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DOES INFLATION MATTER FOR GROWTH?

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ABSTRACT

Does Inflation Matter for Growth?*

Some channels through which increased inflation tends to reduce economic growth, and *vice versa*, are studied within a simple model incorporating money into an optimal growth framework with constant returns to capital. The model includes the potential impact of inflation on: (a) saving through real interest rates (or uncertainty); (b) the income velocity of money; (c) the government budget deficit through the inflation tax and tax erosion; and (d) efficiency in production through the wedge between the returns to real and financial capital. The effect of inflation on growth is estimated using the random-effects panel model applied to two sets of unbalanced panel data side-by-side, from the Penn World Tables and from the World Bank, covering 170 countries from 1960 to 1993. The cross-country links between inflation and growth are economically and statistically significant and robust.

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NON-TECHNICAL SUMMARY

Economists have long had reason to wonder whether inflation is generally conducive or detrimental to economic growth. Various arguments have been put forward on both sides, not least in the ongoing debate among development economists on the long-term development of Latin America. In this debate, which was particularly vivid in the 1960s, monetarists generally considered price stability a prerequisite for economic growth. They maintained that governments should therefore enforce monetary discipline to eliminate inflation, thus creating conditions for rapid growth. Structuralists, on the other hand, contended that in economies with major supply bottlenecks and weak export markets, attempts to achieve price stability through monetary or fiscal restraint would result in unemployment, underutilization of capacity, and slow growth.

For a long time, historical and comparative studies did not provide clear empirical conclusions about the relationship between inflation and growth in Latin America or elsewhere. Over the past decade, however, the contours of an inverse connection between inflation and growth across countries have begun to emerge from econometric studies.

The wide variety of patterns of inflation and growth reported in empirical studies up until the mid-1980s is not surprising. Monotonic bivariate relationships among real magnitudes are hard to find in macroeconomics. Any bivariate relationship must depend on the concurrent position or movement of other relevant variables. Therefore, virtually any economic theory or empirical observation of an inverse relationship between two real macroeconomic variables can be challenged by an alternative theory or observation of a direct link between the two variables, and *vice versa*. So, it is no wonder that economists failed for so long to identify an unambiguous relationship between inflation and growth in the short run or the long run. It was not until the advent of the theory of endogenous growth in the mid-1980s that economists began to specify empirical growth models in a way which made it possible to isolate the analytical and empirical links between inflation and growth. Even so, the long-run properties of some endogenous growth models can be interpreted as, and may even be empirically indistinguishable from, the medium-term properties of the neoclassical growth model.

The purpose of this study is to present a simple model of the simultaneous determination and interaction of inflation and growth and to estimate the growth part of the model. The model is constructed by incorporating money

into an optimal growth framework with increasing returns to scale. Several channels through which increased inflation tends to reduce growth and declining growth tends to amplify inflation are discussed. Special attention is paid to the potential impact of inflation on: (a) saving through real interest rates (or uncertainty); (b) the income velocity of money; (c) the government budget deficit through the inflation tax and tax erosion; and (d) efficiency through the wedge between the returns to real and financial capital. Numerical analysis of the model indicates that, although a wide variety of outcomes is possible, inflation and growth tend: (a) to be negatively correlated for reasonable values and constellations of the structural parameters of the model; and (b) to vary inversely with one another in response to changes in individual parameters. In particular, budget deficits, through their interplay with inflation, saving behaviour, portfolio choice, and taxes, tend to deter growth in the long run.

A growth equation derived from the model is tested by incorporating inflation into the standard Barrovian growth framework. Our specification is estimated with panel data constructed from the Penn World Tables (where the growth figures are derived from purchasing-power-parity-adjusted output figures) and from the World Data Bank (where the growth figures are unadjusted). This gives us the largest possible number of observations (countries) with which to test our hypothesis. The method also enables us to exploit both the time-series and cross-sectional properties of the data.

The effect of inflation on growth is significant and sizeable both in the panel regressions based on the World Data Bank and in those based on the Penn World Tables. From 1960 to 1993, increased inflation tended to retard growth in a large group of countries at all income levels, both across countries and over time. The link between inflation and growth appears fairly strong, both statistically and economically: an increase in inflation from 5% to 50% a year from one country or time to another reduces the rate of growth of GDP per capita by 0.6% to 1.3% a year according to our benchmark regressions, other things being equal. The link is non-linear: growth is relatively more sensitive to an increase in inflation by, say, 45 percentage points a year at low than at high rates of inflation. The link also seems quite robust: it survives the stepwise introduction of several further conditioning variables including: (a) initial income (to capture the catch-up effect, or convergence); (b) investment (unadjusted for quality); (c) human capital (as measured by primary- and secondary-school enrolment); (d) primary exports (to capture the inefficiency caused by rent seeking, the Dutch disease, and perhaps also by the spillover effects of low technology and low-skilled labour in some primary-export industries, e.g. agriculture in developing countries); and (e) a dummy variable for Africa.

1 Introduction

Economists have long had reason to wonder whether inflation is generally conducive or detrimental to economic growth. Various arguments have been put forward on both sides, not least in the ongoing debate among development economists on the long-term development of Latin America. In this debate, which was particularly vivid in the 1960s, monetarists generally considered price stability a prerequisite for economic growth. They maintained that governments should therefore enforce monetary discipline to eliminate inflation, thus creating conditions for rapid growth. Structuralists, on the other hand, contended that in economies with major supply bottlenecks and weak export markets, attempts to achieve price stability through monetary or fiscal restraint would result in unemployment, underutilization of capacity, and slow growth (Ruggles, 1964).

For a long time, historical and comparative studies did not provide clear empirical conclusions about the relationship between inflation and growth in Latin America or elsewhere (Johnson, 1969). The economy of the United States, for example, has grown relatively rapidly and slowly in periods of both inflation and deflation (Friedman and Schwartz, 1963). So have most other economies. In one of the earliest cross-country studies of inflation and growth, Thirlwall and Barton (1971) report a positive relationship between low inflation (i.e., below 8 per cent per year) and growth (unadjusted for population change) in a cross section of 17 industrial countries during 1958-1967, and a negative relationship between high inflation (i.e., above 10 per cent per year) and growth in a cross section of 7 developing countries over the same period.

Over the past decade, however, the contours of an inverse connection between inflation and growth across countries have begun to emerge from econometric studies. In an article published only in German, Heitger (1985) reports a significantly positive relationship between the rate and variability of inflation and a significantly negative relationship between inflation variability and economic growth, inferring that inflation was detrimental to growth in a large cross section of industrial and developing countries during 1950-1980. Specifically, Heitger's results indicate that a 1 per cent increase in the annual average inflation rate is associated with a 0.02 per cent to 0.1 per cent decrease in the annual average rate of growth, *ceteris paribus*. Barro (1990a) reports a negative but weak relationship between inflation and the growth rate of real per capita gross domestic product (GDP) during 1970-1985 in a cross section of 117 countries. Even so. he finds a significantly negative relationship between the intensification of inflation (from 1960-1970 to 1970-1985) and growth,[1] as do Kormendi and Meguire (1985) in a cross section of 47 countries during 1950-1977. Using time series for 21 countries over 27 years. Grimes (1991) reports that an annual inflation rate of about 9 per cent reduces the annual rate of economic growth in each country by around 1 per cent on average.

Applying nonparametric methods to small samples. Gylfason (1991) shows that economies with high inflation (i.e.. 20 per cent or more per year) grew significantly less rapidly on average than economies with low inflation (i.e.. below 5 per cent per year) during 1980-1985. Similarly, Bruno and Easterly (1995) report that inflation rates above 40 per cent a year are generally harmful to growth.

According to Cukierman *et al.*(1993). increased central bank independence is associated with less inflation and more growth in developing countries. but only with less inflation in industrial countries. Here we have an example of a variable. central bank independence. that is associated with movements of inflation and growth in opposite directions, at least in developing countries.

Fischer's (1991,1993) cross-section regression estimates based *inter alia* on the Penn World data compiled by Summers and Heston (1993), from 1960 to 1989, indicate that an increase in inflation from, say, 5 per cent to 50 per cent a year from one country to another reduces the growth of GDP by 1.8 per cent per year. other things being equal. By the same token. Gylfason's (1996b) results based on cross-section data from the World Bank during 1985-1994 indicate that an increase in inflation from 5 per cent to 50 per cent a year from one country to another reduces the growth of GDP per head by 2.4 per cent per year. *ceteris paribus.* Based on data for 100 countries from 1960 to 1990. Barro (1995) reports that an increase in average inflation of 10 per cent a year reduces per capita growth by 0.2 per cent to 0.3 per cent a year, *ceteris paribus.* This means that an increase in inflation from 5 per cent to 50 per cent a year would then reduce per capita growth by 1 per cent to 1.5 per cent per year. An increase in inflation by 1 per cent a year reduces productivity growth in the United States by 0.03 per cent a year according to Motley (1994), and by 0.25 per cent a year according to Taylor (1996). Thus,

[1] See also Barro and Sala-i-Martin (1995, Chapter 12) for an overview of empirical results on the determinants of growth.

by linear extrapolation, an increase in inflation from 5 per cent to 50 per cent per year reduces growth by 1.4 per cent and 11.2 per cent, respectively, according to the two studies. Davis and Kanago (1996) find that an increase in inflation uncertainty reduces growth, but only temporarily. Garrison and Lee (1995) find no evidence that high inflation reduces growth.

Using panel data from twelve Latin American countries from 1950 to 1985, De Gregorio (1992a, 1992b, 1993) finds a semielasticity of per capita growth with respect to average inflation equal to -0.008. This means that an increase in annual inflation from 5 per cent to 50 per cent from one country to another reduces per capita growth by 0.7 per cent per year, *ceteris paribus*. Roubini and Sala-i-Martin (1992) use data from 98 countries from 1960 to 1985 and find that an increase in annual inflation from 5 per cent to 50 per cent from one country to another reduces per capita growth by 2.2 per cent per year, *ceteris paribus*. Fischer *et al.* (1996: Figure 4) report a strong inverse correlation between inflation and growth in 26 transition economies during 1992-1994. Their results imply that an increase in inflation from 5 per cent to 50 per cent per year from one country to another reduces growth by 34 per cent per year, but this presumably reflects short-run transitional dynamics rather than long-run linkages between inflation and growth.

The empirical results reviewed above are summarized in Table 1.

<Table 1. Inflation and Growth: Overview of Empirical Studies>

The wide variety of patterns of inflation and growth reported in empirical studies until the mid-1980s is not surprising. Monotonic bivariate relationships among (stationary) real magnitudes are hard to find in macroeconomics. Any bivariate relationship, static or dynamic, must depend on the concurrent position or movement of other relevant variables. Therefore, virtually any economic theory or empirical observation of an inverse relationship between two real macroeconomic variables can be challenged by an alternative theory or observation of a direct link between the two variables, and *vice versa*. So, it is no wonder that economists failed so long to identify an unambiguous relationship between inflation and growth in the short run or the long run.

Figure 1 shows the average rates of inflation and growth of real gross domestic product (GDP) per capita from 1960 to 1993 for all countries included in the Penn World Tables (upper panel) and all those reporting to the World Bank (lower panel). The figure illustrates the complete absence of a clear relationship between inflation and growth across countries. It was not until the advent of the theory of endogenous growth in the mid-1980s (Romer, 1986) that economists began to specify empirical growth models in a way which made it possible to isolate the analytical and empirical links between inflation and growth. Even so, the long-run properties of some endogenous growth models can be interpreted as, and may even be empirically indistinguishable from, the medium-term properties of the neoclassical growth model (Solow, 1956).

<Fig. 1. Average Inflation and Growth of GDP Per Capita, 1960-1993>

The purpose of this paper is to present a simple model of the simultaneous determination and interaction of inflation and growth and to estimate the growth part of the model. The model is constructed by incorporating money into an optimal growth framework with increasing returns to scale. Several channels through which increased inflation tends to reduce growth and declining growth tends to amplify inflation are discussed. Special attention is paid to the potential impact of inflation (a) on saving through real interest rates (or uncertainty), (b) on the income velocity of money, (c) on the government budget deficit through the inflation tax and tax erosion, and (d) on efficiency through the wedge between the returns to real and financial capital. Numerical analysis of the model indicates that, although a wide variety of outcomes is possible, inflation and growth tend (a) to be negatively correlated for reasonable values and constellations of the structural parameters of the model, and (b) to vary inversely with one another in response to changes in individual parameters. In particular, budget deficits, through their interplay with inflation, saving behavior, portfolio choice, and taxes, tend to deter growth in the long run. This result, which appears also in Alogoskoufis and van der Ploeg (1994) in a model of endogenous growth with overlapping generations, differs from the results of earlier models of money and growth following Tobin (1965), where increased monetary expansion can raise the capital/output ratio and the level of output per head in the long run, but not its rate of growth.

A growth equation derived from the model is tested by the random-effects panel model by incorporating inflation (as in Fischer, 1991, 1993) and raw-material exports (as in Sachs and Warner, 1995a, 1995b) into the standard Barrovian growth framework. Our specification is estimated with unbalanced panel data constructed from the Penn World Tables (where the growth figures are derived from purchasing-power-parity-adjusted output figures) and from the World Data Bank (where the growth figures are unadjusted). This gives us the largest possible number of observations (countries) with which to test our hypothesis. The method also enables us to exploit both the time-series and cross-sectional properties of the data. To rule out simultaneity bias, we test for exogeneity of regressors. To avoid biasing the results towards rapid convergence rates, which is often the case when using fixed-effects panel models, we employ the random-effects model, see Nerlove (1996).

The paper proceeds as follows. Section 2 lays out the theoretical framework. Section 3 reports the results of the regression analysis. Section 4 provides a summary and a brief discussion of the main findings.

2 Theoretical Framework

2.1 Production

Aggregate output Y depends on labor N, real money balances M/P, and capital K, through an extended Cobb-Douglas production function:

$$Y = AN^{\alpha}\left(M/P\right)^{\beta} K^{1-\alpha-\beta}, \tag{1}$$

M is the supply of money. P is the general price level. A is a technological shift parameter, and α, β, and $1-\alpha-\beta$ are the elasticities of output with respect to labor, real balances, and capital. Money is included in the production function on the grounds that holding real balances enables firms to economize on the use of other inputs and that it can be expensive for firms to be short of cash (Fischer, 1974; Gylfason, 1996a). Further, we assume capital-embodied technology and spillovers (externalities) across firms in the form of $A = BK^{\alpha}$ for the economy as a whole, so that $Y = BN^{\alpha}(M/P)^{\beta}K^{1-\beta}$. This implies increasing returns to scale and constant returns to real money balances and capital broadly defined (Romer, 1986; Lucas, 1988; Rebelo, 1991). The parameter B reflects the intensity of factor use (e.g., the number of hours machines are kept running per day). The aggregate production function is thus:

$$Y = EK, \tag{2}$$

where:

$$E = B^{\frac{1}{1-\beta}} N^{\frac{\alpha}{1-\beta}} v^{-\frac{\beta}{1-\beta}}. \quad (3)$$

and $v = Y/(M/P)$ is the velocity of money. E represents the efficiency of real capital, and is simply the inverse of the capital/output ratio. By increasing velocity, increased inflation reduces efficiency as long as money plays a role in the production function ($\beta > 0$), other things being equal.

To maximize profits, firms equate their marginal product of capital $(1 - \alpha - \beta)E$ to the real interest rate r. In their calculation, the firms thus do not take the technological spillovers into account. Similarly, profit maximization requires equality between the marginal product of money βv and the nominal interest rate $r + \pi$, where π is the rate of inflation (and also between the marginal product of labor and the real wage).[2] As long as N and v are constant in equilibrium, output is proportional to the capital stock. Therefore, Y and K must grow at the same endogenously determined rate, which can be positive even if the labor force is fixed by assumption.[3] With increasing returns to scale and constant returns to money and capital, the capital/output ratio does not adjust automatically to ensure equality between the rates of growth of output and the labor force in the long run (with or without labor-augmenting technological progress), as it does in the neoclassical model with constant returns to scale and decreasing returns to capital (Solow, 1956). The deactivation of this dynamic, neoclassical adjustment mechanism is the key to endogenous growth in this framework.[4]

With the automatic adjustment mechanism of neoclassical growth theory out of commission, the literature on endogenous growth has been concerned thus far mostly with the determination of the (broad) capital/output ratio, i.e., efficiency, and its implications for growth.[5] The present model constitutes an attempt to introduce money and inflation into the story in a way that illuminates the effects of monetary and fiscal policy, private saving, and portfolio choice on both inflation and growth in the long run. In contrast

[2]These two first-order conditions together produce a Fisher-Mundell effect: when inflation goes up, velocity also increases, so that efficiency decreases by equation (3) and the real interest rate goes down (Fisher, 1930; Mundell, 1963).

[3]If the labor force grows at an annual rate n, the capital stock depreciates at rate δ, and technology progresses at rate γ, then $g_Y = g_K - \delta + (\alpha n + \gamma)/(1 - \beta)$, where g_Y and g_K are the growth rates of Y and K for given v.

[4]See Romer (1989, 1994), Stern (1991), and Barro and Sala-i-Martin (1995) for reviews of recent developments in growth theory.

[5]See, for example, Romer (1986), Lucas (1988), and Barro (1990b).

to De Gregorio (1992a), where inflation affects growth through investment and its productivity, and Roubini and Sala-i-Martin (1992), where financial repression provides the link between inflation and growth, the link is established here by combining the quantity theory of money and portfolio choice with an optimal growth model that includes money.

2.2 Money and Finance

General macroeconomic equilibrium requires equality between money supply and money demand: $M/P = Y/v$, where M is money supply, P is the price level, Y is real GNP, and v is the velocity of money as before. If the optimal ratio of real money balances to real wealth, $(M/P)/[(M/P)+K]$, is denoted by h (Tobin, 1958), then the corresponding optimal velocity of money is $v = (1-h)E/h$.[6] Hence, if increased inflation reduces money demand[7] so that h falls, then v rises for given E. If h and E are both constant in equilibrium so that v is also constant, the Fisher equation $M/P = Y/v$ can be expressed in rates of change:

$$\pi = m - g. \tag{4}$$

π is the rate of inflation, m is the rate of monetary expansion, and g is the growth of GNP (and also of GNP per capita, because the labor force is held fixed).

If the government finances its budget deficit by printing money, the rate of monetary expansion equals the multiple of velocity and the ratio of the deficit to GNP, d:

$$m = vd. \tag{5}$$

The deficit/GNP ratio can be written as $d = c - \pi/v$, where c is an exogenous component (i.e., government spending less direct and indirect taxes divided by GNP) and π/v represents inflation tax revenue as a proportion

[6] Notice that by substituting $v = (1-h)E/h$ into equation (3) we get the following expression for efficiency: $E = BN^{\alpha}\left((1-h)/h\right)^{-\beta}$. This implies an inverse relationship between inflation and efficiency through h, for given B and N.

[7] A negative relationship between money demand and inflation follows from the condition for profit maximization stated in the text: $\beta v = r + \pi$. See Fisher (1930) and Mundell (1963).

of GNP. Thus. $m = vc - \pi$. This gives the following inverse relationship between inflation and growth:

$$\pi = \frac{vc - g}{2}. \tag{6}$$

This equation is represented by the MM schedule in Figure 2.

<Fig. 2. Inflation and Growth in Reduced Form>

The MM schedule slopes downwards. because increased growth reduces inflation for given v and c, but the reduction of inflation is checked by the increased budget deficit through the inflation-tax-revenue shortfall. An exogenous increase either in the deficit or in velocity shifts the MM schedule to the right. thus raising the rate of inflation (or growth) compatible with any given rate of growth (or inflation).[8]

2.3 Consumption and Saving

Consumers choose a path of consumption C_t that maximizes their utility U_t over time. Specifically. they maximize the utility integral: $\int_0^\infty U_t\left(C_t\right) e^{-\rho t} dt$. where ρ is the discount rate, subject to the constraint that accumulated real capital equals output less consumption: $\Delta K = Y - C = EK - C$: see equation (2). If the utility function is isoelastic. $U_t = (C_t^{1-\theta} - 1)/(1 - \theta)$. where θ is the inverse of the absolute value of the constant elasticity of marginal utility with respect to consumption. the solution to this maximization problem is the Ramsey rule:

$$g = \frac{1}{\theta}\left(E - \rho\right). \tag{7}$$

Here g is the rate of growth of consumption and. therefore. also of output and capital along the optimal consumption path.[9] The above solution for the

[8] If the inflation tax is not included in the analysis. equation (5) simplifies to $\pi = vd - g$ by equations (3) and (4). The MM schedule becomes steeper than shown in Figure 2 (its slope changes from -1/2 to -1). but it retains the qualitative properties described in the text.

[9] If money is included in the utility function so that $U_t = \left[C_t^\lambda (M_t/P_t)^\mu\right]^{1-\theta}/(1 - \theta)$ where $\lambda + \mu < 1$ as in Fischer (1979). then the optimal rate of growth of consumption. real balances. capital. and output is $g = (E - \rho)/\theta[(\lambda + \mu)(1 - \frac{1}{\theta}) + \frac{1}{\theta}]$. which is larger than the growth rate shown in the text as long as $\theta > 0$ and $\lambda + \mu < 1$. Without money in the utility function (i.e., with $\lambda = 1$ and $\mu = 0$), the above expression for optimal growth simplifies to the one shown in the text. See also Sidrauski (1967).

optimal rate of growth can be transformed into the multiple of the saving rate s and efficiency E. adjusted for real monetary expansion (Tobin, 1965, and Sidrauski. 1967):

$$g = [s - (1 - s)\psi]\, E. \tag{8}$$

where $\psi = \frac{m-\pi}{v}$. This equation is derived by writing the flow of real saving S first as the sum of the accumulated stocks of real capital ΔK and real money balances $\Delta(M/P) = (M/P)(m-\pi)$ and then as a fraction s of income including accumulated real money balances. that is, $Y + (M/P)(m - \pi)$.[10] This yields the following expression for the optimal propensity to save:[11]

$$s = \frac{S/Y}{1+\psi} = \frac{g/E + \psi}{1+\psi}. \tag{9}$$

Hence. after some manipulation:

$$s = \frac{(E-\rho)\,(E-v)}{(E-\rho)\,E - \theta v E}, \tag{10}$$

by equations (4) and (7). Therefore, the optimal saving rate is constant for given v, E, ρ. and θ.[12]

If increased inflation reduces money demand and thus raises v for given Y. then s must fall for given E, ρ. and θ, because $ds/dv = -g(1-g/E)/(v+g)^2 < 0$ as long as $0 < g < E$. Quantitatively, however, this link turns out to be weak. as can be confirmed by substituting the values of g, E, and v used in Section 2.5 into the expression for ds/dv above. A potentially more important inverse relation between inflation and saving can be derived (a) by noticing that $ds/dE = (v/E)[g(1 - g/E) + (1 + v/E)\rho\frac{1}{\theta}]/(v + g)^2$, which is positive at least as long as $0 < g < E$; (b) by remembering that profit maximization requires the real rate of interest r to be proportional to the efficiency of capital E: and (c) by assuming that the nominal interest rate does not adjust fully to changes in the rate of inflation (as, e.g., in Fisher,

[10] Equation (8) can also be derived by assuming a fixed saving rate without explicit intertemporal optimization (as in Solow (1956) and Sidrauski (1967), for example). See Sandmo (1968) and Dornbusch and Frenkel (1973) for expositions of money and growth.

[11] Notice that $s < 1$ as long as $g < E$.

[12] A fixed saving rate s can also be derived from the standard intertemporal optimization model within the neoclassical constant-returns-to-scale framework without money by assuming that $\frac{1}{\theta} = s$ and $\rho = 1 - \alpha - s$, where $1 - \alpha$ is the elasticity of output with respect to capital if $\beta = 0$ as in the text. See Kurz (1968).

1930. and Mundell. 1963). Hence. increased inflation lowers the real interest rate. reduces efficiency. and reduces the saving rate independently of the elasticity of intertemporal substitution (more on this below).

Substituting $m = vc - \pi$ into equation (8) gives the following positive relationship between inflation and growth for given v. c. s. and E:

$$g = sE - (1-s)\,cE + \left(\frac{2(1-s)E}{v}\right)\pi. \tag{11}$$

This equation is illustrated by the SS schedule in Figure 2. The SS schedule slopes up, because increased inflation reduces real monetary expansion for given nominal money growth (see equation (8)), and hence increases the rate of growth of output for given v. c. s. and E by equation (11). In anticipation of the numerical analysis presented below. the SS schedule is steep in the figure. An increased budget deficit shifts the SS schedule to the left without affecting its slope, thus increasing inflation for given growth. An increase in velocity increases the slope of the SS schedule without affecting its position, thus reducing the rate of growth that is consistent with any given rate of inflation. An increase in the saving rate shifts the SS schedule to the right and raises its slope. thus increasing the rate of growth that is consistent with low inflation and decreasing the rate of growth that is consistent with high inflation. At last, an increase in efficiency reduces the slope of the SS schedule. but has an ambiguous effect on its position. As an empirical matter. however. an increase in E is likely to shift the SS schedule to the right, because $s > (1-s)c$ for most reasonable values of s and c (see below). thus reducing the rate of growth that is compatible with any given rate of inflation.

2.4 Inflation and Growth

The simultaneous determination of the rates of inflation and growth is described by the intersection of the two lines, SS and MM, in Figure 2. The corresponding reduced-form solutions for inflation and growth are nonlinear functions of the structural parameters of the model:

$$\pi = \frac{1}{2}\left(vc - \frac{sE}{1+\left(\frac{1-s}{v}\right)E}\right), \tag{12}$$

$$g = \frac{sE}{1 + \left(\frac{1-s}{v}\right) E}. \tag{13}$$

Equation (13) follows directly from equations (4) and (8) and equation (12) is obtained by substituting equation (13) into equation (6). Equation (13) can also be derived directly from equation (2) and the expression for real saving: $S = \Delta K + (m - \pi)(M/P) = s[Y + (m - \pi)(M/P)]$ that was used in the derivation of equation (8). The qualitative comparative-statics properties of the model are summarized in Table 2.

TABLE 2. Effects of Exogenous Increases in v, c, s, and E on Inflation and Growth

	v	c	s	E
π	+	+	−	−
g	+	0	+	+

An increase in the autonomous components of the saving rate in efficiency stimulates growth and slows inflation down, *ceteris paribus*,[13] whereas an increase in the autonomous component of velocity increases both inflation and growth; the link between velocity and growth stems from the Tobin effect introduced in equation (8). Insofar as the government budget deficit is financed through foreign borrowing, increased external indebtedness (i.e., an increase in the autonomous part of c) results in higher inflation without raising growth as long as saving behavior and portfolio choice are impervious to increased borrowing. Therefore, inflation and growth can be positively or negatively correlated, or uncorrelated, depending on the changes in the underlying exogenous parameters of the model. Any observed pattern of inflation and growth must be the consequence of changes in their underlying determinants, including the parameters of the present model, which is compatible with a wide variety of such patterns.

The regression estimates presented in Section 3 are based on equation (13).

[13]Because the optimal saving rate depends on both v and E, *inter alia*, as shown in equation (10), other parameters of the model are implicitly assumed to change to make it possible for s to change for given v and E, and so on.

2.5 Numerical Analysis

Before turning to the econometric analysis, a numerical calibration of the model may illuminate its properties further. The structural parameters of the model can all be quantified. Therefore, it is possible to test the sensitivity of the equilibrium solution for the rates of inflation and growth to realistic variations in the parameters. To conserve space, we restrict our attention to the pattern of inflation and growth resulting from exogenous, mutually independent variations in the parameters, without considering the implications of endogenous, mutually interdependent parameter variations.

Structural parameters. The unweighted world average income velocity of money, defined as nominal GNP divided by money holdings broadly defined (M_2), was 3.6 in 1994 (see World Bank, 1996, Table 2). Accordingly, we set $v = 3.6$ to start with. The overall central government deficit amounted to 3 per cent of GNP on average in all reporting countries in 1994 (World Bank, 1996, Table 2). We set $c = 0.03$ initially.[14] A broader measure of the government budget deficit would be preferable for the purpose at hand, but internationally comparable figures on consolidated public-sector deficits are not available. The gross domestic saving rate was 0.16 on average in 1994 (World Bank, 1996, Table 13). We set $s = 0.16$ initially. Finally, the ratio of gross domestic investment to GDP was 0.21 on average in 1994 (World Bank, 1996, Table 13). The efficiency of capital in each country equals the inverted long-run equilibrium capital/output ratio, which equals the investment/GDP ratio divided by the depreciation rate. We set $E = 0.30$ initially. This number is consistent with an average investment/GDP ratio of 0.21 and a depreciation rate of 0.05.[15] A broader measure of capital, including human capital, would be more appropriate here, but the requisite data are unavailable for most of the countries reviewed above. The unweighted averages and corresponding standard deviations of the structural parameters are summarized in Table 3.

[14] This estimate of c does not include inflation tax revenue. Because of seigniorage, increased inflation reduces the rate of monetary expansion $m = vd = vc - \pi$ that is needed to finance the government budget deficit for given v and c.

[15] Specifically, $E = \frac{1}{n}\sum_{i=1}^{n}(\delta/(I_i/Y_i))$, were I_i/Y_i is the investment ratio in country i, δ is the depreciation rate, and n is the number of countries.

TABLE 3. Means and Standard Deviations of Structural Parameters

	v	c	s	E
Means	3.6	0.05	0.16	0.30
Standard deviations	2.4	0.05	0.14	0.24

Note: The efficiency of capital E is the inverse of the capital/output ratio, which is assumed equal to the ratio of investment to GDP, divided by a depreciation rate of 0.05. Sources: World Bank (1996) and authors' computations.

Reduced-form solution. Given the mean values of the parameters listed above, the equilibrium solution to the model is 3.2 per cent inflation and 4.5 per cent growth per year. For comparison, the GDP deflator and real GDP for the world as a whole rose by 14.8 per cent and 3.1 per cent per year on average during 1980-90 (see World Bank, 1996, Table 11). Inflation is underestimated in the model in part because of the narrow definition of the government budget deficit: a doubling of the deficit/GNP ratio to 0.06 almost trebles the equilibrium inflation rate predicted by the model to 8.6 per cent without affecting growth.

Consider now the sensitivity of the reduced-form equilibrium rates of inflation and growth to variations in the structural parameters of the model. An increase in velocity by one standard deviation from 3.6 to 6.0 increases inflation from 3.2 per cent to 6.7 per cent, *ceteris paribus*, but leaves growth practically unchanged: the growth rate rises only from 4.5 per cent to 4.6 per cent, because the SS schedule in Figure 2 is nearly vertical. An increase of the deficit/GNP ratio by one standard deviation from 0.03 to 0.08 (with $v = 3.6$ again) makes inflation jump from 3.2 per cent to 12.2 per cent without affecting growth, because s and v are independent of c by assumption. A decrease in the saving rate by one standard deviation from 0.16 to 0.02 (with $c = 0.03$ again) increases inflation from 3.2 per cent to 5.1 per cent and reduces growth substantially from 4.5 per cent to 0.6 per cent. Finally, an improvement in efficiency by one standard deviation from 0.30 to 0.54 (with $s = 0.16$ again) increases growth from 4.5 per cent to 7.7 per cent and reduces inflation from 3.2 per cent to 1.6 per cent. These experiments show that inflation and growth move within a reasonable range in response to realistic variations in the parameters of the model. In particular, exogenous shocks to s and E produce a negative correlation between inflation and growth, whereas exogenous shocks to v and, especially, c produce no such correlation.

Quantitatively, the inclusion of the Tobin effect in the growth equation (8) does not make much difference. Without money in the model, the neoclassical growth equation of Harrod, Domar, and Solow is restored: $g = sE$, and the SS schedule in Figure 2 becomes vertical. The corresponding reduced-form solution for inflation is $\pi = (vc - sE)/2$. The qualitative comparative-statics properties of the simplified model are the same as in Table 1, except the plus sign in the lower left corner of the table is replaced by zero. Quantitatively, not much would be lost by abstracting from the role of money and portfolio choice in the growth process described in equations (8) and (11) with a constant velocity of money.

Towards the regression analysis. The next step is to consider the potential effects of inflation on the structural parameters of the model, and to investigate the implications of these effects for economic growth in the long run on the basis of equation (13). In particular, the saving rate, efficiency, and velocity may all depend on the rate of inflation.

First, the saving rate varies directly with the real interest rate and inversely with inflation, provided that increased inflation reduces the real interest rate (Fisher, 1930; Mundell 1963).[16] The optimal saving rate is positively related to efficiency by equation (10) and thus also to the real interest rate. Moreover, inflation may increase uncertainty about the future and thus adversely affect saving independently of interest rates (Sandmo, 1970). Either way, by reducing saving, increased inflation retards growth by equation (13), *ceteris paribus*. Second, inflation reduces efficiency by driving a wedge between the returns to real and financial capital (Gylfason, 1996a). This link is explicit in the model through the dependence of efficiency on velocity in equation (3). Third, the velocity of money varies directly with inflation, because inflation reduces the real value of money independently of efficiency (Tobin, 1965; Tanzi, 1982). Through this channel *per se*, increased inflation can stimulate growth.[17]

[16] This link is by now fairly well established in the empirical literature. For a recent overview of the evidence, see, e.g., Gylfason (1993:519, Table 1).

[17] Moreover, the ratio of the budget deficit to GNP varies directly with inflation through the erosion of tax revenues (Tanzi, 1978). Increased inflation can amplify itself through all the above channels: by raising the deficit and velocity and by reducing the saving rate, increased inflation feeds back on itself.

3 Estimation

3.1 Data

We use two sets of unbalanced panel data in parallel. based on the Penn World Tables and the World Data Bank. The data cover the period 1960-1993 and comprise seven units of five-year averages for the variables in question. In the first regression we use World Data Bank data for 170 countries with a maximum of seven observations per country and a minimum of one (986 degrees of freedom): therefore. the panel data are said to be unbalanced. As we move step by step to a more general model specification, the number of observations decreases until in the last model we are left with 447 degrees of freedom and 109 countries. When we move to the Penn World Tables, the maximum number of countries is 145 (857 degrees of freedom). which drops in stages to 94 countries (365 degrees of freedom) in the final regression. This approach enables us to use as much as possible of the information available for each model. For a detailed description of the two data sets, see Appendix A; see also Appendix B for a list of the countries (and the number of observations per country) included in the estimation.

3.2 Estimation Methods

The industry standard when investigating partial correlations between economic growth and other variables in a cross-section of countries is to use Ordinary-Least-Squares (OLS) estimation with dummy variables, as in Barro (1991) and Mankiw. Romer. and Wheil (1992). Since the inclusion of dummy variables represents a lack of knowledge about the underlying model, it is natural to describe this lack of knowledge through the error term of the statistical model. The model-specification problem in turn suggests that the structure of the error term may be a complex one, since it is assumed to result in part from the effects of omitted variables. The difficulty arises because the error term is likely to consist of time-related errors, cross-sectional errors, and a mixture of both in a panel of countries. The *random-effects* panel model is a natural solution to this problem.[18] The basic regression model for an unbalanced panel data set is:

$$y_{it} = X_{it}\beta + u_{it}, \tag{14}$$

[18]This method has also been used by De Gregorio (1993), for example.

where $i = 1, \ldots, N$. $t \in [1, T]$ and u_{it} is based on the following decomposition:

$$u_{it} = \varepsilon_i + \mu_t + \eta_{it}.$$

ε_i is the individual country effect. μ_t is the time effect. and η_{it} is the purely random effect. This estimator is designed to allow the systematic tendency of u_i to be higher for some countries than others (individual country effect). and possibly also higher for some periods than for others (time effect). It treats the constant term in X_{it} as a random variable. so that its stochastic component. ε_i, can be included in the error term of the regression. Because the constant term is common for all of the time series of a given country, the covariance matrix of the errors in (14) is no longer diagonal and the equation has to be estimated by Generalized Least Squares. However. because the random-effects model treats the country-specific effect as part of the error term. it suffers from possible bias due to a correlation with the regressors. see Hausman and Taylor (1981). We assume that individual error components are uncorrelated with each other. both across sections and time.

3.3 Exogeneity

Recently there has been a growing concern about simultaneity bias in the empirical growth literature. This highlights the need for either explicitly modeling endogenous variables or using instrumental methods. In this vein. we are concerned with the exogeneity of inflation. investment, and the school enrolment variables when estimating the semi-reduced form of our growth equation.

It is important that regressors which are treated as conditioning variables are (weakly) exogenous to sustain efficient and valid inference. The concept of weak exogeneity applies when there is immaterial loss in ignoring information in the marginal distributions of the conditioning (independent) variables. Exogeneity modeling can been regarded as an attempt to ascertain if the data can be used for modeling economic growth without modeling the marginal processes. i.e., inflation, investment. and school enrolment.

The test is performed by estimating and saving the residuals from each equation for the marginal processes, i.e.. the equations for inflation, investment. primary education, and secondary education. The residual for the variable (equation) of interest is then inserted into the growth equation. If the outcome is insignificant, or if the residuals of the equation in question and the growth equation are not correlated. the hypothesis that the variable under scrutiny is weakly exogenous is not rejected. In this case the marginal process can be left unmodeled, see Verner (1995).

In Table 4 we show the results of the four marginal processes using both data sets.

<Table 4. Modeling of Endogenous Variables>

The explanatory variables are chosen by intuition rather than on the basis of formal theory.

Inflation is conditioned on initial GDP, openness, investment, and a dummy for the OECD countries. Open economies are supposed to be less inflation-prone than closed economies, because foreign competition keeps domestic inflation in check. High investment rates can either raise or reduce inflation, depending on the interaction of the effects of capital accumulation on aggregate demand and supply. Finally, high inflation is less prevalent in the OECD countries than in the rest of the world on account of more mature monetary, fiscal, and financial institutions. Measures of government budget deficits were not tested, despite equation (12), because then a large number of countries and observations would have been lost from the sample.

The intuition for the investment equation is that higher GDP results in higher investment rates. The higher the inflation, the lower the investment rate as a result of increased exposure to risk, because inflation makes it more difficult to accurately determine relative prices and increases the difficulty of entering into long-term contracts. Increased openness *vis-á-vis* the rest of the world means more access to foreign technology, which can possibly lead to a decline in production costs. Education increases investment opportunities, because it creates possibilities for utilizing new technologies. Also, increased education enhances the productivity of capital.

Various factors influence the primary enrolment rate. First, a larger GDP means that more resources are devoted to education, human capital accumulation, and the attendant buildup of technological leadership. In the second place, primary education enrolment depends on the demographic dispersion of the population indicated by the share of agriculture in GDP.

The secondary enrolment rate is conditioned by the same variables as the primary one, and is, in addition, dependent on the primary enrolment rate and the openness of the economy. Openness matters for enrolment, because more education is demanded with increased access to new foreign technologies.

As stated earlier, we enter the residuals from these regressions into our growth model, one series at a time. In Table 5 we show the result of an F-test of the hypothesis that the coefficient on the residual in question is zero. We also show the correlation between these residuals and residuals from the growth equation.

<Table 5. Tests for Exogeneity>

The null hypotheses of zero coefficients are not rejected. Moreover, the correlations between the residuals from the endogenous-variable equations and the growth equation are weak. The conclusion is that weak exogeneity cannot be rejected. Therefore, we are not concerned with modeling the marginal processes or using instumental-variables methods. These findings are in line with those of Verner (1995) for the period 1983-1990 based on the Penn World data set.

3.4 Estimation and Diagnostics

We analyze the robustness of our results by applying a variation of Leamer's (1983) extreme-bounds test. The robustness of the inflation parameter is examined by alterations in the conditioning information set. The first and seventh regressions consist of the standard (unconditional) convergence regression. In the second and eighth regression we include the variable of interest, inflation, and in regressions (3)-(6) and (9)-(12) we add variables that are widely believed to explain the rate of growth of GDP per capita. If the parameter on inflation does not change signs or become insignificant during this exercise, it is considered to be robust according to Leamer's test. If, on the other hand, it does change sign or significance, it is said to be fragile; see Levine and Renelt (1992).

In Table 6 we report our findings on the partial association between growth and inflation, the standard errors of the estimates (SE), the degrees of freedom (DF), and some diagnostic tests.

<Table 6. Partial Association Between Growth and Inflation>

To test for potential misspecification of functional forms, i.e., for omitted variables, we use the Ramsey RESET test. The functional form is tested against a more general relationship involving higher-order terms in the regression.[19] The test is performed by saving the residual from the growth equation, squaring it, and adding it as an explanatory variable in the growth equation. If the outcome is significant, the hypothesis of misspecification cannot be rejected. In the first four models, the hypothesis of misspecification cannot be rejected. In model (5), on the other hand, misspecification is strongly rejected. In model (6), misspecification is only marginally rejected. In models (7) to (10), misspecification cannot be rejected, but it is strongly rejected both in models (11) and (12). First-order autocorrelation is rejected in all cases on the basis of the Durbin-Watson autocorrelation test. Normality of errors is rejected in the Jarque-Bera test, as is often the case in large data samples, see Figure 3.[20] At last, we tested for heteroscedasticity using the Breusch-Pagan (1989) Lagrange-Multiplier test. The hypothesis of heteroscedasticity was rejected both in the Penn World and World Bank data.[21]

<Fig. 3. Histograms for Models (1) to (12)>

The rest of this section describes in further detail the results obtained for the variables considered as determinants of gowth.

Initial GDP: Model (1) represents an unconditional β-convergence regression.[22] The GDP parameter reflects the speed at which poor countries converge towards rich ones. This parameter is insignificantly different from

[19]The distinctive feature of the Ramsey RESET test is that it emphasizes the fact that the researcher often has the same information set when deciding how to test his model as when choosing his specification. Without additional information, the test variable for the hypothesis of omitted variables should reflect the paucity of information about alternatives. Ramsey assumed that the effect of omitted variables can be proxied by an (unknown) analytic function of $X\beta$ in equation (14); see Godfrey (1990: 106).

[20]The rejection of normality stems from excessive kurtosis, which is a consequence of long tails due to outliers. A substantial departure from normality would invalidate statistical inference. We did run robust regressions on models (5) and (11) using the Huber (1973) robust estimator, thus in effect imposing a normal distribution on the residuals, but the results remained virtually unchanged.

[21]A slight modification of the Brausch-Pagan test was made to be able to relax the assumption of normal residuals. The Breusch-Pagan test statistic is distributed as $\chi^2(3)$. For the Penn World data the test statistic is 2.48, and for the World Bank data, 8.42. The cut-off point is 11.34 at the 1 per cent level.

[22]Both the magnitude and statistical properties of the convergence parameter should be taken with a grain of salt. Evans (1996) and Evans and Karras (1996) show that traditional estimation procedures produce invalid inference unless the economies have identical first-

zero and small, implying a speed of convergence of only 0.1 per cent per year.[23] This is contrary to the conventional wisdom found in the convergence literature, which predicts a convergence speed of approximately 2-3 per cent per year. However, our findings are in line with those of Barrow and Sala-i-Martin (1995:445) when using World Bank figures on GDP. In the Penn World data set the convergence parameter has the right sign in all the regressions but is insignificantly different from zero in model (8), when the investment variable is added. With a convergence speed of 1.2 per cent in model (11), convergence is more rapid in the Penn World data than in the World Bank data. This is less than the 2-3 per cent usually found in the literature, see Barro and Sala-i-Martin (1995:445). Nerlove (1996) illustrates the different estimates of the rates of convergence obtained with different estimation techniques. In particular, he shows that the use of the standard fixed-effects panel models biases the results towards finding relatively rapid convergence. Our findings are thus in line with those of Nerlove.

Africa dummy: In all the above models we use a continent dummy variable for Africa. The reason for this is that the models are not likely to capture some irregularities believed to cause, or inhibit, growth in African countries. The Africa dummy is significantly different from zero in all of the above regressions.

Inflation: In model (2) we add inflation to our regression as the variable of most interest to us. The parameter on inflation has the right sign and is strongly significant statistically in all the regressions and both data sets. The effects of an increase in inflation from 5 to 50 per cent on per year from one country, to another annual growth is -0.6 per cent in the World Bank data, model (5), and -1.3 per cent in the Penn World data, model

order autoregressive dynamic structures and all permanent cross-sectional differences in per capita output are controlled for. Furthermore Lee, Pesaran, and Smith (1996) argue that imposing homogeneity on the slope coefficients will result in inconsistent fixed-effects estimation of the convergence parameter. The use of the random-effects estimator tackles the problem in part, but since the time-related error is still common for the whole sample, the estimator could bias the result. To test for this, one could estimate the convergence parameter for individual countries and average the result. If the average does not depart significantly from the cross-sectional coefficient, the estimator is unbiased. Because we only have a maximum of seven observations for each country, this method is not feasible in our case and, furthermore, we are more interested in other coefficients.

[23]This would imply a capital share of 0.987 in the Solow model with a population growth rate of 1 per cent per year, a productivity increase of 2 per cent per year, and a depreciation rate of 5 per cent per year.

(11). These estimates are a bit lower than those reported in several of the studies summarized in Table 1. but they are nevertheless well within the -1.0 to -1.5 per cent range reported by Barro (1995) based on the Penn World data and also the representative estimate of -1.2 per cent reported by Bruno and Easterly (1995). The inflation coefficient neither changes sign nor becomes insignificant as we add regressors, and therefore, according to Leamer's extreme-bounds test, it seems to be robust.

Investment: Model (3) includes investment as a proportion of GDP. The parameter on investment is economically and statistically significant everywhere and has the right sign. According to our equations (5) and (11) in Table 6, an increase in the investment rate from 20 per cent to 30 per cent of GDP from one country, or time, to another increases growth by 1.5 to 1.6 per cent a year. *ceteris paribus*. This result is rhymes well with those of Levine and Renelt (1992) and Sachs and Warner (1995b).[24] While an investment effect of this magnitude may appear plausible, a reliable assessment of the contribution of investment to growth cannot be offered without adjusting investment for quality, which is an important topic for further research.

Openness: In Model (4) we add the share of trade (exports plus imports) in GDP as a measure of openness. The hypothesis of a zero coefficient is not rejected in the World Bank data, except in model (6), but this coefficient is, on the other hand, highly significant throughout in the Penn World data. The magnitude (0.017 in the Penn World data, model(11)) is in the neighborhood of the 0.014 to 0.016 range reported by Dowrick (1995).

Primary exports: Model (5) includes the ratio of primary exports to GDP (see Sachs and Warner, 1995b). Our findings support their hypothesis that abundant natural resources are a mixed blessing in terms of growth, as also found by Gylfason (1996b). Our benchmark estimates in models (5) and (11) are a bit lower than those of Sachs and Warner. The economic growth differential between countries where primary exports amount to 10 per cent and 20 per cent of GDP is approximately -0.5 to -0.8 according to Sachs and Warner but -0.3 to -0.6 according to our findings, *ceteris paribus*. These results are also in line with Lane and Tornell (1996), who explain the negative relationship between economic growth and abundant natural resources by the so-called *voracity effect*.[25] Moreover, some types of primary export

[24] For comparison, the impact of investment on growth reported by Barro and Sala-i-Martin (1995:433) is much smaller, and is also insignificant in some of their regressions.

[25] The intuition behind the voracity effect is as follows. An increase in the rate of return to capital in an economy with abundant natural resources comprises two conflicting effects:

production involve limited labor skills and low technology, and may thus be inversely related to human capital (Gylfason, 1996b). This may to some extent explain the negative effect of primary exports on growth.

School enrolment: Finally, model (6) includes proxies for human capital, primary and secondary enrolment ratios, which are normally used in this kind of work. Neither variable is significantly different from zero. The primary enrolment ratio even appears with the wrong sign. Two recent studies, Kyriacou (1991) and Benhabib and Spigel (1992), using estimated average schooling of the labor force in a cross-section of countries, found no statistically significant effect of schooling on growth when controlling for convergence. Wolff (1994), using attainment rates and various other variables that have been used as proxies for human capital, reports results similar to that of Kyriacou and Benhabib and Spigel. Using a flow (enrolment) to proxy a stock (human capital) seems problematic. Also, enrolment rates are only partial measures of the rate of investment in human capital and, more importantly, do not account for differences in the quality of schooling. Statistically this results in a negative temporal relationship between the human capital variable used and output growth, see Islam (1995). Finally, measuring output (human capital) by input (number of pupils) seems likely to by misleading.

4 Conclusion

Because inflation is a monetary phenomenon and economic growth is real, many economists find it unlikely that inflation can have lasting, systematic effects on growth.[26] Others disagree, including central bankers: they argue that price stability is a prerequisite for rapid growth.

The econometric evidence reported in this paper supports the latter view. From 1960 to 1993, increased inflation tended to retard growth in a large group of countries at all income levels, both across countries and over time. The link between inflation and growth appears fairly strong, both statistically and economically: an increase in inflation from 5 per cent to 50 per cent a

a direct effect that increases the profitability of investment one to one, and an indirect appropriation effect that leads powerful interest groups to attempt to grab a greater share of national wealth by demanding more transfers from the rest of the society. See Lane and Tornell (1996).

[26]For example, Barro and Sala-i-Martin (1995) do not mention inflation as a potential determinant of growth. See also Sala-i-Martin's sceptical discussion of Fischer (1991:368-378).

year from one country or time to another reduces the rate of growth of GDP per capita by 0.6 per cent to 1.3 per cent a year according to our benchmark regressions (see Table 6. columns 5 and 11), other things being equal. The link is nonlinear: growth is relatively more sensitive to an increase in inflation by, say, 45 percentage points a year at low than at high rates of inflation. The link also seems quite robust: it survives the stepwise introduction of several further conditioning variables including (a) initial income (to capture the catch-up effect, or convergence), (b) investment (unadjusted for quality), (c) human capital (as measured by primary- and secondary-school enrolment), (d) primary exports (to capture the inefficiency caused by rent seeking, the Dutch disease, and perhaps also by the spillover effects of low technology and low-skilled labor in some primary-export industries, e.g., agriculture in developing countries), and (e) a dummy variable for Africa.

The effect of inflation on growth is significant and sizeable both in the panel regressions based on the World Data Bank and in those based on the Penn World Tables. The inflation effect is stronger in the Penn World data, where growth drops by 1.3 per cent a year *ceteris paribus* as inflation goes up from 5 per cent to 50 per cent a year, compared with a 0.6 per cent drop in growth in the World Bank data according to our benchmark regressions (see again Table 6, columns 5 and 11). A likely explanation for the difference is that the growth figures in the Penn World Tables are adjusted for differences in purchasing power across countries, in contrast to the unadjusted growth figures from the World Bank. Inflation-prone countries, whose currencies periodically become overvalued in real terms, tend to have real exchange rates that are too high (i.e., exceed their normal equilibrium values) on average over long periods. This may harm foreign trade, economic efficiency (E in equation (13)), and growth. The impact of inflation on growth through this channel is generally more transparent in the purchasing-power-parity-adjusted measures of GDP than in the unadjusted figures, because the unadjusted figures tend to overstate GDP, when the currency is overvalued; indeed, the main purpose of PPP adjustment is precisely to correct output for unrealistic exchange rates. In our sample, and in the world, there are many more (small) countries with overvalued currencies than there are (large) countries with correspondingly undervalued currencies. Hence the possible bias, which may also help explain why, thus far, relatively few empirical growth studies have been based on World Bank data (see Table 1, column 4).

But the overvaluation of national currencies is not the sole possible source of the observed link between inflation and growth, far from it. Inflation may also distort production by driving a wedge between the returns to real and financial capital, and by thus reducing liquidity and hence also efficiency. It may, moreover, reduce saving and the quality of investment by reducing real interest rates, often far below zero, thus accelerating the depreciation of the capital stock. Inflation can de detrimental to economic growth through one or all of these channels, as shown in equation (13).[27] The relative importance and interplay of these transmission mechanisms is an important topic for further econometric research.

[27] Depreciation is not included in equation (13), but can easily be added.

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5 Appendix A. The Data

We use data from the World Data Bank and the Penn World Tables. The variables are:

- **Growth of GDP**: For the World Bank data this is a five-year average of the log difference of GDP per capita in 1987 US dollars, given by the formula: $\frac{1}{5}\sum_{t=1}^{5}(log(GDP_t) - log(GDP_{t-1}))$. The RGDPCH (real GDP per capita at 1985 international prices, chain index) is used for the Penn World GDP growth rates.

- **Initial GDP**: GDP per capita measures the total output of goods and services for final use occurring within the domestic territory of a given country, regardless of its allocation to domestic and foreign uses. GDP at a purchaser values (market prices) is the sum of GDP at factor cost and indirect taxes less subsidies. GDP_0 is the first observation in the corresponding five-year interval. For the Penn World regressions we use RGDPCH as defined above.

- **Inflation**: This variable is defined as $\pi/(1+\pi)$, where π is the five-year average of the log difference of the GDP deflator. This transformation reflects the magnitude of the inflation distortion in production (as in Gylfason, 1996b) and, equivalently, the implicit inflation tax rate. It is intended to capture the nonlinear relationship between growth and inflation: growth is thus less sensitive to an increase in inflation from 500 per cent to 600 per cent per year than, say, an increase from 0 to 100 per cent per year. The deflator is derived by dividing current-price estimates of GDP at purchaser values (market prices) by constant-price estimates. The World Bank inflation measure is used for all regressions.

- **Investment**: This is a five-year average of the sum of gross domestic fixed investment and the change in stocks, as a percentage of GDP. for the World Bank regressions, and for the Penn World regressions we use gross domestic investment, private and public, as percentage of GDP.

- **Openness**: This is a five-year average of the sum of exports and imports of goods and services divided by GDP. Exports (imports) of goods and services represent the value of merchandise exports (imports) plus amounts receivable from (payable to) nonresidents for the provision of nonfactor services to residents. Nonfactor services include transportation travel, insurance, and other nonfactor services such as government transactions and various fees. For the Penn World regressions we use five year-average of the sum of exports and imports of gods and services divided by CGDP (real GDP per capita at current international prices).

- **Primary exports**: Lack of data made a five-year average impossible. Instead, if one measurement fell into the five-year period, it was used. Exports of primary products comprise commodities in SITC revision 1, sections 0 through 4 and 68 (food and live animals, beverages and tobacco, animal and vegetable oil and fat, and crude materials). The World Bank measure of primary exports is used in all regressions.

- **Primary education**: Here we use five-year averages of gross enrolment of students at the primary levels as a percentage of school-age children as defined by each country and reported to UNESCO. Only four or sometimes three measurements were available in some periods, but this probably causes no harm where these series are not undergoing any dramatic changes between years. For some countries with universal primary education, the gross enrolment ratios may exceed 100 percent, because some pupils are younger or older than the local primary school age.

- **Secondary education**: Here we use five-year averages of gross enrolment of students at the secondary levels as a percentage of school-age children as defined by each country and reported to UNESCO. As with primary education, only four or sometimes three measurements were available in some periods. Late entry of more mature students as well as repetition and "bunching" in the final grade can influence these ratios.

Appendix B. Number of Observations per Country and Model for All Variables.

WB	PWT	Country	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
DZA	1	ALGERIA	7	7	7	7	5	5	7	7	7	7	5	5
BEN	3	BENIN	7	7	7	7	3	3	6	6	6	6	3	3
BWA	4	BOTSWANA	7	7	7	1	0	0	6	6	6	6	0	0
BFA	5	BURKINA FASO	7	7	7	6	5	5	7	7	7	7	5	5
BDI	6	BURUNDI	7	7	7	7	5	5	7	7	7	7	5	5
CMR	7	CAMEROON	7	7	6	6	5	5	7	7	7	7	5	5
CPV	8	CAPE VERDE IS.	4	4	4	4	4	3	7	4	4	4	3	2
CAF	9	CENTRAL AFR.R.	7	7	7	7	5	4	7	7	7	7	5	4
TCD	10	CHAD	7	7	7	7	5	5	7	7	7	7	4	4
COM	11	COMOROS	2	2	2	2	1	0	7	2	2	2	1	0
COG	12	CONGO	7	7	7	7	5	1	7	7	7	7	5	1
DJI	13	DJIBOUTI	3	3	3	3	0	0	2	1	1	1	0	0
EGY	14	EGYPT	7	7	7	7	5	5	7	7	7	7	5	5
ETH	15	ETHIOPIA	1	1	1	0	0	0	5	0	0	0	0	0
GAB	16	GABON	7	7	5	5	5	2	7	7	7	7	5	2
GMB	17	GAMBIA	7	7	7	7	5	5	6	6	6	6	4	4
GHA	18	GHANA	7	7	7	7	5	5	7	7	7	7	5	0
GIN	19	GUINEA	1	1	1	1	0	0	7	1	1	1	0	0
GNB	20	GUINEA-BISS	4	4	4	4	0	0	7	4	4	4	0	0
CIV	21	COTE D'IVOIRE	7	7	6	6	4	4	0	0	0	0	0	0
KEN	22	KENYA	7	7	7	7	5	5	6	6	6	6	4	4
LSO	23	LESOTHO	7	7	7	7	0	0	7	7	7	7	0	0
LBR	24	LIBERIA	6	5	5	0	0	0	5	5	5	5	3	0
MDG	25	MADAGASCAR	7	7	7	7	5	4	7	7	7	7	5	4
MWI	26	MALAWI	7	7	7	7	4	3	7	7	7	7	4	0
MLI	27	MALI	7	5	5	5	5	5	6	4	4	4	4	3
MRT	28	MAURITANIA	7	7	7	7	5	5	7	7	7	7	5	5
MUS	29	MAURITIUS	7	7	7	7	5	5	7	7	7	7	5	1
MAR	30	MOROCCO	7	7	7	7	5	5	7	7	7	7	5	0
MOZ	31	MOZAMBIQUE	2	2	2	2	2	2	7	2	2	2	1	0
NAM	32	NAMIBIA	7	2	2	2	0	0	7	2	2	2	0	0
NER	33	NIGER	7	7	7	7	3	3	6	6	6	6	3	0
NGA	34	NIGERIA	7	7	7	7	5	5	7	7	7	7	5	5
RWA	36	RWANDA	7	7	7	7	5	5	7	7	7	7	5	0
SEN	37	SENEGAL	7	7	7	7	5	5	6	6	6	6	4	4
SYC	38	SEYCHELLES	7	7	4	2	2	0	6	6	6	6	1	0
SLE	39	SIERRA LEONE	7	6	6	6	5	5	6	6	6	6	5	5
SOM	40	SOMALIA	6	6	6	6	4	4	6	6	6	6	4	4
ZAF	41	SOUTH AFRICA	7	7	7	7	5	1	7	7	7	7	5	1
SDN	42	SUDAN	6	6	6	6	4	4	0	0	0	0	0	0
SWZ	43	SWAZILAND	7	7	7	7	0	0	6	6	6	6	0	0
TZA	44	TANZANIA	7	7	7	0	0	0	5	5	5	5	3	0
TGO	45	TOGO	7	7	7	7	5	5	7	7	7	7	5	0
TUN	46	TUNISIA	6	6	6	6	5	5	7	6	6	6	5	5
UGA	47	UGANDA	2	2	2	2	2	2	7	2	2	2	2	2
ZAR	48	ZAIRE	6	6	6	6	4	4	6	6	6	6	4	0
ZMB	49	ZAMBIA	7	7	7	7	4	4	6	6	6	6	3	0
ZWE	50	ZIMBABWE	7	7	7	4	4	4	7	7	7	7	4	3
BHS	51	BAHAMAS	7	7	3	3	3	1	1	1	1	1	1	0
BRB	52	BARBADOS	7	7	7	0	0	0	6	6	6	6	4	4
BLZ	53	BELIZE	7	7	3	3	3	0	2	2	2	2	2	0
CAN	54	CANADA	7	7	7	7	5	5	7	7	7	7	5	5
CRI	55	COSTA RICA	7	7	7	7	5	5	7	7	7	7	5	5
DMA	56	DOMINICA	7	7	3	0	0	0	0	0	0	0	0	0
DOM	57	DOMINICAN REP.	7	7	7	7	5	4	7	7	7	7	5	4
SLV	58	EL SALVADOR	7	7	7	7	5	5	7	7	7	7	5	5

Appendix B. (continued)

GRD	59	GRENADA	2	2	2	2	2	0	1	1	1	1	1	1
GTM	60	GUATEMALA	7	7	7	7	5	5	7	7	7	7	5	0
HTI	61	HAITI	7	7	7	7	5	5	6	6	6	6	3	3
HND	62	HONDURAS	7	7	7	7	4	4	7	7	7	7	4	3
JAM	63	JAMAICA	7	7	7	7	4	4	6	6	6	6	3	3
MEX	64	MEXICO	7	7	7	7	5	5	7	7	7	7	5	5
NIC	65	NICARAGUA	7	7	7	7	5	5	6	6	6	6	4	0
PAN	66	PANAMA	7	7	7	7	5	5	7	7	7	7	5	5
PRI	67	PUERTO RICO	7	7	7	4	0	0	6	6	6	6	0	0
KNA	68	ST.KITTS&NEVIS	3	3	3	3	3	1	0	0	0	0	0	0
LCA	69	ST.LUCIA	1	1	1	0	0	0	2	1	1	1	1	0
VCT	70	ST.VINCENT&GRE	7	7	3	3	2	0	3	3	3	3	3	0
TTO	71	TRINIDAD&TOBAGO	7	7	7	7	5	5	6	6	6	6	4	4
USA	72	U.S.A.	7	7	7	7	5	2	7	7	7	7	5	5
ARG	73	ARGENTINA	7	7	7	7	5	4	6	6	6	6	4	4
BOL	74	BOLIVIA	7	7	7	7	5	5	7	7	7	7	5	5
BRA	75	BRAZIL	7	7	7	7	5	5	7	7	7	7	5	5
CHL	76	CHILE	7	7	7	7	5	5	7	7	7	7	5	5
COL	77	COLOMBIA	7	7	7	7	5	5	7	7	7	7	5	5
ECU	78	ECUADOR	5	5	5	5	5	4	7	5	5	5	5	4
GUY	79	GUYANA	7	7	7	7	4	3	6	6	6	6	3	3
PRY	80	PARAGUAY	7	7	7	7	5	5	7	7	7	7	5	5
PER	81	PERU	7	7	7	7	5	5	7	7	7	7	5	5
SUR	82	SURINAME	4	4	4	0	0	0	6	3	3	3	0	0
URY	83	URUGUAY	7	7	7	7	5	5	7	7	7	7	5	2
VEN	84	VENEZUELA	7	7	7	5	5	5	7	7	7	7	5	5
BHR	85	BAHRAIN	2	2	2	2	2	2	1	0	0	0	0	0
BGD	86	BANGLADESH	7	7	7	7	4	4	7	7	7	7	4	4
CHN	88	CHINA	7	7	7	7	4	4	7	7	7	7	4	4
HKG	89	HONG KONG	7	7	7	7	5	4	7	7	7	7	5	5
IND	90	INDIA	7	7	7	7	5	5	7	7	7	7	5	5
IDN	91	INDONESIA	7	7	7	7	5	4	7	7	7	7	5	4
IRN	92	IRAN	4	4	4	4	4	4	7	4	4	4	4	4
IRQ	93	IRAQ	6	6	0	0	0	0	5	5	5	5	2	2
ISR	94	ISRAEL	7	7	7	7	5	5	7	7	7	7	5	5
JPN	95	JAPAN	7	7	7	7	5	4	7	7	7	7	5	5
JOR	96	JORDAN	2	2	2	2	2	1	6	1	1	1	1	0
KOR	97	KOREA, REP.	7	7	7	7	5	5	6	6	6	6	4	4
KWT	98	KUWAIT	5	5	5	5	4	4	1	1	1	1	1	0
LAO	99	LAOS	2	2	2	2	0	0	1	1	1	1	0	0
MYS	100	MALAYSIA	7	7	7	7	5	5	7	7	7	7	5	0
MNG	101	MONGOLIA	2	2	2	2	0	0	1	1	1	1	0	0
MMR	102	MYANMAR	7	7	7	7	5	4	5	5	5	5	3	3
NPL	103	NEPAL	7	7	7	0	0	0	5	5	5	5	2	2
OMN	104	OMAN	7	7	6	0	0	0	4	4	4	4	4	4
PAK	105	PAKISTAN	7	7	7	7	5	5	7	7	7	7	5	0
PHL	106	PHILIPPINES	7	7	7	7	5	5	7	7	7	7	5	5
SAU	108	SAUDI ARABIA	5	5	5	0	0	0	6	5	5	5	4	4
SGP	109	SINGAPORE	7	7	7	4	4	3	7	7	7	7	5	4
LKA	110	SRI LANKA	7	7	5	5	5	5	7	7	7	7	5	5
SYR	111	SYRIA	5	5	5	3	3	3	6	5	5	5	4	4
THA	113	THAILAND	7	7	7	7	5	5	7	7	7	7	5	5
ARE	114	UNITED ARAB E.	3	3	3	3	3	3	1	1	1	1	1	1
AUT	116	AUSTRIA	7	7	7	7	5	5	7	7	7	7	5	5
BEL	117	BELGIUM	7	7	7	7	5	5	7	7	7	7	5	5
BGR	118	BULGARIA	2	1	1	1	0	0	2	2	2	2	0	0
CYP	119	CYPRUS	3	3	3	3	3	3	7	3	3	3	3	3

Appendix B. (continued)

CZE	120	CZECHOSLOVAKIA	2	2	2	0	0	0	6	1	1	1	0	0
DNK	121	DENMARK	7	7	7	7	5	5	7	7	7	7	5	5
FIN	122	FINLAND	7	7	7	7	5	5	7	7	7	7	5	5
FRA	123	FRANCE	7	7	7	7	5	5	7	7	7	7	5	5
GRC	126	GREECE	7	7	7	7	5	4	6	6	6	6	4	4
HUN	127	HUNGARY	7	7	7	5	5	5	4	4	4	4	4	4
ISL	128	ICELAND	7	7	7	7	5	4	7	7	7	7	5	4
IRL	129	IRELAND	7	7	7	7	5	5	7	7	7	7	5	5
ITA	130	ITALY	7	7	7	7	5	5	7	7	7	7	5	0
LUX	131	LUXEMBOURG	7	7	7	7	0	0	7	7	7	7	0	0
MLT	132	MALTA	7	7	7	7	5	5	6	6	6	6	4	4
NLD	133	NETHERLANDS	7	7	7	7	5	5	7	7	7	7	5	4
NOR	134	NORWAY	7	7	7	7	4	4	7	7	7	7	4	4
POL	135	POLAND	2	2	2	2	2	2	4	2	2	2	2	2
PRT	136	PORTUGAL	7	7	7	7	7	6	6	6	6	6	4	4
ROM	137	ROMANIA	3	3	3	3	0	0	6	2	2	2	0	0
ESP	138	SPAIN	7	7	7	7	5	4	7	7	7	7	5	4
SWE	139	SWEDEN	7	7	7	7	5	5	7	7	7	7	5	5
CHE	140	SWITZERLAND	7	7	7	7	5	2	7	7	7	7	5	4
TUR	141	TURKEY	7	7	7	7	5	5	7	7	7	7	5	5
GBR	142	U.K.	7	7	7	7	5	5	7	7	7	7	5	0
AUS	145	AUSTRALIA	7	7	7	7	5	5	7	7	7	7	5	5
FJI	146	FIJI	7	7	7	0	0	0	6	6	6	6	4	4
NZL	147	NEW ZEALAND	7	7	7	7	5	5	7	7	7	7	5	5
PNG	148	PAPUA N.GUINEA	7	7	7	7	5	5	7	7	7	7	5	4
SLB	149	SOLOMON IS.	4	4	2	0	0	0	0	0	0	0	0	0
TON	150	TONGA	1	1	1	0	0	0	0	0	0	0	0	0
VUT	151	VANUATU	3	3	3	3	3	1	1	1	1	1	1	0
ALB	154	ALBANIA	2	2	2	2	0	0	0	0	0	0	0	0
ATG	157	ANTIGUA AND BARBUDA	2	2	0	0	0	0	0	0	0	0	0	0
ARM	158	ARMENIA	7	7	3	0	0	0	0	0	0	0	0	0
AZE	160	AZERBAIJAN	7	7	3	0	0	0	0	0	0	0	0	0
BLR	161	BELARUS	7	7	3	0	0	0	0	0	0	0	0	0
BMU	162	BERMUDA	5	5	0	0	0	0	0	0	0	0	0	0
BRN	164	BRUNEI	3	3	1	0	0	0	0	0	0	0	0	0
KHM	165	CAMBODIA	1	1	1	0	0	0	0	0	0	0	0	0
KAZ	168	KAZAKHSTAN	7	7	3	0	0	0	0	0	0	0	0	0
GNQ	171	EQUATORIAL GUINEA	1	0	0	0	0	0	0	0	0	0	0	0
EST	173	ESTONIA	7	7	3	0	0	0	0	0	0	0	0	0
GEO	177	GEORGIA	7	7	3	0	0	0	2	2	2	2	0	0
DEU	178	GERMANY	7	7	7	7	5	3	7	7	7	7	5	3
KIR	184	KIRIBATI	3	3	2	0	0	0	0	0	0	0	0	0
KGZ	186	KYRGYZ REPUBLIC	7	7	3	0	0	0	0	0	0	0	0	0
LVA	187	LATVIA	7	7	3	0	0	0	0	0	0	0	0	0
LBY	189	LIBYA	6	6	6	0	0	0	0	0	0	0	0	0
LTU	190	LITHUANIA	7	7	3	0	0	0	0	0	0	0	0	0
MAC	191	MACAO	1	1	1	1	1	0	0	0	0	0	0	0
MDV	193	MALDIVES	1	1	1	0	0	0	1	0	0	0	0	0
RUS	202	RUSSIAN FEDERATION	7	7	3	0	0	0	6	6	6	6	0	0
STP	204	SAO TOME AND PRINCIPE	4	4	4	4	0	0	0	0	0	0	0	0
SVK	205	SLOVAK REPUBLIC	2	2	2	2	0	0	0	0	0	0	0	0
TJK	207	TAJIKISTAN	7	7	3	0	0	0	0	0	0	0	0	0
TKM	208	TURKMENISTAN	6	6	2	0	0	0	0	0	0	0	0	0
UKR	209	UKRAINE	7	7	3	0	0	0	0	0	0	0	0	0
UZB	210	UZBEKISTAN	7	7	3	0	0	0	0	0	0	0	0	0
VNM	211	VIET NAM	2	2	2	0	0	0	0	0	0	0	0	0
VIR	212	VIRGIN ISLANDS	3	3	0	0	0	0	0	0	0	0	0	0

Appendix B. (continued)

NA	ANGOLA	0	0	0	0	0	0	6	0	0	0	0	0
NA	QATAR	0	0	0	0	0	0	1	0	0	0	0	0
NA	REUNION	0	0	0	0	0	0	6	0	0	0	0	0
NA	WESTERN SAMOA	0	0	0	0	0	0	2	2	2	2	2	2
NA	YEMEN	0	0	0	0	0	0	4	0	0	0	0	0
NA	YUGOSLAVIA	0	0	0	0	0	0	6	0	0	0	0	0
Number of Observations in Regression		989	984	881	745	510	456	861	764	764	764	491	374
Number of Countries in Regression		170	169	165	131	115	109	145	137	137	137	120	94

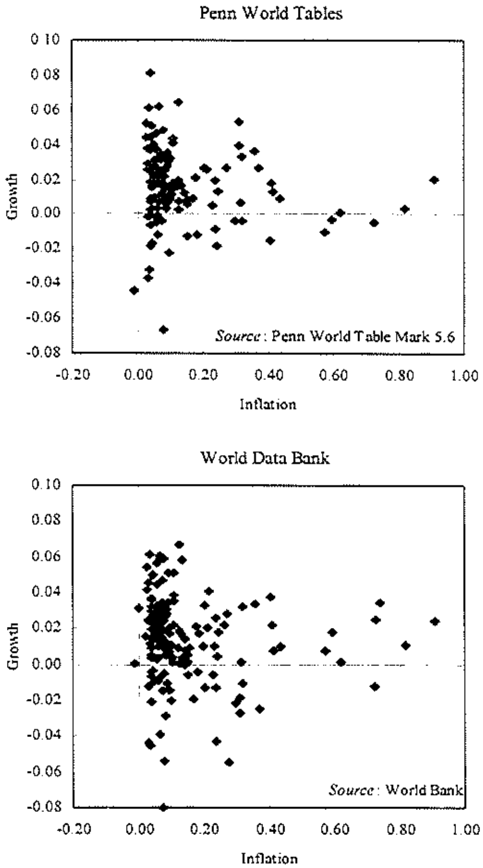

FIGURE 1. *Average Inflation and Growth of GDP Per Capita*, 1960-1993

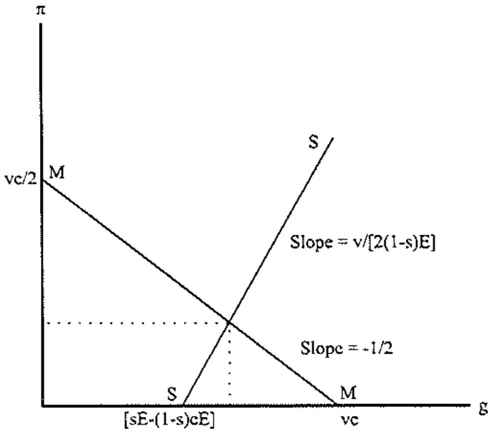

FIGURE 2. *Inflation and Growth in Reduced Form*

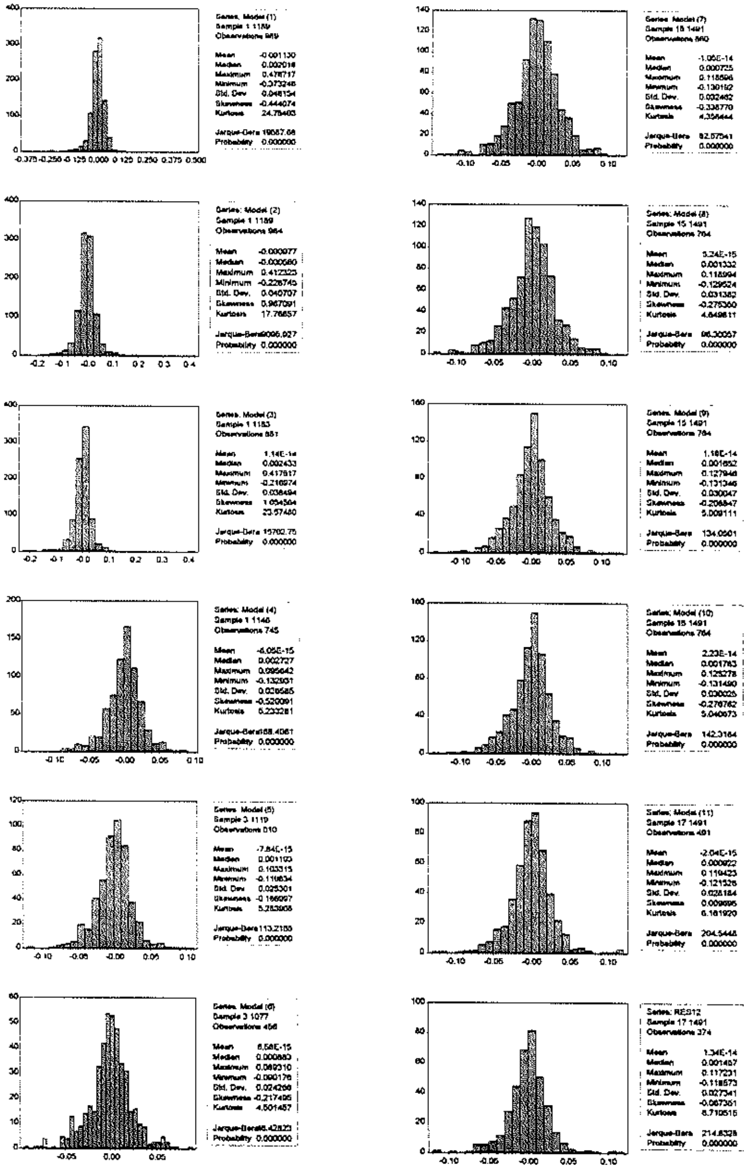

FIGURE 3. *Histograms for Models* (1) *to* (12)

TABLE 1. *Inflation and Growth: Overview of Empirical Studies*

Studies	Countries	Periods	Data (Source)	Effects of an increase in inflation from 5 to 50 per cent a year on growth
Thirlwall and Barton (1971)	51	1958-1967	Cross section (UN)	Not available
Heitger (1985)	115	1950-1980	Panel data. (PWT)	-0.9 to -4.5
Kormendi and Meguire (1985)	47	1950-1977	Cross section (IMF), PC	Not available
Barro (1990a)	117	1960-1985	Cross section (PWT), PC	Insignificant and weak
Fischer (1991)	73	1970-1985	Cross section (PWT), PC	-2.1
Grimes (1991)	21	1960-1987	Panel data (IMF)	-5.0
Gylfason (1991)	37	1980-1985	Cross section (WB), PC	-2.0
De Gregorio (1992a, 1992b, 1993)	12	1950-1985	Cross section (BW,WB,PWT), PC	-0.7
Roubini and Sala-i-Martin (1992)	98	1960-1985	Cross section (BW), PC	-2.2
Fischer (1993)	80	1960-1989	Cross section (WB)	-1.8
Motley (1994)	78	1960-1990	Cross section (PWT), PW	-1.3 to -4.5
Barro (1995)	100	1960-1990	Cross section (PWT), PC	-1.0 to -1.5
Bruno and Easterly (1995)	97	1961-1992	Panel data (WB), PC	-1.2
Gylfason (1996b)	160	1985-1994	Cross section (WB), PC	-2.4
Taylor (1996)	United States	1952-1993	Time series	-11.2

Note: PWT denotes Penn World Tables; WB, World Bank; IMF, International Monertary Fund; BW, the Barro-Wolf data set, and UN, United Nations. PC refers to the use of GDP per capita and PW, per worker.

TABLE 4. *Modeling of Endogenous Variables*

	World Data Bank				Penn World Tables			
	Inflation	Invest.	Prim. edu.	Sec. edu.	Inflation	Invest.	Prim. edu.	Sec. edu.
Initial GDP	-0.009	0.002*	0.012*	0.152	0.050	0.047	0.019*	0.107
	(0.003)	(0.003)	(0.086)	(0.008)	(0.014)	(0.003)	(0.019)	(0.017)
Inflation	-	-0.030	-	-	-	0.005*	-	-
		(0.011)				(0.009)		
Primary edu.	-	0.109	-	0.308	-	0.060	-	0.649
		(0.015)		(0.036)		(0.011)		(0.040)
Openness	-0.042	0.041	-	0.059	-0.096	0.021	-	-0.035*
	(0.008)	(0.008)		(0.020)	(0.020)	(0.007)		(0.024)
Agriculture	-	-	-0.872	0.075*	-	-	-0.460	0.240
			(0.086)	(0.086)			(0.123)	(0.119)
Investment	0.009*	-	-	-	-0.335	-	-	-
	(0.052)				(0.120)			
OECD	-0.034*	-	-	-	-0.130	-	-	-
	(0.01)				(0.027)			
$\overline{R}^2$	0.05	0.17	0.31	0.67	0.07	0.40	0.10	0.47

Note: Standard errors appear below the coefficients. *Not significant at the 1 per cent level. Generalized Least Squares estimation with random effects. Constants are not reported.

TABLE 5. *Tests for Exogeneity*

	World Data Bank				Penn World Tables			
	INFLRES	INVRES	PRIRES	SECRES	INFLRES	INVRES	PRIRES	SECRES
h_0	0.45	0.11	0.05	2.06	4.26	1.74	0.53	0.00
Correlation	0.00	0.01	0.01	0.02	0.00	0.00	0.01	0.03

Note: INFLRES is an abbreviation for the residuals from the inflation equation; INRES, from the investment equation; PRIRES, from the primary equation; and SECRES, from the secondary one. The cut-off point for the h_0 is $F(1,\infty) = 6.63$ at the 1 per cent level.

TABLE 6. *Partial Associations Between Growth and Inflation*

	World Data Bank						Penn World Tables					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Initial GDP	-0.001*	-0.002*	-0.006	-0.004	**-0.004**	-0.006	-0.004	-0.003*	-0.011	-0.012	**-0.012**	-0.012
	(0.001)	(0.001)	(0.001)	(0.009)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Inflation	-	-0.100	-0.080	-0.032	**-0.021**	-0.022	-	-0.011	-0.011	-0.010	**-0.045**	-0.047
		(0.006)	(0.005)	(0.005)	(0.005)	(0.005)		(0.005)	(0.005)	(0.005)	(0.014)	(0.015)
Investment	-	-	0.101	0.111	**0.163**	0.171	-	-	0.161	0.154	**0.148**	0.146
			(0.019)	(0.016)	(0.020)	(0.021)			(0.018)	(0.018)	(0.025)	(0.028)
Openness	-	-	-	0.001*	**0.006***	0.012	-	-	-	0.008	**0.017**	0.022
				(0.003)	(0.004)	(0.004)				(0.003)	(0.004)	(0.004)
Primary exports	-	-	-	-	**-0.028**	-0.094	-	-	-	-	**-0.055**	-0.100
					(0.008)	(0.012)					(0.009)	(0.012)
Primary education	-	-	-	-	-	-0.000*	-	-	-	-	-	0.017*
						(0.009)						(0.009)
Secondary education	-	-	-	-	-	0.007*	-	-	-	-	-	-0.012*
						(0.010)						(0.007)
Constant	0.030	0.052	0.051	0.030	**0.016***	0.026*	0.060	0.049	0.079	0.083	**0.078**	0.084
	(0.012)	(0.012)	(0.012)	(0.009)	(0.012)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.018)	(0.020)
Africa dummy	-0.012	-0.015	-0.012	-0.012	**-0.011**	-0.011	-0.017	-0.015	-0.010	-0.012	**-0.011**	-0.010
	(0.004)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
SE	0.060	0.053	0.038	0.027	**0.025**	0.024	0.032	0.031	0.030	0.030	**0.029**	0.029
$\bar{R}^2$	0.01	0.20	0.25	0.14	**0.21**	0.29	0.04	0.03	0.12	0.13	**0.21**	0.29
DF	986	980	876	739	**503**	447	857	760	759	758	**484**	365
Durbin-Watson	1.83	1.80	1.94	1.83	**2.01**	2.11	1.87	1.85	1.90	1.91	**2.09**	2.02
Misspecification test	590	759	784	28	**1.51**	6.40	30	16	8.53	14.86	**0.01**	0.31

Note: Standard errors appear within parentheses below the coefficients. *Not significant at the 1 per cent level. The Ramsey RESET misspecification test is an F test and the cut-off point is $F(1,\infty) = 6.63$ at the 1 per cent level. Generalized-Least-Squares estimation with random effects.