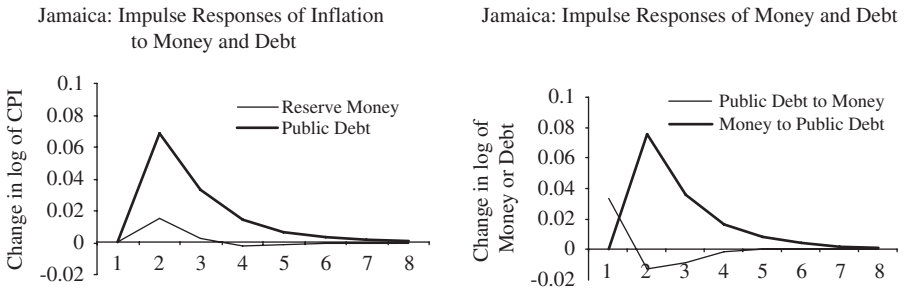
payments, primary surpluses have been generated in excess of 10 percent of GDP over the past several years.

Motivated by the need to reduce the large public debt, the Jamaican authorities started in 2004 an ambitious program that includes as its objective the goal of reducing inflation to single digits. The ultimate goal of the government's comprehensive program is to reduce public debt to 100 percent of GDP by 2008 through fiscal consolidation. This consolidation effort, in turn, is expected to lead to a virtuous circle of higher economic growth, lower inflation, and lower interest rates and hence reduced debt.

Inflation in Jamaica has been high and volatile, compared with neighboring countries. Unlike many other countries in similar circumstances, the Bank of Jamaica (BOJ) has traditionally adopted a conservative monetary policy stance, with seignorage financing of the budget deficit rarely exceeding 1 percent of GDP. This policy stance was possible thanks to its strong operational autonomy, notwithstanding overall low statutory independence (Jácome and Vázquez, 2005). Inflation nonetheless has remained at double digits since 2003 and fluctuated widely but most neighboring countries had much lower inflation during the same period. The BOJ's ability to reduce inflation was hampered by frequent exogenous shocks, large government debt and instruments for open market operations (OMOs), and already high sterilization costs (1½–2½ percent of GDP per year in recent years).

We apply a VAR to Jamaica to test whether the cross-country debt-inflation relationship identified in our panel regressions holds for Jamaica. The estimation uses annual data between 1980 and 2004 for CPI, real GDP,

Figure 4. Jamaica: Impulse Responses[1]



Source: Authors' calculation.
[1]Based on a one year lag VAR using annual data from 1980 to 2004.

reserve money, and government debt, which includes OMO debt. The exchange rates are also included in the robustness test to control for possible biases from exchange rate volatility on the debt dynamics. Data for GDP and CPI are from the Statistical Institute, and government debt from the Finance Ministry. All other data are from the BOJ. All the variables are nonstationary and, as such, we test whether any stationary long-run relation exists among the variables. Both the trace and maximum eigenvalue tests based on the full information maximum likelihood method reject the null hypothesis of no cointegration but the number of cointegration vectors depend on the specification of the cointegration equations, most probably in reflection of the short time span. Hence, we run VARs both with and without the error correction terms.

The VAR outcomes confirm the significance of public debt dynamics in determining inflation in Jamaica. The impulse response functions show that the price level is positively affected by money supply and public debt but the latter has stronger and more lasting effects on inflation (Figure 4). Also, fiscal shocks have positive and persistent effects on money supply but the opposite does not hold. These results are similar to those from the panel VAR estimates for developing countries and robust to changes in the ordering of the shocks. The directions of the impulse responses remain unchanged in an alternative VAR including the exchange rate as an endogenous variable and alternative regressions based on the vector error correction model.

Caution is needed, however, in interpreting these outcomes, as it is not clear which fiscal channel is driving inflation in Jamaica. The regression results do not separate the wealth effects of public debt from its effects on monetization expectations. It could well be that the former effects are more important in Jamaica than the latter effects, given the sustained efforts of the authorities for fiscal consolidation. It should, therefore, be stressed that our VAR results do not necessarily mean that the relatively high inflation in Jamaica signals concerns about monetization of debt. Notwithstanding this caveat, our regression results confirm that the movements of public debt do matter for inflation dynamics in Jamaica.

IV. Policy Implications

Our regression results point to a number of policy implications for countries with high debt. First, there is a significant risk of a debt-inflation trap in highly indebted countries. A rise in inflation expectations will eventually push up nominal interest rates, elevating public debt unless fully countered by a primary surplus. The debt increase will in turn raise inflation expectations further. This vicious feedback effect implies that rising inflation expectations could increase budgetary costs more than proportionally.[5] This also means that rising inflation expectations could be destabilizing to the debt dynamics more than adverse output shocks do—possibly by as much as one-third to one-half (the numerical relationship is derived in Appendix III).

More broadly, the conduct of monetary policy is extremely challenging in highly indebted developing countries. In principle, flexibility in monetary policy would be severely constrained by considerations about implications of interest and exchange rate volatilities on debt dynamics. Operationally, monetary data alone might not provide reliable indications of emerging inflation pressures, as growth in government debt in lieu of money printing could also affect inflation expectations. In this regard, sustained sterilized intervention could backfire since such interventions would limit growth in money supply but raise public debt. In sum, in countries with large debt overhangs, purely money-based stabilization is unlikely to be effective without the support of fiscal consolidation.

Second, the importance of inflation expectations in the debt-inflation dynamics implies that the budgetary costs of noncredible disinflation policy are potentially large in highly indebted countries. In Jamaica, for example, the central bank has medium-term inflation forecasts of 5 percent, which are considerably lower than current inflation. Suppose that bond holders believe that inflation would indeed fall but remain still high at 10 percent over the medium term, with correspondingly higher nominal interest rates that they demand for holding debt. In the event that inflation indeed falls to 5 percent, the ex post budgetary real interest payments would be much higher (by about 3 percent of GDP, given Jamaica's debt profile) than in the case of 10 percent inflation. Conversely, unanticipated inflation would help reduce borrowing costs in the short term but only exacerbate the credibility problem and ratchet up borrowing costs over the medium term. This points to the need for managing inflation and inflation expectations in ways to minimize surprises.

Third, institutional and structural factors matter in the dynamics between public debt and inflation. Fiscal rules that limit the size of budget deficits or public debt could, under appropriate circumstances, be an important institutional tool for safeguarding price stability to the extent that the commitment is credible. Independence of the central bank could also help

[5]A similar observation has been made in Blanchard (2004) and Favero and Giavazzi (2004), which examined the relationship between depreciation expectations and public debt in Brazil.

reduce monetization concerns. The development of the financial sector could help promote price stability as a developed financial market tends to support the central bank's policy autonomy (Posen, 1995). The financial sector could also reinforce fiscal discipline by providing immediate and clear signals about perceived risks of debt monetization (Rubin and Weisberg, 2003).

V. Summary and Conclusions

Our study provides comprehensive and robust evidence in support of Sargent and Wallace's (1981) "unpleasant monetary arithmetic" that an increase in government debt is typically inflationary, in countries with large public debt. The regression results show that an increase in public debt is significantly and strongly associated with high inflation in indebted developing countries, after controlling for money growth and real output growth. In contrast, this pattern holds less strongly in other developing countries and does not hold in major advanced economies, consistent with the thesis of a forward-looking model of inflation that—unlike the implications of a static aggregate demand model—policy regimes matter in the debt-inflation nexus. These results are invariant over subsample periods and robust to the inclusion of other variables, corrections for possible endogeneity biases and relaxation of common-slope restrictions. Our regressions also show that public debt growth is more inflationary in high-debt countries than in low-debt countries and that the debt-inflation linkage is weak in fixed or managed exchange rate regimes. A panel VAR traces out the transmission mechanism that a positive innovation to debt has a positive and persistent effect both on inflation and money supply. Wealth effects of public debt could also affect inflation, as hypothesized by the FTPL, but our study does not find supporting evidence.

The findings highlight challenges for price stabilization in highly indebted countries. They point to a significant risk of a debt-inflation trap, potentially large budgetary costs of noncredible disinflation policy, and limitations of sustained sterilized interventions in stabilizing prices and exchange rates. They also stress the importance of institutional and structural factors in the debt-inflation link, such as fiscal rules, inflation targeting, and the depth and breadth of the financial sector. They also indicate that, notwithstanding an important role of monetary policy in managing inflation expectations, fiscal policy would likely be the dominant factor for inflation in highly indebted developing countries. This implies that price stability achieved mainly through the issuance of central bank open market instruments (that is, accumulation of public debt) in lieu of deficit monetization could be sustained only if supported by fiscal consolidation and structural reforms to boost monetary policy independence.

Further research could be usefully undertaken in several areas. The link between inflation and economic growth has been extensively investigated both in empirical (for example, Barro, 1996; Ghosh and Phillips, 1998) and

theoretical studies (Smith and van Egteren, 2005). Our findings of a direct link between public debt growth and inflation could shed further light on the effect of fiscal policy on economic growth. In addition, our rich empirical findings could be utilized to fine-tune debt sustainability analysis. Finally, our empirical framework could be modified to assess the impact of debt structures, in particular currency and maturity, on inflation dynamics although data limitations would be a major challenge.

APPENDIX I. RELATIONSHIP BETWEEN PRICE, MONEY, DEBT, AND OUTPUT

A simplified version of Castro, De Resende, and Ruge-Murcia (2003) can be used to derive a functional relationship between price on the one hand and money, debt, and output on the other. In this simple version, a representative household is endowed with fixed resources, y, for each period, and allocates its real wealth among real consumption (c), real domestic money (m/p), and nonindexed real government bonds (b/p) in order to maximize the following utility function:

$$\sum_{t=0}^{\infty} \beta^t (\ln(c_t) + \gamma \ln(m_t/p_t)), \tag{A.1}$$

subject to a resource constraint of

$$c_t + \frac{m_t}{p_t} + \frac{b_t}{p_t} = y_t - \tau_t + \frac{m_{t-1}}{p_t} + \frac{i_{t-1} b_{t-1}}{p_t}, \tag{A.2}$$

where τ is the lump-sum tax and i_{t-1} is a nominal gross return of a government bond between periods $t-1$ and t. This maximization problem yields the following standard first-order conditions for consumption and real money demand, respectively:

$$\frac{c_{t+1}}{c_t} = \frac{\beta i_t}{\pi_{t+1}}, \tag{A.3}$$

$$\frac{m_t}{p_t} = \frac{\gamma c_t i_t}{i_t - 1}, \tag{A.4}$$

where $\pi_t = p_{t+1}/p_t$. These two first-order conditions nest a Cagan-type money demand function, which is inversely related to inflation expectations.

The government is faced with the following intertemporal budget constraint:

$$G_t + (i_{t-1} - 1)\frac{B_{t-1}}{p_t} = \tau_t + \frac{(M_t - M_{t-1})}{p_t} + \frac{(B_t - B_{t-1})}{p_t}. \tag{A.5}$$

Forward iteration on Equation (A.5) and no-Ponzi game conditions on the government imply the following long-term budget constraint of the government:

$$\frac{i_{t-1} B_{t-1}}{p_t} = \sum_{j=0}^{\infty} \frac{\tau_{t+j}}{R_{t,j}} - \sum_{j=0}^{\infty} \frac{G_{t+j}}{R_{t,j}} + \sum_{j=0}^{\infty} \frac{M_{t+j} - M_{t+j-1}}{p_{t+j} R_{t,j}}, \tag{A.6}$$

where G is the real government spending and $R_{t,j}$ is the compounded real discount rate, as expressed as $R_{t,j} = \prod_{h=1}^{j} r_{t+h}$ where r_{t+h} is the exogenous real interest rate between periods $t+h-1$ and $t+h$. In the case of a fiscal policy rule of backing a part, $(1-\delta)$, of the debt service by future primary surpluses and monetizing the remainder (δ), we obtain the

following money supply function:

$$\frac{M_t}{P_t} = \frac{i_t - 1}{i_t}\left[\frac{\delta i_{t-1} B_{t-1}}{p_t} + \frac{M_{t-1}}{p_t} - \sum_{j=1}^{\infty} \frac{M_{t+j}}{p_{t+j} R_{t,j}} \frac{i_{t+j} - 1}{i_{t+j}}\right]. \tag{A.7}$$

Equation (A.7) shows that the path of money supply is determined by the extent of debt monetization (the first variable in the right) and savings in the future interest payments brought about by current monetary financing of the budget deficit (the third variable).

Imposing equilibrium conditions on Equations (A.4) and (A.7) and exploiting the recursive nature of the Euler equation in (A.3), we obtain the equilibrium price as follows:

$$p_t = \frac{(1-\beta)(M_{t-1} + \delta i_{t-1} B_{t-1})}{\gamma c_t}. \tag{A.8}$$

Given the recursive nature of the equilibrium and no arbitrage between bond and real asset returns ($r_{t+1} = i_t/(p_{t+1})/p_t)$), the equilibrium price can be rearranged to:

$$p_t = \frac{(1-\beta)(M_t + \delta B_t)}{\gamma c_t}. \tag{A.9}$$

APPENDIX II. DATA SOURCES AND DEFINITIONS AND COUNTRY GROUPING

Our main data set is a panel data set spanning 71 countries over up to 43 years, collected from a variety of sources. The main data set includes annual data for CPI, money, public debt, and real GDP of each country for the maximum period of 1962–2004. Country selections were based primarily on the availability of the data and hence exclude many African countries and some small Caribbean countries. Data for inflation and real GDP—a proxy for real consumption—are mostly from the *International Financial Statistics* (IFS), but, in some cases, are from the World Economic Outlook data set of the IMF. Public debt data are from a variety of sources, including the IFS, World Economic Outlook and OECD databases, and, for Jamaica, Russia, and Turkey, the country authorities. Our debt data refer to both foreign-, and domestic-currency-denominated debt, and cover general government debt in most developed countries and consolidated central government in most developing countries. Given that fiscal autonomy of local governments, in particular borrowing rights, is limited in developing countries, we do not think that the use of narrower definitions of public debt for developing countries affects our findings materially. Monetary data are mainly from the IFS and the World Economic Outlook database, and, in the case of the euro-zone countries, the OECD. The definition of money is reserve money, or the narrowest definition available in the databases. Appendix Table A1 shows the definitions and sources for public debt and money for each country.

In addition to the four main variables, several other data were used for alternative specifications and various robustness tests. These include exchange rate regimes (Reinhart and Rogoff, 2004), exchange rates (IFS), and output gap estimates (derived from detrended real GDP using the H-P filter).

Countries are divided into 13 major advanced economies and 58 other countries, based on the classification of the IMF's *World Economic Outlook* (IMF, 2005). The other countries include 48 developing countries and 10 nonmajor advanced economies as defined in the *World Economic Outlook* such as Korea, Israel, and Ireland, which could be considered as developing countries in a broad sense. This classification is broadly in line with other studies on fiscal variables and inflation (Catao and Terrones, 2005), which reported some evidence of significant heterogeneity between developed and developing countries.

Table A1. Sources and Definitions of Key Data

	Public Debt (in foreign or local currencies)		Money	
	Source[1] and period	Definition	Source[1]	Definition
Advanced economies				
Major advanced economies				
Austria	WEO (1970–2005)	General government	OECD	Broad money
Belgium	OECD (1969–2003)	General government	OECD	Broad money
Canada	WEO (1962–2005)	General government	IFS	Reserve money
Finland	WEO (1962–2005)	General government	OECD	Broad money
France	IFS (1962–97)/WEO (1998–2005)	General government	OECD	Broad money
Germany	IFS (1962–76)/WEO (1977–2005)	General government	IFS	Reserve money
Ireland	IFS (1962–77)/WEO (1978–2005)	General government	OECD	Broad money
Italy	IFS (1962–97)/WEO (1998–2005)	Budgetary central government	OECD	Broad money
Japan	WEO (1969–2005)	General government	IFS	Reserve money
Netherlands	IFS (1962–97)/WEO (1998–2005)	General government	IFS	Reserve money
Spain	IFS (1962–80)/WEO (1981–2005)	General government	OECD	Broad money
United Kingdom	OECD (1966–2005)	General government	IFS	Reserve money
United States	IFS (1962–2004)	Consolidated central government	IFS	Reserve money
Other advanced economies				
Australia	IFS (1962–87)/WEO (1988–2005)	General government	IFS	Reserve money
Cyprus	IFS (1970–2003)	Consolidated central government	IFS	Reserve money
Denmark	WEO (1962–2005)	General government	IFS	Reserve money
Iceland	IFS (1962–2004)	Budgetary central government	IFS	Reserve money
Israel	IFS (1972–2001)	Consolidated central government	IFS	Reserve money
Korea	IFS (1962–97)/OECD (1998–2005)	Consolidated central government	IFS	Reserve money
New Zealand	IFS (1962–99)/WEO (2000–05)	Budgetary central government	IFS	Reserve money
Norway	IFS (1962–2003)	Consolidated central government	IFS	Reserve money
Sweden	IFS (1962–2004)	Budgetary central government	IFS	Reserve money
Switzerland	IFS (1962–2004)	Budgetary central government	IFS	Reserve money

Table A1 *(concluded)*

Other emerging market and developing economies				
Net credit countries				
Botswana	IFS (1977–2004)	Budgetary central government	WEO	Broad money
Malaysia	IFS (1962–99)	Budgetary central government	IFS	Reserve money
Oman	IFS (1971–2001)	Budgetary central government	IFS	Reserve money
Russia	Ministry of Finance (1993–2005)	Consolidated central government	IFS	Reserve money
Ukraine	WEO (1995–2005)	General government	IFS	Reserve money
Venezuela	IFS (1962–85)/WEO (1986–2005)	Consolidated central government	IFS	Reserve money
Net debtor countries				
Albania	WEO (1995–2005)	General government	IFS	Reserve money
Argentina	WHD (1991–2005)	General government	IFS	Reserve money
Bahamas, The	IFS (1965–2004)	Budgetary central government	IFS	Reserve money
Barbados	IFS (1977–2004)	Budgetary central government	IFS	Reserve money
Bolivia	WHD (1995–2005)	General government	IFS	Reserve money
Brazil	IFS (1980–86)/WHD (1987–2005)	General government	IFS	Reserve money
Burundi	IFS (1964–2004)	General government	IFS	Reserve money
Chile	WEO (1988–2005)	General government	IFS	Reserve money
Colombia	WEO (1996–2005)	General government	IFS	Reserve money
Costa Rica	IFS (1966–2002)	Budgetary central government	IFS	Reserve money
Dominica	WHD (1996–2005)	General government	IFS	Reserve money
Dominica Republic	WHD (1989–2005)	General government	IFS	Reserve money
Ecuador	WEO (1979–2005)	General government	IFS	Reserve money
El Salvador	IFS (1962–2000)	Budgetary central government	IFS	Reserve money
Ethiopia	IFS (1971–99)	Budgetary central government	IFS	Reserve money
Fiji	IFS (1962–86)/WEO (1987–2005)	Budgetary central government	IFS	Reserve money
Grenada	WEO (1990–2005)	General government	IFS	Reserve money
Guatemala	WHD (1989–2005)	General government	IFS	Reserve money
Guyana	IFS (1962–97)/WHD (1998–2005)	Budgetary central government	IFS	Reserve money
Honduras	IFS (1962–2004)	Budgetary central government	IFS	Reserve money
India	IFS (1962–2001)	Consolidated central government	IFS	Reserve money
Indonesia	IFS (1972–2001)	Consolidated central government	IFS	Reserve money
Jamaica	Ministry of Finance (1980–2005)	Consolidated central government	IFS	Reserve money
Jordan	IFS (1969–2001)	Budgetary central government	IFS	Reserve money

Haiti	WHD (1991–2005)	General government	IFS	Reserve money
Lebanon	WEO (1990–2005)	General government	IFS	Reserve money
Maldives	IFS (1981–2004)	Consolidated central government	IFS	Reserve money
Malta	IFS (1962–98)	Consolidated central government	IFS	Reserve money
Mauritius	IFS (1972–2003)	Consolidated central government	IFS	Reserve money
Mexico	IFS (1965–2004)	Consolidated central government	IFS	Reserve money
Morocco	IFS (1962–2003)	Consolidated central government	IFS	Reserve money
Nepal	IFS (1974–2003)	Budgetary central government	IFS	Reserve money
Nicaragua	WHD (1962–2005)	General government	IFS	Reserve money
Pakistan	IFS (1962–93)/WEO (1994–2005)	Consolidated central government	IFS	Reserve money
Panama	IFS (1962–2003)	Consolidated central government	WEO	Broad money
Papua New Guinea	IFS (1975–2002)	Consolidated central government	IFS	Reserve money
Paraguay	WHD (1989–2005)	Budgetary central government	IFS	Reserve money
Peru	WHD (1998–2005)	General government	IFS	Reserve money
Philippines	IFS (1962–94)/WEO (1995–2005)	Budgetary central government	IFS	Reserve money
Rwanda	IFS (1976–2003)	Consolidated central government	IFS	Reserve money
Philippines	IFS (1962–94)/WEO (1995–2005)	Budgetary central government	IFS	Reserve money
Rwanda	IFS (1976–2003)	Consolidated central government	IFS	Reserve money
St. Kitts and Nevis	WHD (1993–2005)	General government	IFS	Reserve money
St. Lucia	WHD (1989–2005)	Central government	IFS	Reserve money
Sierra Leone	IFS (1974–2004)	Consolidated central government	IFS	Reserve money
Sri Lanka	IFS (1973–2004)	Budgetary central government	IFS	Reserve money
St. Vincent and the Grenadines	IFS (1986–88)/WHD (1989–2005)	Budgetary central government	IFS	Reserve money
South Africa	WEO (1980–2005)	General government	IFS	Reserve money
Swaziland	IFS (1978–2003)	Budgetary central government	IFS	Reserve money
Thailand	WEO (1996–2005)	General government	IFS	Reserve money
Trinidad and Tobago	IFS (1962–89)/WHD (1990–2005)	Consolidated central government	IFS	Reserve money
Tunisia	IFS (1971–99)	Consolidated central government	IFS	Reserve money
Turkey	IFS (1970–99)/WEO (2000–05)	General government	IFS	Reserve money
Uruguay	IFS (1972–94)/WHD (1995–2005)	Consolidated central government	IFS	Reserve money

[1]IFS refers to government financial statistics in the IMF's International Financial Statistics (IFS) database (line 88). WEO refers to data from IMF's World Economic Outlook database. WHD refers to data from IMF's Western Hemisphere Department, using the broadest definition of government debt in each country.

Further groupings have been made on the basis of the extent of each country's external balance positions and financing sources in line with the World Economic Outlook criteria. Subgroups have also been made on the basis of inflation rates and the size of public debt.

- Developing countries—creditors vs. debtors: If the sum of current account balances over 1972–2005 (1992–2005 for transition economies) is positive, the country is a net creditor; and if the result is negative, the country is a net debtor.
- Debtor developing countries—by financing sources: If the net external borrowing from official creditors[6] are on average over 2001–05 equal or larger than 66 percent of the net external financing,[7] then the country's financing source is official financing. The source is private financing if the ratio is less than 33 percent, and is diversified financing if the ratio is in between.
- High-inflation and low-inflation countries: Countries with average annual inflation higher than the group median rate are high-inflation countries. Those with below median inflation rates are low-inflation countries.
- High-debt and low-debt countries: Countries with average public debt-to-GDP ratios higher than the group median rate are high debt countries and the others low debt countries.

APPENDIX III. DEBT-INFLATION TRAP AND DEBT SUSTAINABILITY

A rise in inflation will eventually push up nominal interest rates, which will in turn increase public debt unless countered by a higher primary surplus. This feedback effect implies that budgetary costs of rising inflation expectations rise more than proportionally to the increase in inflation expectations. This point can be illustrated by simple debt dynamic accounting as follows:

$$\frac{\Delta B_t}{B_t} = R_t - \frac{S_t}{B_t}, \tag{A.10}$$

where B is public debt, R is the interest rate, and S is the primary surplus. If the interest rate is set in line with inflation expectations (π_t^e) and the primary surplus in percent of GDP is predetermined,[8] the debt dynamics can be simplified as follows:

$$\frac{\Delta B_t}{B_t} = (\pi_t^e + r) - \frac{S_t}{Y_t}\Big/\frac{B_t}{Y_t} = (\pi_t^e + r) - C, \tag{A.11}$$

where $C = (S_t/Y_t)/(B_t/Y_t)$. In a steady state of no change in the debt-to-GDP ratio, C is constant. If inflation expectations (π_t^e) rise in a proportion to debt growth ($\Delta B_t/B_t$) in line with our empirical findings, $\pi_t^e = \alpha(\Delta B_t/B_t) + \beta X + \varepsilon$, then $\Delta B_t/B_t = (\beta X + \varepsilon + r - C/1 - \alpha)$.

[6]Official debt securities + liabilities to official creditors + balance on the capital account.

[7]Current account balance − direct investment abroad − reserve assets − portfolio investment assets − other investment assets − errors and omissions.

[8]These are strong, simplified assumptions that hardly hold in reality in the current form since most revenues and expenditures are likely to be affected by contemporaneous inflation and inflation expectations. Persson, Persson, and Svenson (1998) presents, for example, a calibrated model where changes in inflation and inflation expectations affect government revenues and expenditures significantly due to a variety of indexation schemes in tax rules and expenditure arrangements. In their model, changes in inflation expectations do not necessarily lead to simultaneous and equal changes in interest rates.

Hence, an increase in inflation expectations (as embodied in a jump in ε) raises debt not only directly (through an immediate increase in the borrowing cost) but also indirectly (through a multiplier effect resulting from the debt-inflation nexus).

An alternative way of looking at this is to see the implications on the debt-stabilizing levels of the primary surplus (S_t^*). The levels can be represented as follows:

$$\frac{S_t^*}{Y_t} = \left[\frac{R_t B_t}{Y_t} - \frac{B_t}{Y_t}\frac{\Delta Y_t}{Y_t}\right] = \frac{B_t}{Y_t}\left(R_t - \frac{\Delta Y_t}{Y_t}\right)$$

$$= \frac{B_t}{Y_t}((1+\pi_t^e)(1+r) - (1+\pi_t)(1+g_t))$$

$$\approx \frac{B_t}{Y_t}((\pi_t^e - \pi_t) + (r - g_t)). \tag{A.12}$$

Given that inflation expectations, (π_t^e), could rewritten as

$$\pi_t^e = \frac{\beta X + \varepsilon + r}{1-\alpha} - \frac{\alpha C}{1-\alpha}, \tag{A.13}$$

it follows that the debt-stabilizing primary surplus could be rearranged to the following simplified form:

$$\frac{S_t^*}{Y_t} \approx \frac{B_t}{Y_t}(\beta X + \varepsilon + r) + (1-\alpha)\frac{B_t}{Y_t}(-\pi_t + r - g_t). \tag{A.14}$$

This means that rising inflation expectations (as embodied in a jump in ε) would elevate the debt-stabilizing level of the primary surplus more than the same percentage decline in real GDP growth would. Our regression results for the debt-inflation link place α in the range of ¼ (mean group estimator) to ½ (GMM estimator). This implies that the effect of rising inflation expectations could be larger than the effect of a decline in real GDP by as much as one-third to one-half.

REFERENCES

Aiyagari, S., and M. Gertler, 1985, "The Backing of Government Debt and Monetarism," *Journal of Monetary Economics*, Vol. 16, No. 1, pp. 19–44.

Akitoby, Bernardin, B. Clements, S. Gupta, and G. Inchauste, 2004, "The Cyclical and Long-Term Behavior of Government Expenditures in Developing Countries," IMF Working Paper 04/202 (Washington, International Monetary Fund).

Ardagna, Silvia, F. Caselli, and T. Lane, 2004, "Fiscal Discipline and the Cost of Public Debt Service: Some Estimates for OECD Countries," NBER Working Paper 10788 (Cambridge, Massachusetts, National Bureau of Economic Research).

Arellano, Manuel, and Stephen Bond, 1991, "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, Vol. 58, No. 2, pp. 277–97.

Barro, R.J., 1996, "Inflation and Growth," *Federal Reserve Bank of St. Louis Review* (May/June), pp. 153–69.

Blanchard, Olivier, 2004, "Fiscal Dominance and Inflation Targeting: Lessons from Brazil" (unpublished: Cambridge, Massachusetts MIT and National Bureau of Economic Research).

Blundell, Richard, and Stephen Bond, 2000, "GMM Estimation with Persistent Panel Data: An Application to Production Functions," *Taylor and Francis Journals*, Vol. 19, No. 3, pp. 321–40.

Bohn, Henning, 1988, "Why Do We Have Nominal Government Debt?" *Journal of Monetary Economics*, Vol. 21, No. 1, pp. 127–40.

———, 1998, "Behavior of U.S. Public Debt and Deficits," *Quarterly Journal of Economics*, Vol. 113, No. 3, pp. 949–63.

Bond, R. Stephen, 2002, "Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice," *Portuguese Economic Journal*, Vol. 1, No. 2, pp. 141–62.

Breusch, T.S., and A.R. Pagan, 1980, "The Lagrange Multiplier Test and its Application to Model Specification in Econometrics," *Review of Economic Studies*, Vol. 47, No. 1, pp. 239–53.

Buiter, Willem H., 1999, "The Fallacy of the Fiscal Theory of the Price Level," NBER Working Paper 7302 (Cambridge, Massachusetts, National Bureau of Economic Research).

Calvo, Guillermo A., 1988, "Servicing the Public Debt: The Role of Expectations," *American Economic Review*, Vol. 78, No. 4, pp. 647–61.

Canzoneri, M., R. Cumby, and B. Diba, 2001, "Is the Price Level Determined by the Needs of Fiscal Solvency?" *American Economic Review*, Vol. 91, No. 5, pp. 1221–38.

Castro, R., C. De Resende, and F. Ruge-Murcia, 2003, "The Backing of Government Debt and the Price Level," The Centre for Interuniversity Research in Quantitative Economics (CIREQ) Working Paper No. 2003–2022.

Catao, L., and M. Terrones, 2005, "Fiscal Deficits and Inflation," *Journal of Monetary Economics*, Vol. 52, No. 3, pp. 529–54.

Christiano, L., and T. Fitzgerald, 2000, "Understanding the Fiscal Theory of the Price Level," NBER Working Paper 7668 (Cambridge, Massachusetts, National Bureau of Economic Research).

———, 2003, "Inflation and Monetary Policy in the Twentieth Century," *Economic Perspectives, Federal Reserve Bank of Chicago*, Vol. 27, No. 1, pp. 22–45.

Cochrane, J.H., 2001, "Long-Term Debt and Optimal Policy in the Fiscal Theory of the Price Level," *Econometrica*, Vol. 69, No. 1, pp. 69–16.

———, 2005, "Money as Stock," *Journal of Monetary Economics*, Vol. 52, No. 3, pp. 501–28.

Duck, W. Nigel, 1993, "Some International Evidence on the Quantity Theory of Money," *Journal of Money, Credit and Banking*, Vol. 25, No. 1, pp 1–2.

Dwyer Jr., Gerald P., 1982, "Inflation and Government Deficits," *Economic Inquiry*, Vol. 20 (July), pp. 315–29.

Elmendorf, Douglas W., 1993, "Actual Budget Deficit Expectations and Interest Rates," Harvard Institute of Economic Research, Discussion Paper No. 1639.

———, and N. Gregory Mankiw, 1999, "Government Debt," In *Handbook of Macroeconomics*, Vol. 1, ed. by J.B. Taylor and M. Woodford (Amsterdam, Elsevier Science).

Engen, Eric, and G. Glenn Hubbard, 2004, "Federal Government Debts and Interest Rates," NBER Working Paper 10681 (Cambridge, Massachusetts, National Bureau of Economic Research).

Evans, Paul, 1987a, "Do Budget Deficits Raise Nominal Interest Rates? Evidence from Six Countries," *Journal of Monetary Economics*, Vol. 20, No. 2, pp. 281–300.

———, 1987b, "Interest Rates and Expected Future Budget Deficits in the United States," *Journal of Political Economy*, Vol. 95, No. 1, pp. 34–58.

Favero, Carlo A., and Francesco Giavazzi, 2004, "Inflation Targeting and Debt: Lessons from Brazil," NBER Working Paper 10390 (Cambridge, Massachusetts, National Bureau of Economic Research).

———, and Franco Spinelli, 1999, "Deficits, Money Growth and Inflation in Italy: 1875–1994," *Economic Notes by Banca Monte dei Paschi di Siena SpA*, Vol. 28, No. 1, pp. 43–71.

Feldstein, Marin, 1986, "Budget Deficits, Tax Rules and Real Interest Rates," NBER Working Paper 1970 (Cambridge, Massachusetts, National Bureau of Economic Research).

Fischer, Stanley, R. Sahay, and C. Vegh, 2002, "Modern Hyper- and High inflations," *Journal of Economic Literature*, Vol. 40, No. 3 (September), pp. 837–80.

Ghosh, A., A.M. Gulde, J.D. Ostry, and H. Wolf, 1997, "Does the Nominal Exchange Rate Regime Matter?," NBER Working Paper 5874 (Cambridge, Massachusetts, National Bureau of Economic Research).

———, and Stephen Phillips, 1998, "Warning: Inflation May be Harmful to Your Growth," *IMF Staff Paper*, Vol. 45, No. 4, pp. 672–710.

Gordon, D., and E. Leeper, 2002, "The Price Level, The Quantity Theory of Money, and The Fiscal Theory of the Price Level," NBER Working Paper 9084 (Cambridge, Massachusetts, National Bureau of Economic Research).

Hendry, David F., Adrian R. Pagan, and J. Denis Sargan, 1984, "Dynamic Specification," In *Handbook of Econometrics*, Vol. II, ed. by Z. Grilliches and M.D. Intriligator (Amsterdam, Elsevier Science).

International Monetary Fund, 2003, "Public Debt in Emerging Markets: Is It Too High?," Chapter XX. In *World Economic Outlook* (Washington, International Monetary Fund, September).

———, 2005, "Statistical Appendix," *World Economic Outlook* (Washington: International Monetary Fund, April).

Jácome, Luis I., and Francisco Vázquez, 2005, "Any Link Between Central Bank Independence and Inflation? Evidence from Latin America and the Caribbean," IMF Working Paper 05/75 (Washington, International Monetary Fund).

Judson, Ruth A., and Ann L. Owen, (1999), "Estimating Dynamic Panel Data Models: A Guide for Macroeconomists," *Economics Letters*, Vol. 65, No. 1, pp. 9–15.

Kaminsky, Graciela L., Carmen M. Reinhart, and Carol Vegh, 2004, "When it Rains, It Pours: Procyclical Capital Flows and Macroeconomic Policies," NBER Working Paper 10780 (Cambridge, Massachusetts, National Bureau of Economic Research).

Kiviet, Jan F., 1995, "On Bias, Inconsistency, and Efficiency of Various Estimators in Dynamic Panel Models," *Journal of Econometrics*, Vol. 68, No. 1, pp. 53–78.

Leeper, M. Eric, and Tack Yun, 2006, "Monetary-Fiscal Policy Integration and the Price Level: Background and Beyond," *International Tax and Public Finance*, Vol. 13, No. 4, pp. 373–409.

Loyo, Eduardo, 1999, "Tight Money Paradox on the Loose: A Fiscalist Hyperinflation," (unpublished; Cambridge, Massachusetts, Harvard University).

Lucas, Robert E., 1980, "Two Illustrations of the Quantity Theory of Money," *American Economic Review*, Vol. 70 (September), pp. 1005–14.

Mélitz, Jacques, 1997, "Some Cross-Country Evidence About Debt, Deficits and the Behavior of Monetary and Fiscal Authorities," CEPR Discussion Paper Series 1653 (London, Centre for Economic Policy Research).

Niepelt, Dirk, 2004, "The Fiscal Myth of the Price Level," *Quarterly Journal of Economics*, Vol. 119 (February), pp. 277–300.

Orr, Adrian, Malcolm Edey, and Michael Kennedy, 1995, "Real Long-Term Interest Rates: The Evidence from Pooled Time-Series," OECD Economic Studies No. 25, pp. 75–107.

Pedroni, Peter, 1999, "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors," *Oxford Bulletin of Economics and Statistics*, Special Issue, Vol. 61, pp. 653–70.

———, 2000, "Fully Modified OLS for Heterogeneous Cointegrated Panels," In *Advances in Econometrics, Nonstationary Panels, Panel Cointegration and Dynamic Panels*, Vol. 15, ed. by B. Baltagi and C. Kao (New York, Elsevier Science), pp. 93–130.

Persson, Mats, Torsten Persson, and Lars E.O. Svenson, 1998, "Debt, Cash Flow and Inflation Incentives: A Swedish Example," in *The Debt Burden and Its Consequences for Monetary Policy*, ed. by Guillermo Calvo and Mervyn King (London, Palgrave Macmillan).

Pesaran, M. Hashem, and Ron Smith, 1995, "Estimating Long-Run Relationships from Dynamic Heterogeneous Panels," *Journal of Econometrics*, Vol. 68, No. 1, pp. 79–13.

Posen, Adam S., 1995, "Declarations Are Not Enough: Financial Sector Sources of Central Bank Independence," In *NBER Macroeconomics Annual, 1995*, ed. by Ben Bernanke and Julio Rotemberg (Cambridge, Massachusetts, National Bureau of Economic Research).

Reinhart, Carmen M., and Kenneth Rogoff, 2004, "The Modern History of Exchange Rate Arrangements: A Reinterpretation," *Quarterly Journal of Economics*, Vol. 119 (February), pp. 1–48.

Rubin, Robert E., and Jacob Weisberg, 2003, *In an Uncertain World: Tough Choices from Wall Street to Washington* (New York, Random House).

Sargent, T.J., 1982, "Beyond Demand and Supply Curves in Macroeconomics," *American Economic Review*, Vol. 72, No. 2, pp. 382–9.

———, and N. Wallace, 1981, "Some Unpleasant Monetary Arithmetic," *Quarterly Review* (Fall), Federal Reserve Bank of Minneapolis, pp. 1–17.

Schwartz, Anna J., 1973, "Secular Price Change in Historical Perspective," *Journal of Money, Credit and Banking*, Vol. 5 (February), pp. 243–69.

Sims, C., 1994, "A Simple Model for Study of the Price Level and the Interaction of Monetary and Fiscal Policy," *Economic Theory*, Vol. 4, No. 3, pp. 381–99.

Singh, Anoop, and others 2005, *Stabilization and Reform in Latin America: A Macroeconomic Perspective on the Experience since the Early 1990s*, IMF Occasional Paper 238 (Washington, International Monetary Fund).

Smith, R. Todd, and Henry van Egteren, 2005, "Inflation, Investment and Economic Performance: The Role of Internal Financing," *European Economic Review*, Vol. 49, No. 5, pp. 1283–303.

Stock, James H., Jonathan H. Wright, and Motohiro Yogo, 2002, "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments," *Journal of Business & Economic Statistics*, Vol. 20, No. 4, pp 518–29.

Vogel, Robert C., 1974, "The Dynamics of Inflation in Latin America, 1950–1969," *American Economic Review*, Vol. 64 (March), pp. 102–14.

Woodford, M., 1994, "Monetary Policy and Price Level Determined in a Cash-in-Advance Economy," *Economic Theory*, Vol. 4, No. 3, pp. 345–80.