Inflation and economic growth

By Professor Robert J Barro.[1]

In this article, Robert Barro uses data for around 100 countries from 1960 to 1990 to assess the effect of inflation on economic performance. If a number of country characteristics are held constant, then regression results indicate that an increase in average inflation of ten percentage points per year reduces the growth rate of real per capita GDP by 0.2–0.3 percentage points per year and lowers the ratio of investment to GDP by 0.4–0.6 percentage points. Since the statistical procedures use plausible instruments for inflation, there is some reason to believe that these relations reflect causal influences from inflation to growth and investment.

Although the adverse influence of inflation on growth looks small, the long-term effects on standards of living are substantial. For example, a shift in monetary policy that raises the long-term average inflation rate by ten percentage points per year is estimated to lower the level of real GDP after 30 years by 4%–7%, more than enough to justify a strong interest in price stability.

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In recent years, many central banks, including the Bank of England, have placed increased emphasis on price stability. Monetary policy—whether expressed in terms of interest rates or growth of monetary aggregates—has been increasingly geared toward the achievement of low and stable inflation. As one indicator of this concern, the Bank of England began in February 1993 to issue the *Inflation Report*.

Central bankers and most other observers view price stability as a worthy objective because they think that inflation is costly. Some of these costs involve the average rate of inflation, and others relate to the variability and uncertainty of inflation. But the general idea is that businesses and households are thought to perform poorly when inflation is high and unpredictable.

The academic literature contains a lot of theoretical work on the costs of inflation; a thorough review by Briault (1995) appeared in the February issue of the *Bulletin*. This analysis provides a presumption that inflation is a bad idea, but the case is not decisive without supporting empirical findings. Although some empirical results (also surveyed by Briault) suggest that inflation is harmful, the evidence is not overwhelming. It is therefore important to carry out additional empirical research on the relation between inflation and economic performance. This article explores this relation in a large sample of countries over the last 30 years.

1 Data

The data set covers over 100 countries from 1960 to 1990. Table A provides information about the behaviour of inflation in this sample. Annual inflation rates were computed in most cases from consumer price indices. (The deflator for the gross domestic product was used in a few instances, when the data on consumer prices were unavailable.) The table shows the mean and median across the countries of the inflation rates in three decades: 1960–70, 1970–80 and 1980–90. The median inflation rate was 3.3% per year in the 1960s (117 countries), 10.1% in the 1970s (122 countries) and 8.9% in the 1980s (119 countries).[3]

The annual data were used for each country over each decade to compute a measure of inflation variability, the standard deviation of the inflation rate around its decadal mean. Table A shows the mean and median of these standard deviations for the three decades. The median was 2.4% per year in the 1960s, 5.4% in the 1970s and 4.9% in the 1980s. Thus, a rise in inflation variability accompanied the increase in the average inflation rate since the 1960s.

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(2) The Houblon-Norman Fund, established by the Bank in 1944, finances academic research into subjects relevant to central banking. More details of the Fund were given in an article in the August 1993 *Quarterly Bulletin*.
The author acknowledges useful comments from Clive Briault and Tony Garratt, and help with the inflation data from Simon Frew, of the Bank's Monetary Assessment and Strategy Division.
(3) The cross-country mean of inflation exceeds the median for each decade because the distribution of inflation rates is highly skewed to the right, as shown in Charts 1–3; that is, there are a number of outliers with positive inflation rates of large magnitude, but none with negative inflation rates of high magnitude. Because this skewness increased in the 1980s (there were more countries with very high inflation rates), the mean inflation rate rose from the 1970s to the 1980s, although the median rate declined.

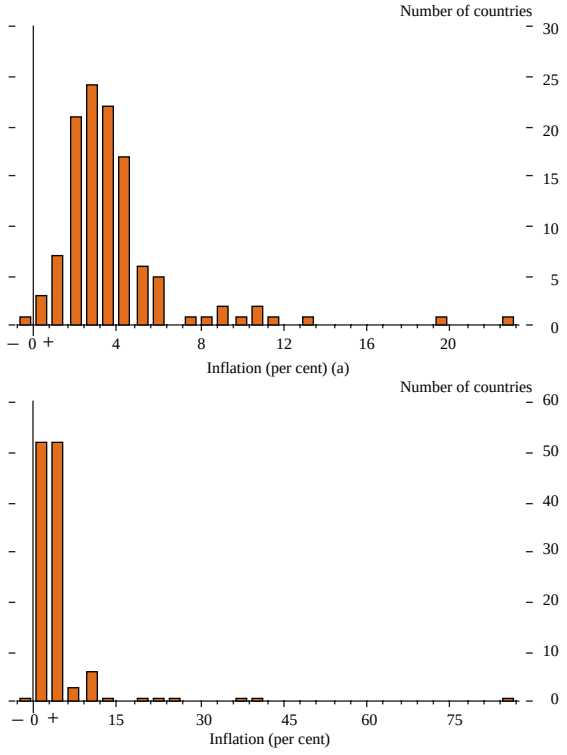
Table A
Descriptive statistics on inflation, growth and investment[a]

Per cent

Variable	Mean	Median	Number of countries
1960–70:			
Inflation rate	5.4	3.3	117
Standard deviation of inflation rate	3.9	2.4	117
Growth rate of real per capita GDP	2.8	3.1	118
Ratio of investment to GDP	16.8	15.6	119
1970–80:			
Inflation rate	13.3	10.1	122
Standard deviation of inflation rate	7.5	5.4	122
Growth rate of real per capita GDP	2.3	2.5	123
Ratio of investment to GDP	19.1	19.3	123
1980–90:			
Inflation rate	19.1	8.9	119
Standard deviation of inflation rate	13.4	4.9	119
Growth rate of real per capita GDP	0.3	0.4	121
Ratio of investment to GDP	17.4	17.3	128

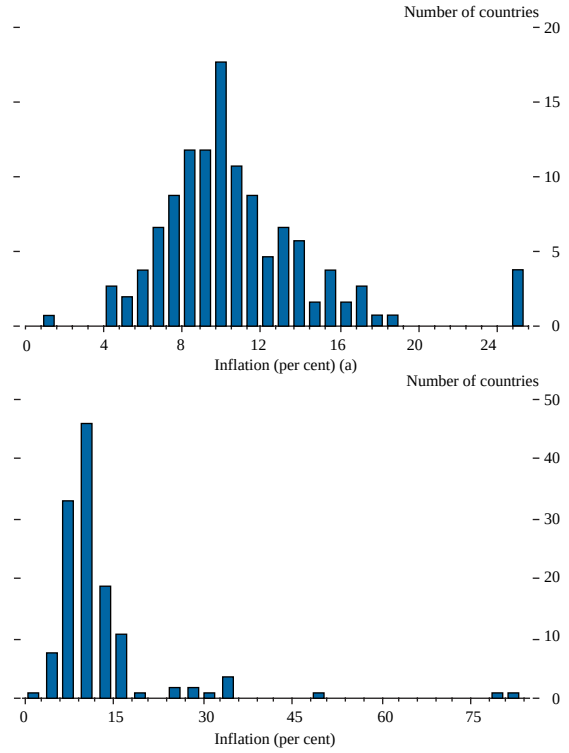
(a) The inflation rate is computed on an annual basis for each country from data on consumer price indices (from the World Bank, STARS databank and issues of *World Tables*; International Monetary Fund, *International Financial Statistics*, yearbook issues; and individual country sources). In a few cases, figures on the GDP deflator were used. The average inflation rate for each country in each decade is the mean of the annual rates. The standard deviation for each country in each decade is the square root of the average squared difference of the annual inflation rate from the decadal mean. The values shown for inflation in this table are the mean or median across the countries of the decade-average inflation rates. Similarly, the figures for standard deviations are the mean or median across the countries of the standard deviations for each decade. The growth rates of real per capita GDP are based on the purchasing power adjusted GDP values compiled by Summers and Heston (1993). For the 1985–90 period, some of the figures come from the World Bank (and are based on market exchange rates rather than purchasing-power comparisons). The ratios of real investment (private plus public) to real GDP come from Summers and Heston (1993). These values are averages for 1960–69, 1970–79 and 1980–89.

Chart 1
Distribution of inflation rates across countries: 1960–70



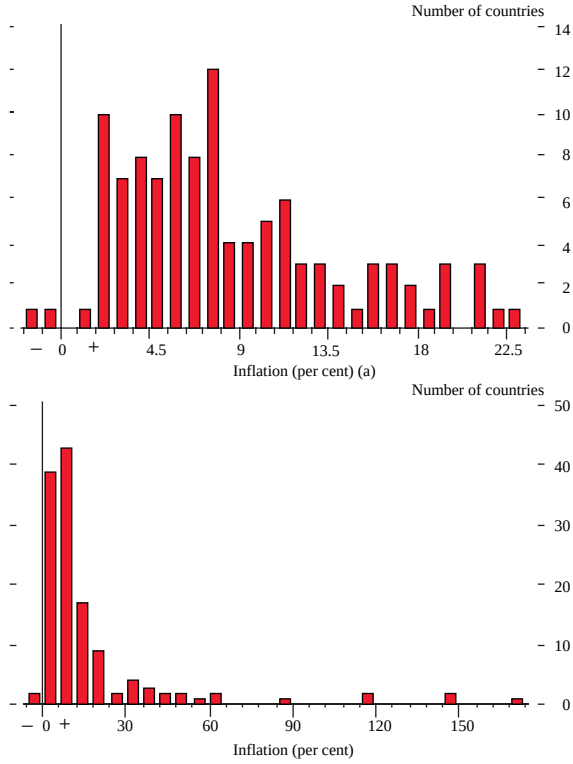
(a) For those countries whose average inflation rate was less than 25% per year.

Chart 2
Distribution of inflation rates across countries: 1970–80



(a) For those countries whose average inflation rate was less than 25% per year.

Chart 3
Distribution of inflation rates across countries: 1980–90

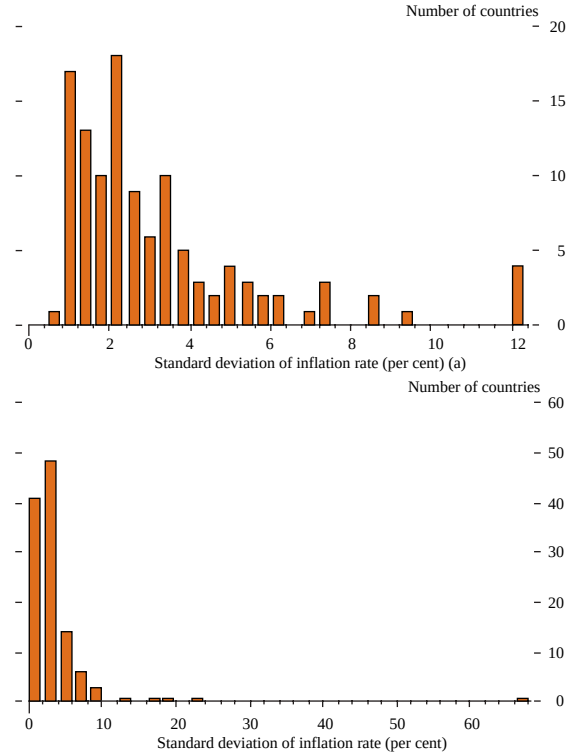


(a) For those countries whose average inflation rate was less than 25% per year.

Charts 1–3 provide information about the distribution of inflation rates across the countries in the three decades. To ease the presentation, the upper panel considers inflation rates below 25% per year, whereas the lower panel looks at the entire range. Aside from the clustering of inflation rates around the median for each decade, the charts show the outlier countries with extremely high inflation rates (see footnote 3). Charts 4–6 provide the parallel information

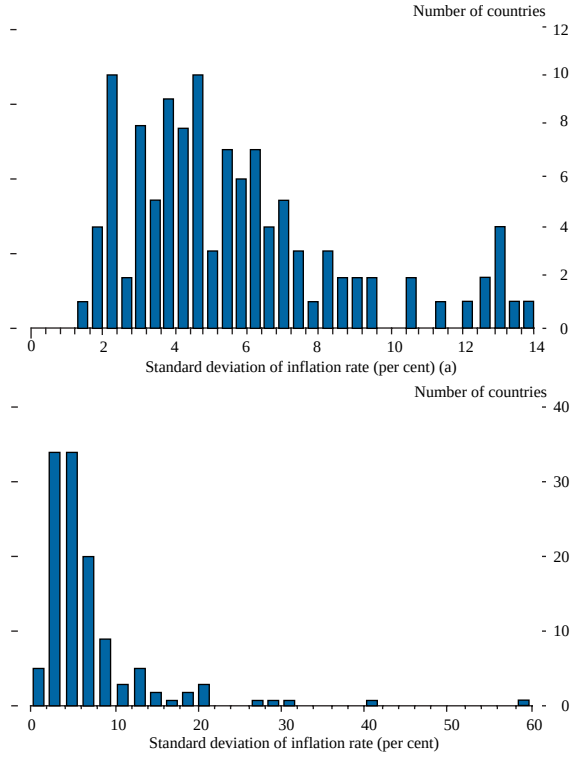
about the cross-country distribution of the decadal standard deviations of inflation. In these cases, the upper panels consider only standard deviations below 15% per year, whereas the lower panels examine the full range.

Chart 4
Distribution of standard deviations of inflation rates: 1960–70



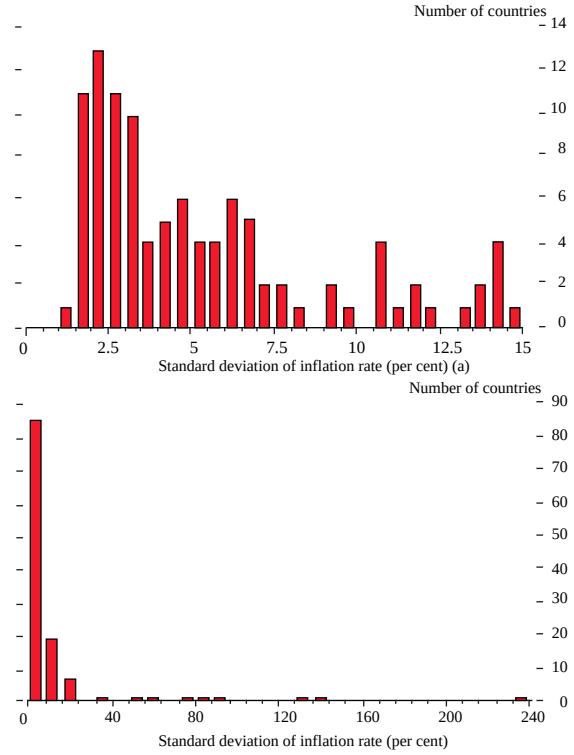
(a) For those countries whose average standard deviation of inflation rate was less than 15% per year.

Chart 5
Distribution of standard deviations of inflation rates: 1970–80



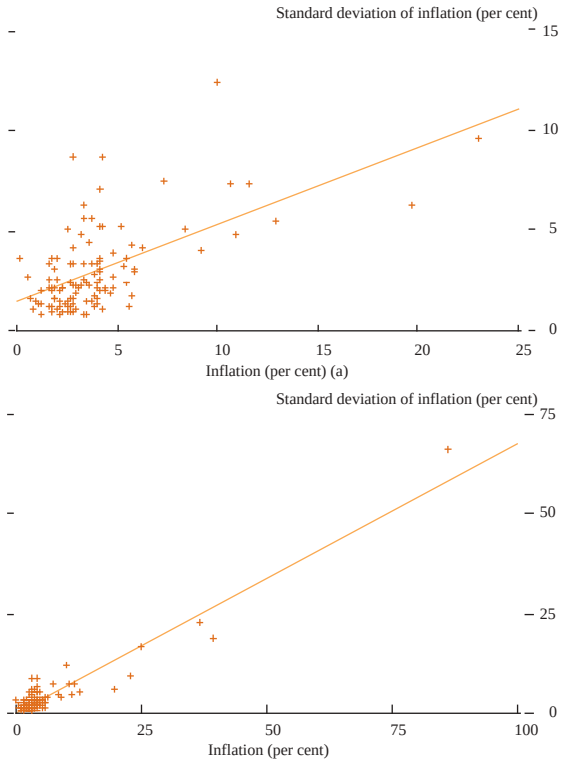
(a) For those countries whose average standard deviation of inflation rate was less than 15% per year.

Chart 6
Distribution of standard deviations of inflation rates: 1980–90



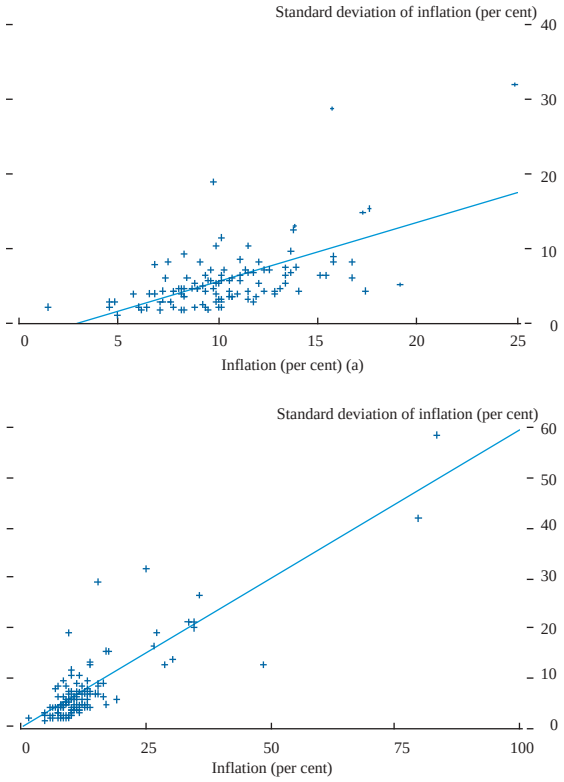
(a) For those countries whose average standard deviation of inflation rate was less than 15% per year.

Chart 7
Standard deviation of inflation versus inflation rate: 1960–70



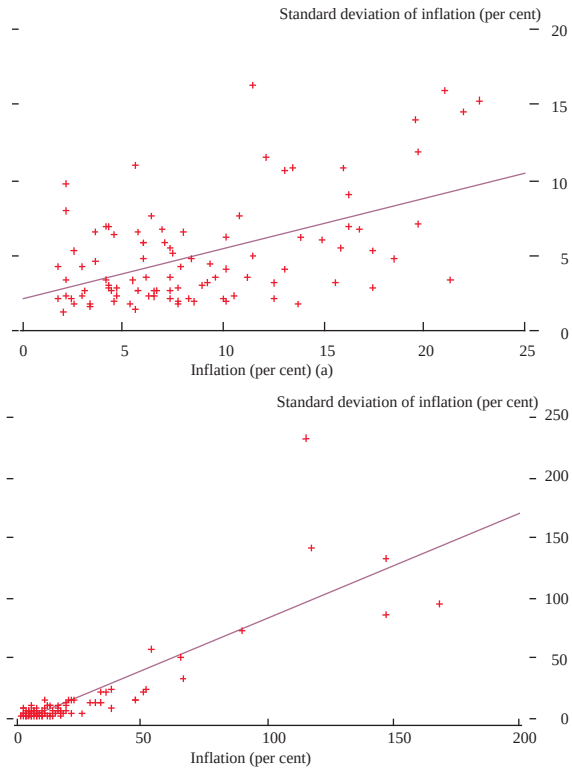
(a) For those countries whose average inflation rate was less than 25% per year.

Chart 8
Standard deviation of inflation versus inflation rate: 1970–80



(a) For those countries whose average inflation rate was less than 25% per year.

Chart 9
Standard deviation of inflation versus inflation rate: 1980–90



(a) For those countries whose average inflation rate was less than 25% per year.

Charts 7–9 confirm the well-known view that a higher variability of inflation tends to accompany a higher average rate of inflation [see, for example, Okun (1971) and Logue and Willett (1976)]. These charts provide scatter plots for each decade of the standard deviation of inflation (measured for each country around its own decadal mean) against the average inflation rate (the mean of each country's inflation rate over the decade). The upper panels of each chart consider only inflation rates below 25% per year, whereas the lower panels look at the entire range. The positive relation between variability and mean is apparent throughout, but is stronger in the plots that include the full range of inflation rates.

Table A also gives the means and medians of the growth rate of real per capita GDP and the ratio of investment to GDP for the three decades. The median growth rate fell from 3.1% in the 1960s (118 countries) to 2.5% in the 1970s (123 countries) and 0.4% in the 1980s (121 countries). The median investment ratio went from 16% in the 1960s to 19% in the 1970s and 17% in the 1980s. In contrast to inflation rates, the growth rates and investment ratios tend to be symmetrically distributed around the median.

2 Framework for the analysis of growth

To assess the effect of inflation on economic growth, I use a system of regression equations in which many other determinants of growth are held constant. The framework is one that I have developed and applied previously.(1)

A general notion in the framework is that an array of government policies and private-sector choices determine where an economy will go in the long run. For example, favourable public policies—including better maintenance of the rule of law and property rights, fewer distortions of private markets, less non-productive government consumption and greater public investment in high-return areas—lead in the long run to higher levels of real per capita GDP. (Henceforth, the term GDP will be used as a shorthand to denote real per capita GDP.) Similarly, a greater willingness of the private sector to save and a reduced tendency to expend resources on child-rearing (lower fertility and population growth) tend to raise standards of living in the long run.

Given the determinants of the long-run position, an economy tends currently to grow faster the *lower* its GDP. In other words, an economy's per capita growth rate is increasing in the gap between its long-term prospective GDP and its current GDP. This force generates a *convergence* tendency, in which poor countries grow faster than rich countries and tend thereby to catch up in a proportional sense to the rich places. However, poor countries grow quickly only if they have favourable settings for government policies and private-sector choices. If a poor country selects unfavourable policies—a choice that likely explains why the country is currently observed to be poor—then its growth rate will not be high and it will not tend to catch up to the richer places.

(1) See Barro (1991, 1994), Barro and Sala-i-Martin (1995, Chapter 12).

Another important element is a country's human capital in the forms of education and health. For given values of prospective and actual GDP, a country grows faster—that is, approaches its long-run position more rapidly—the greater its current level of human capital. This effect arises because *first* physical capital tends to expand rapidly to match a high endowment of human capital, and *second* a country with more human capital is better equipped to acquire and adapt the efficient technologies that have been developed in the leading countries.

Table B provides a qualitative summary of the estimated growth effects of the various determinants other than inflation. The quantitative results that underlie these patterns come from information about growth rates and the indicated explanatory variables for 78 countries from 1965 to 1975, 89 countries for 1975 to 1985 and 84 countries from 1985 to 1990.(1) (This sample reflects the availability of the necessary data.) The details for a similar set-up appear in Barro (1994).

Table B
Framework for the determination of growth rates across countries(a)

Determinant	Estimated effect on growth
Variables related to an economy's position at the start of each period:	
Initial real per capita GDP	Negative
Initial school attainment	Positive
Initial life expectancy (health status)	Positive
Variables related to government policy:	
Government consumption (relative to GDP)	Negative
Government spending on education (relative to GDP)	Positive, not significant
Distortions of markets (black-market premium on foreign exchange)	Negative
Subjective index for maintenance of the rule of law	Positive
Subjective index of democracy (political rights)	Positive at low levels, negative at high levels
Variables related to private-sector choices:	
Investment ratio	Positive, not significant
Fertility rate	Negative

(a) The table indicates the qualitative effect of each explanatory variable on the growth rate of real per capita GDP. The underlying estimates use 251 observations on growth rates, broken down among 78 countries for 1965–75, 89 countries for 1975–85 and 84 countries for 1985–90. Lagged values of the explanatory variables (except for initial schooling and life expectancy and the rule-of-law index) are used as instruments in the estimation. For details of the variables and statistical procedure, see Barro (1994).

3 Estimated effects of inflation on economic growth

Preliminary results

To get a first-pass estimate of the effect of inflation on economic growth, I included the inflation rate over each period as an explanatory variable along with the growth determinants described in Table B. Section A of Table C indicates that the estimated coefficient of inflation is -0.024 (standard error = 0.005). Thus, an increase of ten percentage points in the annual inflation rate is associated with a decline of 0.24 percentage points in the annual growth rate of GDP. Since the *t*-statistic for the estimated coefficient is 4.9, this result is statistically significant.(2)

Table C
Estimated effects of inflation on economic growth

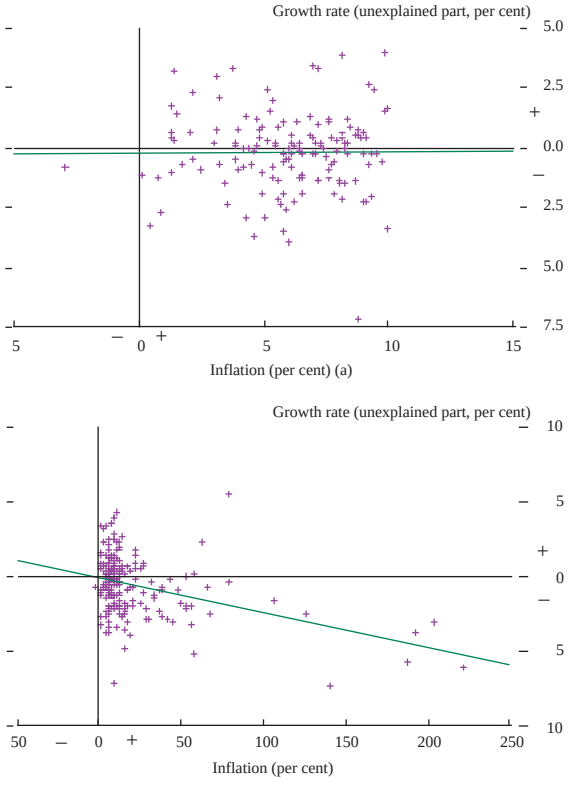
Estimation procedure	Estimated effect of an increase in the annual inflation rate of one percentage point on the growth rate of real per capita GDP (in percentage points per year) (a)	
A. Using actual inflation	-0.024	*0.005*
B. Using prior inflation as instrument	-0.020	*0.007*
C. Using prior colonial status as instruments	-0.031	*0.008*

(a) The numbers in italics are standard errors for the estimated effects of inflation on the growth rate of real per capita GDP. The estimates come from the systems described in Table B.

Chart 10 depicts graphically the relation between growth and inflation. The horizontal axis shows the inflation rate; each observation corresponds to the average rate for a particular country over one of the time periods considered (1965–75, 1975–85 and 1985–90). The top panel in the chart considers inflation rates below 10% per year, whereas the bottom panel includes the full range of inflation. The vertical axis shows the growth rate of GDP *net of the part of the growth rate that is explained by all of the explanatory variables aside from the inflation rate*.(3) Thus, the panels illustrate the relation between growth and inflation after all of the other growth determinants have been held constant.

The bottom panel of Chart 10 fits a downward-sloping regression line (least-squares line) through the scatter plot; the slope of this line corresponds to the significantly

Chart 10
Growth rate of real per capita GDP (part unexplained by other variables) and inflation rate



(a) For those countries whose average inflation rate was less than 10% per year.

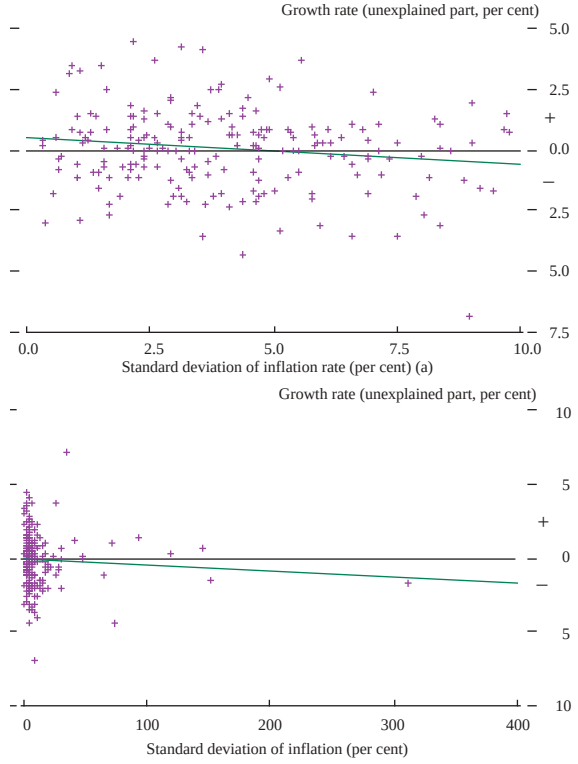
(1) The first period starts in 1965, rather than 1960, so that the estimation procedure can use lagged values of the various explanatory variables.
(2) This estimate is similar to that reported by Fischer (1993, Table 9). For earlier estimates of inflation variables in cross-country regressions, see Kormendi and Meguire (1985) and Grier and Tullock (1989).
(3) The residual is computed from the regression system that includes all of the variables, including the inflation rate. But the contribution from the inflation rate is left out to compute the variable on the vertical axis in the scatter diagram.

negative coefficient shown in Section A of Table C. The panel shows, however, that the fit is dominated by the inverse relation between growth and inflation at high rates of inflation, say at rates above 10%–20% per year. For lower inflation rates, as shown in the upper panel, the relation between growth and inflation is not statistically significant.

To check for linearity of the relation between growth and inflation, I estimated the system with separate coefficients for inflation in three ranges: up to 15%, between 15% and 40%, and over 40%. The estimated coefficients on inflation in this form are -0.016 (standard error = 0.035) in the low range, -0.037 (0.017) in the middle range, and -0.023 (0.005) in the upper range. Thus the clear evidence for the negative relation between growth and inflation comes from the middle and upper intervals. However, since the three estimated coefficients do not differ significantly from each other,(1) the data conform to a linear relationship. In particular, even at low rates of inflation, the data would not reject the hypothesis that growth is negatively related to inflation.

The estimates are also reasonably stable over time. If different coefficients for inflation are allowed for each period, then the resulting values are -0.019 (0.015) for 1965–75, -0.029 (0.010) for 1975–85, and -0.023 (0.005) for 1985–90. These values do not differ significantly from one another.

Chart 11
Growth rate of real per capita GDP (part unexplained by other variables) and standard deviation of inflation



(a) For those countries whose average standard deviation of inflation rate was less than 10% per year.

The standard deviation of inflation can be added to the system to see whether inflation variability has a relation with growth when the average inflation rate is held constant. The strong positive correlation between the mean and variability of inflation (Charts 7–9) suggests that it would be difficult to distinguish the influences of these two aspects of inflation. However, when the two variables are entered jointly into the regression system, the estimated coefficient on inflation remains similar to that found before [-0.021 (standard error = 0.008)], and the estimated coefficient on the standard deviation of inflation is virtually zero [-0.004 (0.009)]. Thus, for a given average rate of inflation, the variability of inflation has no significant relation with growth.

The nature of the relationship between the growth rate and the standard deviation of inflation is depicted in Chart 11. In this construction, the vertical axis plots the growth rate of GDP after allowing for the contributions of the other explanatory variables, including the average rate of inflation. The two panels in the chart show that the lack of relationship applies over the full range of experience. One possible interpretation of this surprising result is that the variability of inflation does not adequately measure the uncertainty of inflation, the variable that one would have expected to be negatively related to growth.

Instrumental variables for inflation

A key problem in the interpretation of the results is that they need not reflect causation from inflation to growth. Inflation is an endogenous variable, which may respond to growth or to other variables that are related to growth. For example, an inverse relation between growth and inflation would arise if an exogenous slowing of the growth rate tended to generate higher inflation. This increase in inflation could result if monetary authorities reacted to economic slowdowns with expansionary policies. Moreover, if the path of monetary aggregates did not change, then a reduction in the growth rate of output would tend automatically to raise the inflation rate (to be consistent with the equality between money supply and demand at each point in time).

It is also possible that the endogeneity of inflation would produce a positive relation between inflation and growth. This pattern tends to emerge if output fluctuations are driven primarily by shocks to money or to the aggregate demand for goods.

Another possibility is that some omitted third variable is correlated with growth and inflation. For example, better enforcement of property rights is likely to spur investment and growth, and is also likely to accompany a rules-based set-up in which the monetary authority generates a lower average rate of inflation. The idea is that a committed monetary policy represents the application of the rule of law to the behaviour of the monetary authority. Some of the explanatory variables in the system attempt to capture the degree of maintenance of the rule of law. However, to the extent that these measures are imperfect, the inflation rate

(1) The *p*-value for the hypothesis of equal coefficients is 0.65.

may proxy inversely for the rule of law and thereby show up as a negative influence on growth. The estimated coefficient on the inflation rate could therefore reflect an effect on growth that has nothing to do with inflation *per se*.

In general, the way to avoid these difficulties is to isolate relatively exogenous variations in inflation; that is, to use the data to try to mimic the results from experiments in which inflation is set arbitrarily at different values. The implementation of this idea requires satisfactory *instrumental* variables—reasonably exogenous variables that are themselves significantly related to inflation. If these instrumental variables can be found, then one can investigate whether the changes in inflation that are related to the instruments (and are, accordingly, exogenous) still have the kind of negative relation with growth that appears in Chart 10.

Central bank independence

One promising source of instruments for inflation involves legal provisions that guarantee more or less central bank independence. A recent literature(1) argues that a greater degree of independence leads to lower average rates of money growth and inflation, and to greater monetary stability. The idea is that independence enhances the ability of the central bank to commit to price stability and, hence, to deliver low and stable inflation. Alesina and Summers (1993, Figures 1a, 1b) find striking negative relationships among 16 developed countries from 1955 to 1988 between an index of the degree of central bank independence and the mean and variance of inflation. Thus, in this sample, the measure of central bank independence satisfies one condition needed for a good inflation instrument; it has substantial explanatory power for inflation.

Because of the difficulty of enacting changes in laws, it is plausible that a good deal of the cross-country differences in legal provisions that influence central bank independence can be treated as exogenous. Problems arise, however, if the legal framework changes in response to inflation (although the sign of this interaction is unclear). In addition, exogeneity would be violated if alterations in a country's legal environment for monetary policy are correlated with changes in unmeasured institutional features—such as structures that maintain property rights—that influence growth rates. This problem is, however, mitigated by the inclusion of other explanatory variables, notably the index of the rule of law, in the regression framework.

Cukierman (1992, Chapter 19) argues that the legal provisions that govern central bank action differ substantially from the way that the banks actually operate. In particular, he distinguishes the legal term of office of the central bank governor from the actually observed turnover. The latter variable would be more closely related to bank performance (and hence to inflation), but cannot be treated as exogenous to growth or omitted third variables. Thus, for the purpose of constructing instruments for inflation, the preferred strategy is to focus on the extent to which inflation can be explained by differences in legal provisions for the central bank.

Table D shows an index of central bank independence for 67 countries, based on the information compiled by Cukierman (1992, Chapter 19, Appendix A) over time periods that correspond roughly to the four decades from the 1950s to the 1980s. The index is an average over the time periods and for numerous categories of legal provisions contained in the charters of the central banks; see the notes to Table D. The details of construction differ somewhat from those used by Cukierman, but the values shown in the table are similar to those reported in his Table 19.3 for the 1980s.

Table D shows the average inflation rate from 1960 to 1990 for the 67 countries in my sample that have data on the index of central bank independence. A comparison between the index and the inflation rate reveals a crucial problem; the

Table D
Inflation rates and central bank independence(a)

Country	Index of independence	Inflation rate, 1960–90	Country	Index of independence	Inflation rate, 1960–90
West Germany	0.71	0.037	South Africa	0.33	0.099
Switzerland	0.65	0.038	Nigeria	0.33	0.125
Austria	0.65	0.043	Malaysia	0.32	0.034
Egypt	0.57	0.094	Uganda	0.32	0.353
Denmark	0.53	0.069	Italy	0.31	0.088
Costa Rica	0.52	0.117	Finland	0.30	0.073
Greece	0.52	0.109	Sweden	0.30	0.067
United States	0.51	0.049	Singapore	0.30	0.034
Ethiopia	0.50	0.058	India	0.30	0.074
Ireland	0.50	0.083	United Kingdom	0.30	0.077
Philippines	0.49	0.107	South Korea	0.29	0.113
Bahamas	0.48	0.063 (b)	China	0.29	0.039
Tanzania	0.48	0.133	Bolivia	0.29	0.466
Nicaragua	0.47	0.436	Uruguay	0.29	0.441
Israel	0.47	0.350	Brazil	0.28	0.723
Netherlands	0.47	0.045	Australia	0.27	0.067
Canada	0.47	0.054	Thailand	0.27	0.052
Venezuela	0.45	0.100	Western Samoa	0.26	0.112 (c)
Barbados	0.44	0.075	New Zealand	0.25	0.085
Argentina	0.44	0.891	Nepal	0.23	0.084
Honduras	0.44	0.058	Panama	0.23	0.033
Peru	0.44	0.606	Zimbabwe	0.22	0.074
Chile	0.43	0.416	Hungary	0.21	0.047
Turkey	0.42	0.235	Japan	0.20	0.054
Malta	0.42	0.035	Pakistan	0.19	0.072
Iceland	0.42	0.229	Colombia	0.19	0.170
Kenya	0.40	0.082	Spain	0.16	0.096
Luxembourg	0.40	0.044	Morocco	0.15	0.055
Zaire	0.39	0.357	Belgium	0.13	0.048
Mexico	0.37	0.227	Yugoslavia	0.12	0.395
Indonesia	0.36	0.366	Poland	0.12	0.293 (b)
Botswana	0.36	0.076	Norway	0.12	0.066
Ghana	0.35	0.256			
France	0.34	0.064			
Zambia	0.34	0.174			

(a) The index of central bank independence is computed from data in Cukierman (1992, Chapter 19, Appendix A). The index is a weighted average of the available data from 1950 to 1989 of legal provisions regarding: (1) appointment and dismissal of the governor (weight 1/6); (2) procedures for the formulation of monetary policy (weight 1/6); (3) objectives of central bank policy (weight 1/6); and (4) limitations on lending by the central bank (weight 1/2). The first category is an unweighted average of three underlying variables that involve the governor's term of office and the procedures for appointment and dismissal. The second category is an unweighted average of two variables, one indicating the location of the authority for setting monetary policy and the other specifying methods for resolving conflicts about policy. The third category relates to the prominence attached to price stability in the bank's charter. The fourth category is an unweighted average of four variables: limitations on advances, limitations on securitised lending, an indicator for the location of the authority that prescribes lending terms, and the circle of potential borrowers from the central bank. For each underlying variable, Cukierman defines a scale from 0 to 1, where 0 indicates least favourable to central bank independence and 1 indicates most favourable. The overall index shown in Table D runs correspondingly from 0 to 1. See Table A for a discussion of the inflation data.
(b) 1970–90.
(c) 1975–90.

(1) See Bade and Parkin (1982), Grilli, Masciandaro and Tabellini (1991), Cukierman (1992), Alesina and Summers (1993), Eijffinger and de Haan (1995).

correlation between the two variables is essentially zero. This verdict is also maintained if one looks separately over the three decades from the 1960s to the 1980s and if one holds constant other possible determinants of inflation. In this broad sample of countries, differences in legal provisions that ought to affect central bank independence have no explanatory power for inflation.(1) This negative finding is of considerable interest—it suggests that low inflation cannot be attained merely by instituting legal changes that appear to promote a more independent central bank. However, the result also means that we have to search further for instruments to clarify the relation between growth and inflation.(2)

Lagged inflation

Earlier values of a country's inflation rate have substantial explanatory power for inflation. Lagged inflation would also be exogenous with respect to innovations in subsequent growth rates. Hence, if lagged inflation is used as an instrument, then the estimated relation between growth and inflation would not tend to reflect the short-run reverse effect of growth on inflation.

One problem, however, is that lagged inflation would reflect persistent characteristics of a country's monetary institutions (such as the extent to which policy-makers have credibility), and these characteristics could be correlated with omitted variables that are relevant to growth (such as the extent to which political institutions support the maintenance of property rights). The use of lagged inflation as an instrument would therefore not rule out the problems of interpretation that derive from omitted third variables. However, the inclusion of the other explanatory variables in the regression framework lessens this problem.(3)

Section B of Table C shows the estimated effect of inflation on the growth rate when lagged inflation (over the five years prior to each sample period) is used as an instrument. The estimated coefficient is -0.020, similar to that found in Section A when actual inflation is used in the estimation. Thus, it seems that most of the estimated negative relation between growth and inflation does not represent reverse short-term effects of growth on inflation. It remains true, however, that the significant negative influence of inflation on growth shows up only for high inflation rates; the relation is insignificant if the sample is limited to rates below 10% per year.(4)

Results about the variability of inflation are also similar to those found before. If the standard deviation of inflation is included in the regressions (and a lag of this standard deviation is used as an instrument), then the estimated coefficient on average inflation changes little, and the estimated effect of the standard deviation of inflation is still around zero.

Prior colonial status

Another possible instrument for inflation comes from the observation that prior colonial status has substantial explanatory power for inflation. Table E breaks down averages of inflation rates from 1960 to 1990 by groups of countries classified as non-colonies (defined as those that were independent prior to US independence in 1776) and former colonies of Britain, France, Spain or Portugal, and other countries (in this sample, Australia, Belgium, the Netherlands, New Zealand and the United States).

Table E
Inflation rates and prior colonial status(a)

Per cent

Period	All countries	Non-colonies	British colonies	French colonies	Spanish or Portuguese colonies	Other colonies	Latin American other than Spanish or Portuguese colonies
1960–70	5.4 *121*	4.5 *31*	3.3 *43*	3.0 *21*	8.9 *19*	19.4 *7*	3.1 *7*
1970–80	13.1 *131*	11.0 *32*	12.0 *50*	9.3 *20*	21.8 *21*	14.7 *8*	10.9 *11*
1980–90	18.2 *132*	12.4 *31*	13.9 *51*	7.4 *22*	52.3 *20*	13.6 *8*	9.7 *11*
1960–90	12.6 *117*	8.9 *30*	10.4 *42*	6.6 *20*	29.4 *18*	16.1 *7*	9.0 *7*

(a) The numbers in italics are the numbers of countries with available data that fall into each category. See Table A for a discussion of the inflation data. Countries that were independent before 1776 are treated as non-colonies. Otherwise, the colonial status refers to the most recent outside power; for example, the Philippines is attributed to the United States, rather than Spain; Rwanda and Burundi are attributed to Belgium, rather than Germany; and the Dominican Republic is attributed to France, rather than Spain. Some countries that were dominated by other countries for some periods are treated as non-colonies; examples are Hungary, Poland, South Korea and Taiwan. The only present colony in the sample is Hong Kong. The last column refers to countries that are located in Latin America but are not former Spanish or Portuguese colonies.

Table E indicates that the average inflation rate for all 117 countries from 1960 to 1990 is 12.6% per year. The average for the 30 non-colonies of 8.9% is similar to that of 10.4% for the 42 British colonies and 6.6% for the 20 French colonies. However, the rates are strikingly higher for the 18 Spanish or Portuguese colonies—29.4%—and somewhat higher for the seven other colonies—16.1%.

A key reason for the low average inflation rate for the former French colonies is the participation of most of the sub-Saharan African states in the fixed-exchange rate regime of the CFA franc.(5) This type of reasonably exogenous commitment to relatively low inflation is exactly the kind of experiment that provides for a good instrument for inflation.

(1) Cukierman's (1992, Chapter 20) results concur with this finding, especially for samples that go beyond a small number of developed countries, the kind of sample used in most of the literature on central bank independence.
(2) Cukierman *et al* (1993) use as instruments the turnover rate of bank governors and the average number of changes in bank leadership that occur within six months of a change in government. These measures of actual bank independence have substantial explanatory power for inflation but need not be exogenous with respect to growth.
(3) Another favourable factor is that the residuals from the growth equations turn out not to be significantly correlated over time within countries.
(4) The estimated coefficients of inflation are again stable over the three time periods. A scatter plot of the unexplained part of the growth rate against the inflation rate is virtually the same as that shown in Chart 10. However, the line drawn through the points differs somewhat from that shown in the chart (the least-squares line) when lagged inflation is used as an instrument.
(5) For discussions of the CFA franc zone, see Boughton (1991) and Clement (1994). The zone maintained a fixed exchange rate with the French franc for 45 years until the devaluation from 50 to 100 CFA francs per French franc in January 1994. At the time of the devaluation, the zone covered 14 African countries grouped around three central banks: the West African Monetary Union of Benin, Burkina Faso, Ivory Coast, Mali, Niger, Senegal and Togo; a group of central African countries consisting of Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea and Gabon; and the Comoros. Some original members of the zone left to establish independent currencies—Djibouti in 1949, Guinea in 1958, Mali in 1962 (until it rejoined in 1984), Madagascar in 1963, Mauritania in 1973 and the Comoros in 1981 (to set up its own form of CFA franc). Equatorial Guinea, which joined in 1985, is the only member that is not a former colony of France (and not French-speaking).

For many of the former British colonies, a significant element may be their prior experience with British-organised currency boards, another system that tends to generate low inflation [see Schwartz (1993)]. These boards involved, at one time or another before independence, most of the British colonies in Africa, the Caribbean, south east Asia and the Middle East.

The high average inflation rate for the 16 former Spanish colonies in the sample does not reflect *per se* their presence in Latin America. For seven Latin American countries that are not former Spanish or Portuguese colonies,(1) the average inflation rate for 1960–90 is only 9.0%, virtually the same as that for the non-colonies (see Table E). Also, four former Portuguese colonies in Africa experienced the relatively high average inflation rate of around 20%.(2) For Portugal and Spain themselves, the average inflation rate of 10.9% for 1960–90 is well below the rate of 29.4% experienced by their former colonies. However, 10.9% inflation is substantially higher than that experienced by France (6.4%) and the United Kingdom (7.7%).

Section C of Table E shows the estimated effect of inflation on the growth rate of GDP when prior colonial status is used as an instrument.(3) The estimated coefficient is now -0.031, somewhat higher in magnitude than that found when actual inflation is used in the estimation. The significant negative relation again arises only for high inflation rates; the relation is insignificant if the sample is limited to rates below 10% per year.(4)

One question about the procedure is whether prior colonial status works in the growth regressions because it serves as an imperfect proxy for Latin America, a region that is known to have experienced surprisingly weak economic growth [see, for example, the results in Barro (1991)]. However, if a dummy variable for Latin America is included in the system (and prior colonial status is retained as an instrument), then the estimated coefficient of inflation remains negative and significant: it becomes -0.025, essentially the same as that found when actual inflation is used in the estimation (Section A of Table C).(5) Thus, the negative effect of inflation on growth does not reflect the tendency for many high-inflation countries to be in Latin America.

4 Estimated effects of inflation on investment

A likely channel by which inflation decreases growth is through a reduction in the propensity to invest. I have investigated the determination of the ratio of investment to GDP within a framework that parallels the one set out in Table B. The results for the effects of inflation are in Table F (see the notes to the table for a discussion of the other determinants of investment).

In the case of the investment ratio, the use of instruments turns out to be crucial for isolating a negative effect of inflation. Specifically, the procedures that use lagged inflation or prior colonial status as instruments (Sections B and C of Table F) reveal these significantly negative effects. An increase in average inflation by ten percentage points per year is estimated to lower the investment ratio by 0.4–0.6 percentage points. In contrast, when actual inflation is used, the estimated coefficient is close to zero (Section A of the table). These results suggest that the reverse relation between investment and inflation is positive and that the instrumental procedures isolate the negative effect of inflation on investment.

Table F
Estimated effects of inflation on investment

Estimation procedure	Estimated effect of an increase in the annual inflation rate by one percentage point on the ratio of investment to GDP (in percentage points) (a)	
A. Using actual inflation	-0.001	*0.011*
B. Using prior inflation as instrument	-0.059	*0.017*
C. Using prior colonial status as instruments	-0.044	*0.022*

(a) The numbers in italics are standard errors for the estimated effects of inflation on the ratio of investment to GDP. The estimates come from systems that include the explanatory variables described in Table B, other than the investment ratio itself. The main findings for these explanatory variables are that the investment ratio is positively related to initial human capital and to the rule-of-law index, negatively related to government consumption, positively related to democracy at low levels of democracy and negatively related to democracy at high levels of democracy.

Even when the instruments are used, the adverse effect on investment shows up clearly only for inflation rates above 10%–20% per year. For lower inflation rates, the estimated effect of inflation on the investment ratio tends to be negative, but not significantly different from zero. This finding accords with the results for growth rates.

5 Concluding observations

The bottom line from the empirical analysis is that the estimated effects of inflation on growth and investment are significantly negative when some plausible instruments are used in the statistical procedures. Thus, there is some reason to believe that the relations reflect causation from higher long-term inflation to reduced growth and investment.

It should be stressed that the clear evidence for adverse effects of inflation comes from the experiences of countries in which inflation exceeded 10%–20% per year in some

(1) The seven in the sample are Barbados, Dominican Republic (attributed to France rather than Spain; see the notes to Table E), Guyana, Haiti, Jamaica, Surinam, and Trinidad and Tobago. Five other former British colonies in Latin America that are not in this sample—Bahamas, Belize, Grenada, St. Lucia and St. Vincent—experienced the relatively low average inflation rate of 6.9% from 1970 to 1990.
(2) These four are Angola, Cape Verde, Guinea-Bissau and Mozambique. Data are unavailable for Cape Verde and Guinea-Bissau in the 1960s (prior to independence). The figures for Angola in the 1980s are rough estimates.
(3) The inclusion of years since independence does not materially alter the results. Also, the number of years since independence has no explanatory power for inflation. This result may arise because the former colonies of Spain and Portugal in Latin America all attained independence at roughly the same time. Moreover, the tendency toward high inflation predates the experiences since the end of the Second World War. See Bordo and Schwartz (1994) for a discussion of inflationary propensities during the nineteenth century in Argentina, Brazil and Chile.
(4) The estimated coefficients on inflation are still stable over the three time periods. A scatter plot of the unexplained part of the growth rate against the inflation rate is again virtually the same as that shown in Chart 10. The line drawn through the points differs from that shown in the chart (the least-squares line) because prior colonial status is used as an instrument.
(5) This system includes the inflation rate and the Latin America dummy as explanatory variables, and includes as instruments prior colonial status and the Latin America dummy. The estimated coefficient on the dummy variable is -0.0060 with a standard error of 0.0034. Thus, the effect is negative, but now only marginally significant. The results are basically the same if the Latin America dummy is added to the system in which actual inflation is used. It therefore appears that much of the estimated effect of the Latin America dummy on growth rates in previous research reflected a proxying of this dummy for high inflation.

periods. The magnitudes of effects are also not that large; for example, an increase in the average inflation rate by ten percentage points per year is estimated to lower the growth rate of real per capita GDP by 0.2–0.3 percentage points per year.

Over long periods, however, an apparently small change in the average growth rate has dramatic effects on standards of living. For example, if the growth rate of UK GDP from 1960 to 1990 had been higher by 1.1 percentage points per year, then UK GDP in 1990 would have been the highest in the world, instead of the 15th highest. More specifically, a reduction in the growth rate by 0.2–0.3 percentage points per year (produced by ten percentage points more of average inflation) means that the level of real gross domestic product would be lowered after 30 years by 4%–7%.(1) In 1994, the UK gross domestic product was £670 billion; 4%–7% of this amount equals the substantial sum of £27–47 billion, more than enough to justify the Bank of England's keen interest in price stability.

(1) In the model, the fall in the growth rate by 0.2%–0.3% per year applies on impact in response to a permanent increase in the inflation rate. The growth rate would also decrease for a long time thereafter, but the magnitude of this decrease diminishes toward zero as the economy converges back to its (unchanged) long-run growth rate. Hence, in the very long run, the effect of higher inflation is a permanently lower level of output, not a reduced growth rate. The numerical estimates for the reduced level of output after 30 years take account of these dynamic effects. The calculation depends on the economy's rate of convergence to its long-term growth rate (assumed, based on the cross-country evidence, to be 2%–3% per year).

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