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INFLATION AND MACROECONOMIC PERFORMANCE:

Some Cross-Country Evidence

by

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The views expressed in this paper are those of the authors. No responsibility for them should be attributed to the Bank of Canada.

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Abstract

The paper examines the hypothesis that high and variable inflation damages long-run macroeconomic performance. Empirical studies of this hypothesis are scarce despite numerous theoretical arguments as to why inflation and inflation uncertainty hinder economic performance. The results — based on 25 years of data from 62 countries — suggest that significant net benefits derive from a monetary policy that is directed to maintaining a stable and predictable price level. This paper tests for costs of inflation within the context of a modified version of the neoclassical growth model with human capital, developed by Mankiw, Romer and Weil (*A Contribution to the Empirics of Economic Growth*, NBER, 1990). The neoclassical model is well-suited to testing the hypothesis that inflation is harmful to economic performance. The vast majority of the literature on the costs of inflation suggests that the distortions caused by inflation are fundamentally long lasting and have their largest effect on total-factor productivity, which is a primary determinant of income per capita. These distortions should show up clearly in the Solow model, since it was designed to explain the steady-state level of income per capita.

The empirical work in the paper uses the Summers-Heston data base of macroeconomic variables standardized to facilitate international comparisons (Summers and Heston, "A New Set of International Comparisons of Real Product and Price Levels Estimates for 130 Countries, 1950-1985," *Review of Income and Wealth*, 1988). The results of the study indicate that the level of inflation and perhaps also its volatility have a negative long-run effect on income per capita, even after controlling for differences in savings rates, investment in human capital and population growth rates. The effect is particularly pronounced within countries belonging to the Organisation for Economic Co-operation and Development (OECD). The results are consistent with inflation having its largest distorting effect on total-factor productivity. The introduction of inflation into the model does not affect Mankiw, Romer and Weil's finding that countries converge to their steady-state level of income per capita at about the rate predicted by the augmented Solow model. This result is consistent with the view that inflation has its largest effect on the steady-state *level* of per capita income.

Résumé

La présente étude examine l'hypothèse selon laquelle un taux d'inflation élevé et variable nuit à la tenue de l'ensemble de l'économie en longue période. Peu de travaux empiriques se sont intéressés à cette question, même s'il existe de nombreux arguments théoriques quant aux raisons pour lesquelles l'inflation et l'incertitude qui entoure son évolution causent du tort à la tenue de l'économie. Selon les résultats obtenus par les auteurs à partir de données portant sur 62 pays et couvrant une période de 25 ans, une politique monétaire orientée vers le maintien des prix à un niveau stable et prévisible peut comporter de nets avantages. L'étude cherche à mesurer les coûts de l'inflation à l'aide d'une version modifiée du modèle de croissance néoclassique avec capital humain, mise au point par Mankiw, Romer et Weil (*A Contribution to the Empirics of Economic Growth*, National Bureau of Economic Research, 1990). Le modèle néoclassique est le modèle tout désigné pour vérifier l'hypothèse selon laquelle l'inflation nuit à la tenue de l'économie. La très grande majorité des travaux se rapportant aux coûts de l'inflation donne à penser que les distorsions liées à l'inflation sont fondamentalement durables et influent surtout sur la productivité globale des facteurs, qui est l'un des principaux déterminants du revenu par habitant. Le modèle de Solow devrait clairement faire ressortir ces distorsions, puisqu'il a été conçu pour expliquer le niveau du revenu par habitant en régime permanent.

La recherche empirique des auteurs s'appuie sur la base de données constituée par Summers et Heston («A New Set of International Comparisons of Real Product and Price Levels Estimates for 130 countries, 1950-1985», *Review of Income and Wealth*, 1988), dont les variables macroéconomiques sont normalisées afin d'être comparables entre pays. Les résultats de cette recherche indiquent que le niveau de l'inflation et peut-être également sa volatilité ont un effet négatif à long terme sur le revenu par habitant, même si l'on tient compte des différences observées en ce qui concerne le taux d'épargne, l'accumulation du capital humain et le taux de croissance démographique. Cet effet est particulièrement marqué dans les pays de l'Organisation de coopération et de développement économiques (OCDE). Les résultats confirment que la variable la plus perturbée par l'inflation est la productivité globale des facteurs. La prise en

compte de l'inflation dans le modèle ne modifie pas la conclusion de Mankiv, Romer et Weil voulant que le revenu par habitant des différents pays converge vers son niveau en régime permanent à la vitesse prévue par le modèle de Solow élargi. Ce résultat s'accorde avec le point de vue voulant que l'inflation agisse surtout sur le *niveau* en régime permanent du revenu par habitant.

1. Introduction

There are many reasons why inflation and/or inflation uncertainty should have a negative effect on macroeconomic performance. Yet, in spite of its pervasiveness, economists have had difficulty in identifying and measuring the separate mechanisms by which inflation distorts economic decision-making. This difficulty does not mean that the effects of inflation are unimportant. Rather, it suggests that a macro perspective may prove more fruitful in identifying them empirically.

The purpose of this paper is to estimate the total, long-run effect of inflation and inflation uncertainty on aggregate economic output. Using data from 22 countries belonging to the Organisation for Economic Co-operation and Development (OECD) as well as a larger "world" sample, we find that inflation has a negative effect on economic output that is economically large and statistically significant. The framework for the analysis is the augmented Solow growth model of Mankiw, Romer and Weil (1990).

Perhaps the most important effect that inflation can have on economic output is its effect on the efficient functioning of the price system — the menu costs of inflation. Included in these costs are the resources devoted to the "unproductive" activity of changing prices frequently (Cecchetti, 1986), the deadweight loss arising from unco-ordinated price adjustments (Leijonhufvud, 1980), the efficiency loss from resource misallocation that occurs as the distinction between relative prices and absolute prices becomes blurred (Friedman, 1986), the efficiency loss from increased product standardization (Carlton, 1982), the deadweight loss from increased relative price dispersion (Parks, 1978), and increased search costs (Paroush, 1986). Inflation can also increase the cost of wage determination by necessitating more frequent labour negotiations that often result in strikes and other disruptions to work that reduce output (Lacroix and Dussault, 1979).

Inflation can also discourage capital formation by reducing the rate of return on capital through higher effective tax rates on corporate profits (Feldstein, 1982) and through higher effective tax rates on investment income (Gilson, 1984) and capital gains (Feldstein and Slemrod, 1978).

Moreover, the aggregate capital stock is not as efficient as it would otherwise be, because inflation can distort relative rates of taxation across different classes of investment (Boadway, Bruce and Mintz, 1984) and across different industries (Bossons, 1983). Inflation may also reduce capital efficiency by diverting investment away from long-lived assets towards assets with shorter service lives (Mauskopf and Conrad, 1981).

Then there are the well-known "shoe-leather" costs of inflation. These include the private costs of the increased transactions necessitated by reduced money holdings (Friedman, 1969) and the social cost of holding sub-optimal amounts of the public-good money (Laidler, 1978).

Inflation uncertainty also can exact a toll from the economy. Uncertain inflation can reduce innovation in new goods and processes by diverting resources to the "unproductive" activity of managing the effects of inflation (Howitt, 1990). Economic agents may make larger and more frequent forecast errors that hinder the efficient allocation of resources (Frohman, Laney and Willett, 1981). It can mean higher and more volatile interest rates because of higher risk premiums (Baranea, Dotan and Lakonishok, 1979) and because expectations shift more frequently (Khan, 1977). Inflation uncertainty can discourage capital formation (Abel, 1980). It also makes the credibility of macroeconomic policies hard to establish (Fellner, 1976).

Despite the many theoretical arguments for costs of inflation, it would be fair to say that the empirical work on quantifying the effects of inflation on economic activity has not conclusively demonstrated the importance of these costs. The work has not been very convincing because it tends to suffer from a number of deficiencies.

First, studies that use time-series data have a difficult time distinguishing the long-run relationship between output and inflation from the cyclical relationship (due for example to labour hoarding in response to supply shocks or countercyclical monetary policy). These studies run the risk of attributing the cyclical correlation between inflation and productivity growth to long-run structural factors, thereby overstating the long-run effect. Cyclical fluctuations in productivity are not permanent and therefore do not constitute a true cost of inflation.

Second, most studies that use cross-sectional data use average data for the period to avoid problems with cyclical correlations. By using average data, however, they introduce a problem with causality. It is not clear from average data whether a country has (for example) high inflation early in the sample followed by low growth later, or whether it has low growth early followed by high inflation later. The difference is important to the interpretation of the results.

Third, empirical studies on the costs of inflation usually lack theoretical structure, usually consisting of fairly loosely specified empirical equations (an exception is De Gregorio (1991)).

Fourth, the studies make little distinction between the level and growth rate effects of inflation. Thus they risk confusing the temporary effects of inflation on the growth rate of output (permanent effects on the level of output) with permanent effects on the growth rate of output.

Finally, not enough attention is paid to distinguishing between effects due to the level of inflation and those that are in fact due to inflation volatility. Since the mean and variance of inflation are highly correlated, this is not a trivial issue.

In attempting to quantify the effects of inflation on output and productivity, our study seeks to avoid these pitfalls. We use cross-sectional data to avoid cyclical correlations. We avoid the causality problem by correlating end-point output with average inflation over the sample. Thus, inflation precedes output in our analysis. In some of our regressions, we also have the starting-point level of output as a regressor, further minimizing the chance of reverse causation. We base our estimating equations on an explicit theoretical framework, namely, a version of the neoclassical growth model modified to include human capital. This model is used as an organizing framework for estimating the effect of inflation on macroeconomic efficiency (total factor productivity). We make a sharp distinction between the effects of inflation on the level of output and the effects on the growth rate of output along a convergence path to the steady state. Finally, we include both the level and the volatility of inflation in our regressions.

The remainder of the paper proceeds as follows. Section 2 briefly summarizes the results of previous studies estimating the effects of inflation on output. Section 3 is a first look at the data with some preliminary regressions. Section 4 adds costs of inflation to a version of the neoclassical growth model and estimates the effects of inflation and of inflation volatility on the level of efficiency. Section 5 estimates the effects of inflation on the rate of growth of output along the convergence path. Based on the preceding results, Section 6 seeks to answer the question: How large are the benefits of disinflation? Section 7 is a conclusion.

2. Previous Empirical Estimates of the Costs of Inflation

The link between inflation and inflation uncertainty

Inflation and inflation uncertainty tend to move together, making it difficult to identify empirically their separate effects on output. Okun (1971) was one of the first to document the link between inflation and uncertainty. He finds a strong positive correlation between average inflation and inflation uncertainty as measured by the standard deviation of inflation for 17 industrial countries over the period 1951 to 1968. Jaffee and Kleiman (1977) extend Okun's analysis to the inflation experience of Latin American countries and find a positive relationship there as well. Logue and Willett (1976) measure inflation uncertainty by the naive forecast errors of models designed to predict inflation and find a positive correlation between inflation and inflation uncertainty across 41 countries for the period 1949 to 1970. Foster (1978) uses the average absolute year-to-year change in inflation to measure inflation uncertainty and finds a positive relationship between inflation and uncertainty for 23 advanced economies and 17 Latin American economies over the period 1954 to 1975. In one of the few studies to use time series data, Mitchell (1981) finds that inflation uncertainty is related to the level of inflation expectations in the United States.

The link between inflation and output

Economists have typically employed one of three estimation strategies in obtaining estimates of the effect of inflation or inflation uncertainty on output — a "back-of-the-envelope" calculation, an estimate from a time-series model, or an estimate from a cross-sectional regression.

Back-of-the-envelope calculations

Howitt (1990) uses a back-of-the-envelope calculation to estimate the effect of inflation on output in Canada. He concentrates on the effect of inflation-induced tax distortions on the cost of capital. He estimates that a one percentage point decrease in inflation is likely to reduce the after-tax marginal product of capital by 0.3 percentage points, and that such a decline should enhance the productivity of capital enough to generate a permanent increase in GDP of 1.9 per cent.

Time series models

Jarrett and Selody (1982) use a tri-variate time-series model of inflation, productivity growth and hours to examine the link between output and inflation in Canada over the period 1963 to 1979. They estimate that a one percentage point decrease in inflation would induce a 0.3 percentage point increase in the growth rate of labour productivity and hence GDP. Novin (1991) extends the Jarrett and Selody study to include data from the 1980s. He obtained the same estimate of the effect of inflation on productivity growth once he controlled for changes in relative factor costs. Selody (1990) uses Canadian data for the period 1955 to 1989 to estimate a four-variable time-series model that controls for cyclical movements in labour productivity associated with labour hoarding. These estimates suggest that a one percentage point decline in inflation should increase labour productivity growth by 0.2 percentage points.

Clark (1982) estimates a bi-variate time-series model of inflation and productivity growth using American data for the period 1947 to 1981. Estimates from the model indicate one-way causality from inflation to productivity growth with coefficients large enough to suggest that a one percentage point decline in inflation would result in an unbelievably large 0.4 percentage point increase in productivity growth and hence GNP growth. The parameters estimated by Clark are likely contaminated by the short-run cyclical correlation between inflation and productivity associated with supply shocks and labour hoarding, and thus the results probably overstate the long-run relationship. Selody (1990) attempts to correct this by using American data for the period 1955 to 1989 to estimate a four-variable time series model that controls for variations in labour productivity arising from variations in the capital-labour ratio and from labour hoarding. The estimates suggest that a one percentage point reduction in inflation increases labour productivity growth more believably by 0.1 percentage points.

Grimes (1990) estimates time-series equations for 21 industrial countries for the period 1961 to 1987 using seemingly unrelated regressions. The model includes a variable to control for variations in productivity growth caused by supply shocks transmitted through the terms of trade. Estimates from the model suggest that, on average, a one percentage point reduction in inflation increases output growth by 0.1 percentage points. The estimates range from a high of 0.4 for Spain to a low of 0.0 for Ireland.

In a more detailed industry study using pooled time-series and cross-sectional data, Buck and Fitzroy (1988) estimate a production function (consisting of hours, electricity, capital and labour) to examine the link between inflation and productivity growth for 40 West German industries pooled into five industrial groups over the period 1950 to 1977. They find that a one percentage point decrease in inflation would increase output growth by 0.16 percentage points in the mining sector, by 0.14 percentage points in the production goods sector, by 0.04 percentage points in the investment goods sector, and by 0.45 percentage points in the consumer goods sector. Another finding is that output growth in the foodstuffs industry is positively related to inflation.

Cross-section equations

Kormendi and Meguire (1985) regress average GDP/GNP growth for the period 1950 to 1977 against average inflation, the average variance of the money supply and other economic variables. They include data from 47 countries in their cross-sectional regression and find a significant negative relationship between inflation and growth such that a one percentage point reduction in inflation corresponds to an increase in growth of 0.5 percentage points. Greater variability in the money supply is also found to lower growth, explaining a large 22 per cent of the variation in growth. Grier and Tullock (1989) extend the analysis of Kormendi and Meguire to 115 countries for the period 1950 to 1981. Estimates from their model suggest that a one percentage point reduction in inflation would result in a 0.16 percentage point increase in growth. They also found that the standard deviation of inflation is significantly and negatively related to output growth.

In another ad hoc regression, Barro (1991) uses the Summers and Heston (1988) data base to regress the average growth rate of per capita real GDP on 33 potential determinants of growth. Inflation is not one of these determinants, but the equation includes a dummy variable for Latin American countries. Roubini and Sala-i-Martin (1991) add inflation to the Barro equation and find that it reduces the significance of the Latin American dummy.[1]

De Gregorio (1991) estimates an equation that is consistent with an endogenous growth model. The equation uses pooled cross-section and time-series data for 12 Latin American countries. The data is grouped into 6-year averages and covers the period 1950 to 1985. The equation is specified such that the logarithm of inflation is related to output growth. One can infer from the equation that a halving of average inflation from sample means would produce an increase in growth of 0.5 percentage points. De Gregorio presents evidence to suggest that the negative effect of inflation on growth is mostly associated with lower factor productivity growth.

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1. As reported by De Gregorio (1991).

Mullineaux (1980) examine data for the United States and estimates that a unitary decrease in the standard deviation of inflation would result in a 1 to 2 percentage point decrease in unemployment over a two-year period. Levi and Makin (1980) estimate that a unitary decrease in the standard deviation of inflation would raise employment by 2.25 per cent using American data for the period 1965 to 1975. These changes in employment are equivalent to an increase in GNP of between 2 and 4.5 per cent, assuming an Okun coefficient of two. Darrat and Lopez (1989) examine the time series evidence for 12 Latin American countries over the period 1952 to 1984 and find that a unitary decrease in the standard deviation of inflation would raise real GDP by an average of 0.37 per cent.

3. A First Look at the Cross-Country Evidence

The data and their sources are described in detail in Appendix A. Table 1 (p. 32) presents summary statistics on the key variables used in the paper. Essentially, data on real income per working-age population are from the Summers-Heston data base (Summers and Heston, 1988), and data on CPI inflation are from the IMF's IFS data tape.

Figure 1 (p. 52) shows average inflation over a 25-year period (1960 to 1985) plotted against average growth in GDP per working age population for the same 25-year period for 22 OECD countries. Figure 2 (p. 52) shows the same variables for 62 countries (henceforth referred to as the world) for which reliable data are available (including the 22 OECD countries).[2] For the OECD countries, there is no apparent negative relationship between growth and inflation. In fact, the simple correlation between inflation and growth in income per capita is slightly positive at 0.19. This correlation is also weak

2. We used the maximum number of countries for which data on all the variables was available for the full 1960 to 1985 period.

for the world sample of 62 countries (see Figure 2, p. 52 and Table 2, p. 32), though the correlation is now slightly negative at -0.17.[3]

Many studies find that inflation volatility is positively related to the level of inflation. This is true in our samples as well: the correlation between the level of inflation and its standard deviation is 0.95 for both the OECD and world samples. In fact, a regression of the standard deviation of inflation on the level using data from the world sample of countries yields a coefficient of 1.2 and a t-statistic of 24. Thus, in order to minimize multicollinearity problems, most of the empirical work in this paper uses the coefficient of variation to measure inflation volatility, that is, the standard deviation divided by the mean.[4] This is really a measure of volatility that is over and above changes in average inflation. Indeed, Davis and Kanago (1992) and Davis (1992) argue that such a relative measure of inflation volatility is to be preferred on theoretical grounds.[5]

Figures 3 and 4 (p. 53) plot inflation volatility (as measured by the coefficient of variation) against average growth in per capita income for the OECD and the world. The impression created by the graphs is that there is no relation between the variables. These conclusions are also valid when the unadjusted standard deviation is used as the measure of inflation volatility. The correlations given in Table 2 confirm this.

Overall therefore, neither the level nor the variability of inflation seem systematically related to average growth rates of income per capita (in a bivariate sense) across countries. A dramatically different picture emerges,

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3. Of course, simple correlations are an inadequate test of the hypothesis that inflation affects productivity, since important economic variables are excluded from the relationship [a point made by Grimes (1990)]. We deal with this point later in the paper.

4. In practice, we often use the logarithm of the coefficient of variation in our regressions. We also tried the residuals from the regression of standard deviation on the level of inflation as a measure of volatility. The empirical results using this measure were very close to those obtained using the coefficient of variation, as one would expect given that the estimated coefficient on the level of inflation is close to unity.

5. The coefficient of variation is appropriate when the effects of inflation uncertainty come through uncertainty about the real values of economic variables generated by volatility in the price deflator. This ignores other channels by which uncertainty could affect economic behaviour.

however, when one examines the relationship between the inflation variables and the level of income. Figure 5 (p. 54) shows an obvious negative relation between average inflation over the 1960-85 period and the level of GDP per worker in 1985 for the 22 OECD countries.[6] The correlation coefficient is strongly negative at -0.87 (see Table 2, p. 32). For the world sample (Figure 6, p. 54), the relationship also appears to be a negative one, though somewhat less clear-cut, and the correlation coefficient is correspondingly lower at -0.24.

Figures 7 and 8 (p. 55) plot inflation volatility over the 1960-85 period against the level of GDP per worker in 1985 for the two samples. There is a strong suggestion of a negative relationship here as well, though again the correlation is stronger for the OECD countries than for the world (-0.86 and -0.35 respectively, see Table 2).

The graphs and simple correlations discussed above suggest the existence of a negative relationship between inflation and the level of productivity across countries. Simple regressions confirm the above findings. We regress the level and the growth rate of GDP per worker in 1985 on the level and volatility of inflation both separately and together. Note that here and throughout the remainder of the paper, we use the log-log form -- that is, the relationship is estimated as one between the logarithm of income per capita and the logarithm of inflation and/or inflation volatility as measured by the coefficient of variation.[7] While the data for the OECD countries shows a slight preference for the semi-log specification, the world data seem to prefer the log-log specification (that is, the inflation coefficient is an elasticity rather than a semi-elasticity) in the sense that t-statistics are significantly higher. This is consistent with the correlations in Table 2 which, for the world sample, are always significantly higher for the log-log case.

6. Note that the GDP variable is its level at the end point (1985), and thus the relationship with inflation over the preceding 25 years suggests a causal relationship.

7. While the log-log specification seems to fit the data better, at least for the world sample, it should be noted that there is a problem with the interpretation of the inflation coefficient at low inflation rates. As the inflation rate approaches zero, the effect of inflation on income approaches infinity. This may not be a problem in our sample, where the lowest inflation rate is 3.6, but caution should be used in applying our estimates to countries with very low inflation rates. Later, we make use of estimates based on a semi-log specification for the low inflation case.

Note also that here and in other regressions in the paper, volatility is measured by the coefficient of variation.[8] Figures 9 and 10 (p. 56) present the log-log graphs for inflation and the level of GDP per worker.

Table 3 (p. 33) presents the estimation results for the 22 OECD countries. The coefficients on the level and volatility of inflation are negative and significant at the 5 per cent level when entered separately; however, when they are entered together, only the level is significant.[9] The level of inflation is particularly significant. Table 4 (p. 33)presents simple regressions for the 62-country sample. The coefficients on both the level and volatility of inflation are always negative, and also significant in the separate regressions. When they appear together (column 3), however, inflation volatility is significant while the level is not (barely). There is a suggestion in Figure 10 that there are really two separate curves in the full sample for the richer and poorer countries. To test this idea somewhat crudely, we include a dummy which equals 0 for OECD countries and 1 for non-OECD countries in the regression with the two inflation variables. This regression is presented in the column 4 of Table 4. The dummy is highly significant, indicating perhaps the presence of excluded variables which determine the level of GDP per capita. Also, the level of inflation is now significant while volatility is not.

Tables 5 and 6 (p.34) present regressions with the dependent variable being the 1960-85 average growth rate of income per capita. There is no evidence of a negative effect of inflation on growth amongst the OECD countries, and only weak evidence at best on the world sample.

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8. The coefficient of variation can be interpreted as capturing the effect of an increase in volatility that is over and above that associated with an increase in the mean inflation rate. Another way to view this is that even though the level and volatility of inflation are closely related over history and across countries, it is still possible to conceive of an increase in volatility that is over and above that associated with higher average inflation. The coefficient on our relative volatility measure estimates this effect.

9. This illustrates one advantage of the coefficient of variation used to measure volatility. The raw standard deviation of inflation is so highly correlated with its level that, while they are separately significant in the regressions, their inclusion together renders their estimates imprecise though jointly significant.

Overall, the graphs, correlations and simple regressions suggest that there is a significant negative effect of both the level and volatility of inflation on income per capita (or productivity). These effects appear to be primarily on the level of productivity rather than its rate of growth, and they appear to be somewhat stronger within the OECD countries than for the world as a whole. To conclude that we have succeeded in isolating costs of inflation, however, we must first resolve a number of issues.

It is possible that the negative relation between inflation and per capita income reflects some form of reverse causation. One explanation may be that rich countries have better-developed market economies and tax systems and depend less on the inflation tax. Another possibility is suggested by the Barro-Gordon (1983) framework. Suppose that high-income countries get that way because they are high savers (and investors in physical and human capital), and that their high savings rates reflect low rates of time preference (low rate of preference for current consumption relative to future consumption). A society with a low rate of time preference would be more focussed on any long-run benefits of low inflation and would be less willing to trade them off against the short-term gains from exploiting the Phillips curve. As a result, high- income countries might have low inflation by choice, with other real factors causing both the low inflation and high income.

In an attempt to control for these possibilities of reverse causation, we nest possible inflation effects on productivity within a modified version of the neoclassical growth model due to Mankiw, Romer and Weil (1990). That is, we control for the real factors which theory suggests determine the level of income per capita: rates of investment in human and physical capital, as well as population growth. The idea is to verify whether costs of inflation still appear when we control for the fundamental real determinants of income variations across countries. There are two other ways in which we control for the possibility of reverse causation: first, we estimate the effect on income in a given year of inflation in the preceding 25 years; second, we control for the initial level of income (that is, the level 25 years before) to verify whether inflation has effects on income over and above that which could be predicted from simply the initial income plus other real factors.[10] Another issue which we shall address is the effect of inflation on the growth path of income per capita. If inflation has such a clear negative effect on the level of productivity, should such effects not also be apparent on the growth rate? Presumably, the economy is always on a convergence path to the steady state, and inflation effects should be apparent along this path. Since there are other factors that affect the growth rate of income per capita, including the initial level, it is possible that the effect of inflation on growth is being masked. Thus, it will be important to control for these other factors. We shall address this issue by estimating the rate of convergence in the growth model with inflation effects.

4. The Costs of Inflation within a Modified Solow Growth Framework

The theoretical approach

The traditional neoclassical growth model originating with Solow (1956) explains variations in the steady-state level of income per capita as a function of variations in savings (or investment) rates and population growth rates, as well as variations in the level of technology or total factor productivity. However, since technology is commonly viewed as being easily diffused among countries, it is the first two variables which are usually held to be important. The pure Solow model has, however, been criticized for its seemingly counterfactual prediction that countries will converge in levels of income per capita, controlling for differences in savings and population growth rates. For example, Barro (1991) and Lucas (1988) argue that the data do not support such convergence, and propose

10. Of course, we cannot entirely rule out the possibility of reverse causation. It is possible that causal inference based on the period-average inflation rate and the beginning and end points for income may be flawed because of peculiarities in the timing of changes in inflation and income during the 25-year period.

models with human capital and endogenous growth. Endogenous growth models typically predict no convergence. Mankiw, Romer and Weil (1990) take up the challenge and introduce human capital accumulation into the Solow model. They find that this modified Solow growth model is able to explain the stylized facts on levels and rates of convergence of per capita incomes across countries. The inclusion of the rate of investment in human capital (measured by the percentage of the working-age population attending school) leads to a sharp improvement in the performance of the model. This approach provides a particularly convenient way of testing for costs of inflation. We nest cost of inflation effects within the Mankiw-Romer-Weil growth model by positing that there are such effects on the level of efficiency or technology.

Mankiw, Romer and Weil assume a Cobb-Douglas production function, so that production at time t is given by

$$Y = K^{\alpha} H^{\beta} (ZL)^{1-\alpha-\beta} \tag{1}$$

$$0 < \alpha < 1, \alpha + \beta < 1,$$

where Y is output, K is physical capital, H is human capital, L is labour, and Z is the level of technology. The parameters α and β are the shares in income of physical and human capital respectively.[11] Labour is assumed to grow exogenously at rate n:

$$L_t = L_0 e^{nt}. \tag{2}$$

The level of technology is assumed to grow exogenously at rate g. In addition, however, we will assume for the purposes of this paper that the level of technology at a point in time is a function of both the level of inflation, π, and inflation volatility, σ:

$$Z_t = Z_0 e^{gt} f(\pi, \sigma). \tag{3}$$

11. This production function implies that the measured share of labour can be subdivided into the share of pure labour, L, and the share of human capital, H. Another implication is that the growth of total factor productivity in models which exclude human capital is determined by the rate of growth of human capital per worker, in addition to pure technical progress.

In particular, we shall assume a log-linear form for the function *f(.)*:

$$Z_t = Z_0 e^{gt} \pi^{\theta} \sigma^{\phi}, \tag{4}$$

where the elasticities of technology with respect to inflation and inflation volatility, respectively θ and ϕ, will be verified empirically.

Define k as the stock of capital per effective unit of labour (efficiency units), $k = K/ZL$, h as the stock of human capital per effective unit of labour, $h = H/ZL$, and y as the level of output per effective unit of labour, $y = Y/ZL$. Let s_k denote the fraction of income spent on investment in physical capital, and s_h denote the fraction spent on human capital accumulation. Then the physical and human capital stocks evolve according to

$$\dot{k} = s_k y - (n + g + \delta) k \tag{5}$$

$$\dot{h} = s_h y - (n + g + \delta) h, \tag{6}$$

where it is assumed, for simplicity, that both types of capital depreciate at the same rate δ. The steady state is defined as the state when both types of capital are constant in efficiency units.[12] The equilibrium values of the physical and human capital stocks, k^* and h^*, are given by

$$k^* = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n + g + \delta} \right)^{\frac{1}{1-\alpha-\beta}} \tag{7}$$

$$h^* = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n + g + \delta} \right)^{\frac{1}{1-\alpha-\beta}} . \tag{8}$$

12. It should be noted that returns on the two types of capital will not be equalized in the steady state, since their savings rates are taken as exogenous.

The equilibrium level of output per effective unit of labour , y^*, is

$$y^* = s_k^{\frac{\alpha}{1-\alpha-\beta}} s_h^{\frac{\beta}{1-\alpha-\beta}} (n+g+\delta)^{-\frac{(\alpha+\beta)}{1-\alpha-\beta}}. \tag{9}$$

Output per effective labour unit depends positively on rates of investment in physical and human capital, and negatively on population growth.

The log of output per capita (Y/L), is thus given by

$$ln(\frac{Y}{L}) = lnZ + (\frac{\alpha}{1-\alpha-\beta}) ln(s_k) + (\frac{\beta}{1-\alpha-\beta}) ln(s_h)$$

$$-\frac{(\alpha+\beta)}{(1-\alpha-\beta)} ln(n+g+\delta), \tag{10}$$

where the level of technology is a function of the level and volatility of inflation from equation (4):

$$lnZ_t = lnZ_0 + gt + \theta ln(\pi) + \phi ln(\sigma). \tag{11}$$

The empirical equation that we estimate is

$$ln(\frac{Y}{L}) = a_0 + a_1 ln(s_k) + a_2 ln(s_h) + a_3 ln(n+g+\delta)$$

$$+ a_4 ln(\pi) + a_5 ln(\sigma), \tag{12}$$

where the predicted coefficients are

$$a_0 = ln\,(A_0) + gt > 0 \tag{13}$$

$$a_1 = \frac{\alpha}{1-\alpha-\beta} > 0 \tag{14}$$

$$a_2 = \frac{\beta}{1-\alpha-\beta} > 0 \tag{15}$$

$$a_3 = -\frac{(\alpha+\beta)}{1-\alpha-\beta} < 0 \tag{16}$$

$$a_4 = \theta < 0 \tag{17}$$

$$a_5 = \phi < 0. \tag{18}$$

Notice that the model implies a restriction on the coefficients:

$$a_1 + a_2 + a_3 = 0. \tag{19}$$

By estimating equation (12), we are able to verify whether the inflation variables still have a negative impact on income per capita across countries, even when controlling for differences in rates of investment in physical and human capital and population growth rates.

Finally, a note on the generality of the result: The model used here takes the savings rate as given, in contrast to optimal-consumption versions of the neoclassical growth model in which the rate of time preference is given. In Appendix B, we analyse a neoclassical growth model with money and costs of inflation, in which agents are intertemporally optimizing. Inflation effects on the level of efficiency in the optimal growth model result in the same steady-state relation between income per capita, the savings rate, and the population growth rate, as in equation (12).

The results

Like Mankiw, Romer and Weil, we assume that the rate of technical progress and the rate of depreciation vary randomly across countries. Since we do not measure them, their effects will show up in the constant term and in the residuals. We follow them in assuming that $g+\delta$ averages 5 per cent. The Summers-Heston data on output per worker, investment to GDP and population growth are used to measure Y/L, s_k and n respectively. We use the Mankiw, Romer and Weil measure of the rate of investment in human capital, s_h: the proportion of the working-age population attending secondary school, referred to as SCHOOL. This variable is strongly correlated with GDP per capita. Effectively, we are assuming that the true human capital investment rate is proportional to the variable SCHOOL.

Table 7 (p. 35) presents the results of estimating unrestricted versions of equation (12) on the 22 OECD countries.[13] With the exception of the measure of the human capital investment rate, SCHOOL, the real variables (that is those suggested by the pure growth model) fare rather poorly on the OECD sample. Only SCHOOL is significant. In contrast, the inflation variables perform well. The level of inflation always enters negatively and significantly. Inflation volatility is significant when alone, but is insignificant though still negative when the rate of inflation is included. Table 8 (p. 36) presents results under the restriction (19). The restriction is never rejected at the 5 per cent significance level. The results are very similar to those for the unrestricted model. The implied human capital share, β, is around 0.3 and significant. The implied physical capital share, α, is poorly defined and always insignificant at the 5 per cent level, reflecting the poor performance of the investment rate on the OECD sample. The elasticity of output per capita with respect to inflation is estimated at -0.67 in the version

13. We conducted Breusch-Pagan tests for heteroscedasticity on these and subsequent regressions. We could find no evidence of heteroscedasticity based on this test.

with both inflation variables present, with a t-statistic of -4.5. This is very similar to the results of the simple regressions in Table 3, column 3, p. 33. Moreover, the addition of inflation adds significantly to the explanatory power of the regression, raising the Rbar-squared from 0.3 to 0.7.

Tables 9 (p. 37) and 10 (p. 38) present the results of estimating unrestricted and restricted versions of equation (12) on the full sample of 62 countries. Since the restrictions are easily satisfied and the results similar, we will confine our discussion to the restricted regressions in Table 10. Unlike the case for the OECD sample, the fit of the growth model is very good. All of the real variables are significant at the 5 per cent level. The implied values of α and β are about 0.2 and 0.3 respectively, and are significant. In spite of the performance of the real variables, the inflation variables -- particularly the level of inflation -- still contribute negatively and significantly to explaining variations in income per capita. While both the level and volatility of inflation are significant when entered separately, the level dominates in terms of significance when both are included. In the joint regression, column 4 of Table 10, the inflation elasticity is -0.30 and significant at the 5 per cent level while the inflation volatility elasticity is -0.41 and close to significance. These estimates are remarkably close to those from the simple regressions with dummy (column 4 of Table 4, p.33). That is, the negative effect of inflation on income per capita appears not to be explainable as a spurious correlation, arising from a relation between inflation and the fundamental determinants of growth, like savings rates and investment in human capital.

Figures 11 and 12, (p.57) present graphs of per capita income against inflation for the OECD and world samples respectively, where we correct for variations in human and physical investment rates and population growth. This correction is done by subtracting from the logarithm of income per capita deviations of the above variables from their means, adjusted by their estimated coefficients from the restricted regressions. These bear comparison to the uncorrected graphs in Figures 9 and 10 (p. 56). For the OECD, correcting for the real determinants of growth hardly changes the correlation between income per capita and inflation. This is not surprising, given the low explanatory power of these variables. For the world sample, however, the corrected graphs are significantly different, showing much less of the dispersion between low- and high-income countries that is present in the raw data (Figure 10, p. 56). This reflects the much better explanatory power of the real variables in the world sample.

Overall, the results based on nesting costs of inflation effects within a modified neoclassical growth framework suggest that the level of inflation, and perhaps also its volatility, have significant negative effects on the level of productivity and income per capita.[14]

5. Inflation and the Rate of Convergence to the Steady State

The theoretical approach

Assume that income per capita Y/L converges to its steady state level $(Y/L)^*$ at rate λ. Thus:

$$\frac{d\ln\left(\frac{Y}{L}\right)}{dt} = \lambda\left[\ln\left(\frac{Y}{L}\right)^* - \ln\left(\frac{Y}{L}\right)\right] + g, \tag{20}$$

where $(Y/L)^*$ is the equilibrium or steady-state path of income per capita from equation (10), and λ is the speed of convergence to the steady state level of Y/L. The solution to this differential equation is

$$\ln\left(\frac{Y}{L}\right) - \ln\left(\frac{Y}{L}\right)_0 = (1 - e^{-\lambda t})\frac{g}{\lambda} + (1 - e^{-\lambda t})\left[\ln\left(\frac{Y}{L}\right)^* - \ln\left(\frac{Y}{L}\right)_0\right], \tag{21}$$

14. While the neoclassical growth framework used here restricts us to level effects of inflation on the level of efficiency, it is possible that an alternative endogenous growth approach would result in permanent effects of inflation on the growth rate as well. This was pointed out to us by Peter Howitt.

which describes the growth of income per capita between time *0* and time *t*. Substituting equation (10) for $ln(Y/L)^*$ yields an empirical equation for the growth of income per capita:

$$ln\left(\frac{Y}{L}\right) - ln\left(\frac{Y}{L}\right)_0 = b_0 + b_1 ln(s_k) + b_2 ln(s_h) + b_3 ln(n+g+\delta)$$

$$+ b_4 ln\left(\frac{Y}{L}\right)_0 + b_5 ln(\pi) + b_6 ln(\sigma)\,, \tag{22}$$

where

$$b_0 = (1-e^{-\lambda t})\,ln(A_0^*) + (1-e^{-\lambda t})\,(t+\frac{1}{\lambda})g > 0 \tag{23}$$

$$b_1 = (1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta} > 0 \tag{24}$$

$$b_2 = (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta} > 0 \tag{25}$$

$$b_3 = -(1-e^{-\lambda t})\frac{(\alpha+\beta)}{1-\alpha-\beta} < 0 \tag{26}$$

$$b_4 = -(1-e^{-\lambda t}) < 0 \tag{27}$$

$$b_5 = (1-e^{-\lambda t})\,\theta < 0 \tag{28}$$

$$b_6 = (1-e^{-\lambda t})\,\phi < 0. \tag{29}$$

Equation (22) implies that the growth rate of income per capita should depend positively on investment rates for physical and human capital and negatively on population growth. The coefficients are predicted to be smaller than those in the level equation because of gradual adjustment to the steady state, scaled by the adjustment factor $(1 - e^{-\lambda t})$. In addition, the initial level of income per capita is predicted to have a negative coefficient, equal to the adjustment factor. The size of this coefficient indicates the rate of convergence to the steady state. The inflation level and volatility terms will also be scaled by the adjustment factor. As before, the model implies a restriction:

$$b_1 + b_2 + b_3 = 0. \tag{30}$$

The results

The results of estimating the convergence regression (22) on the OECD sample are presented in Table 11, p. 39 for the unrestricted case and Table 12, p. 40 for the restricted case. Our comments focus on the restricted version, since the restrictions are easily accepted. Overall, the fit is quite good in terms of the Rbar-squared statistic. The implied physical capital share is better defined here than in the level equations for the OECD. Population growth always contributes negatively and significantly to growth as predicted. The initial level of GDP per capita has the expected negative coefficient, and it is always significant. This is strong evidence of convergence. The implied speed of adjustment, λ, is 0.02 (2 per cent per year) in the regression without the level of inflation. This is similar to that reported by Mankiw, Romer and Weil.[15] The speed of adjustment increases to 0.03 in the regressions with inflation. A speed of adjustment of 0.03 implies that it takes 23 years for half of any deviation from the steady state to disappear.

The *short-run* coefficients on the inflation variables, while always negative, are never significant at the 5 per cent level. However, the estimated long-run inflation elasticity, θ, is significant when inflation enters alone, but is just

15. In a recent paper, Barro and Sala-i-Martin (1992) estimate the speed of convergence in the neo-classical growth model using data from 48 U.S. states. Their estimated convergence speed of 2 per cent per year is close to ours.

insignificant when entered jointly with the measure of inflation volatility. Its value in column 4 of Table 12, -0.43, is somewhat lower than that in the level equation. The long-run elasticity of inflation volatility, ϕ, is not significant.

Tables 13 (p. 41) and 14 (p. 42) present the convergence regressions for the 62- country sample. Once again, the pure growth model appears to do better on the full sample than on the OECD sample. In Table 14, specifically, all the real variables are significant and of the correct sign, and the restriction is not rejected. Moreover, the implied capital shares seem reasonable. There is once again evidence of convergence, since the coefficient on the initial level of income per capita is negative and highly significant. The implied speed of adjustment is smaller than for the OECD group, around 0.02. The half-life is around 34 years. In this case, both the short- and long- run inflation effects are significantly negative. Once again, however, the measure of inflation volatility is insignificant. The implied long-run inflation elasticity is around -0.6, considerably higher than the estimate from the level equation.

The convergence results suggest that the absence of a significant negative simple correlation between income growth and inflation in the cross-country data arises because the underlying negative effect of inflation along convergence paths to the steady state is masked by variations across countries in population growth, the rates of investment in physical and human capital, and the initial levels of income. Once we correct for the influence of these variables in the regressions, a negative relationship emerges. Another way to see this is to compare Figures 13 and 14 (p. 58) where we control for these variables by using the fitted regressions, with Figures 1 and 2 (p. 52) which show just the direct relation between inflation and growth.[16] A negative slope is apparent in the corrected graphs but not in the raw data. The difference is particularly striking for the OECD countries, where a slight positive relation in the raw data is transformed into a significantly negative relation in the corrected data.

16. The corrected graphs are produced using the methodology used in Figures 11 and 12 (p.57).

6. How Large are the Benefits of Disinflation?

The empirical results in this paper, whether for the OECD countries or for the world, whether for the level or growth rate specification, indicate a significant negative effect of inflation on real income per capita. To settle on a single "best" estimate of the benefits of disinflation, we need to choose between estimates from the level and convergence specifications of the model. We use the convergence specification because it explicitly allows for gradual adjustment to steady state and is therefore presumably more realistic. The long-run elasticity of income per capita with respect to inflation in the world convergence regression (Table 14, p. 42) is -0.6. This means that a one percentage point reduction in inflation from the world sample average of 9.0 per cent would raise income per capita in the long run by 6.5 per cent.

The adjustment to steady state is slow, however, with a half life of 34 years. The increase in income attributable to lower inflation should therefore also take effect slowly, reflecting the estimated slow speed of adjustment. The estimates from the convergence regression imply that a one percentage point reduction in inflation would raise the growth rate of income per capita by about 0.1 percentage points per annum on average along the transition path to the new steady state.

Our estimate of the effect of inflation on the transitional growth rate is similar to estimates of the effect of inflation on growth in the literature. Selody's (1990) estimate of the effect of inflation on growth using U.S. time series data is close to ours, as is that of Grimes (1990), who uses seemingly unrelated regressions for 21 countries, and that of Grier and Tullock (1989) in their 115- country study. Thus, the estimate seems robust. What is different here is that inflation has only a transitional effect on growth, lasting as long as the economy is converging to its new steady state. Previous studies with less explicit models tend to see the effect as impacting on growth permanently.

As previously noted, however, there is a problem with our logarithmic specification when it is used to assess the effects on income of low inflation rates. The benefits explode in an unrealistic fashion as inflation approaches zero. In order to deal with this problem, we also estimated regressions using the semi-logarithmic specification, that is, where the inflation coefficient is a semi-elasticity rather than an elasticity. This is appropriate for the lower-inflation OECD countries since, unlike the case for world sample, the semi-log specification fits just as well as the log-log one. The semi-log convergence regressions for the OECD yield a long-run inflation semi-elasticity of -6.7 (with a t-statistic of -3.0) implying that a one percentage point reduction in inflation raises income per capita by 6.7 per cent in the long run. The growth rate of income is predicted to rise by 0.14 percentage points along the transition path.

Overall, the results suggest that there are substantial gains from low inflation. A permanent one-percentage-point reduction in inflation would raise growth by just over 0.1 percentage points, and would eventually raise output by about 6 per cent. After 30 years, output would be about 3 per cent higher.[17]

17. A related issue is what the results say about the optimal rate of inflation. Our preferred interpretation is that the estimates of costs apply to the costs of price change -- whether inflation or deflation. Thus, both inflation and deflation would be costly, when the optimal inflation rate is zero. However, since no country in our sample experienced average deflation, there is still an some uncertainty about this.

7. Conclusions

There are many reasons why inflation and/or inflation volatility should have a negative effect on macroeconomic performance. They force economic agents to devote more resources to the "unproductive" activity of managing and predicting inflation and fewer resources to productive activities; they reduce the efficiency of the price system, causing resource misallocation and lost output; they raise the cost of capital; and they reduce investment and the efficiency of capital. These effects are all well- known. Less is known about the magnitude of these effects.

This paper attempts to estimate the effects of the level and volatility of inflation on long-run macroeconomic performance. Using a 62-country data base of internationally comparable data, we find evidence of a significant negative effect of inflation on the level of income per capita or productivity. We assess the robustness of the result by nesting inflation effects within a modified version of the neoclassical growth model with human capital due to Mankiw, Romer and Weil. The basic result appears to be robust. The level of GDP per worker in 1985 is negatively related to average inflation over the previous 25-year period, even when we control for the fundamental sources of variations in income such as investment rates, human capital and population growth. We also find some evidence that increases in inflation volatility, as measured by the coefficient of variation, may also have a negative effect on the level of income.

Although the evidence presented in the paper suggests that the effect of inflation is on the level of income, we also find that inflation has a negative transitional effect on the growth of income. The apparent absence of this correlation in the cross-country data simply reflects a missing variables problem; once we control for international variability in initial income, savings rates and so forth, the correlation emerges.

Overall, the results in this paper imply that there are substantial benefits to a policy of low inflation. A one-percentage-point reduction in inflation raises the growth rate of income by about 0.1 percentage points along the path of transition to a new level of income that is about 3 per cent higher after 30 years.

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Table 1: Simple Statistics

	Mean		Standard Deviation	
Sample	**OECD**	**World**	**OECD**	**World**
Observations	22	62	22	62
Inflation 1960-85	7.7	9.0	3.3	5.9
Standard deviation of inflation 1960-85	4.6	7.7	3.5	7.3
Log GDP per capita in 1985	9.42	8.44	0.38	0.99
Log GDP per capita in 1960	8.71	7.89	0.51	0.88
Growth of GDP per capita 1960-85	2.9	2.3	1.0	1.6
Investment to GDP ratio 1960-85 average	25.8	19.6	5.0	7.4
Population growth 1960-85	1.0	2.1	0.6	1.0
SCHOOL 1960-85 average	9.1	6.6	2.1	3.2

Table 2: Cross Correlations

	Cross correlations with			
	log of GDP per capita in 1985		**growth of GDP per capita 1960 - 1985**	
Sample	OECD	World	OECD	World
Observations	22	62	22	62
Inflation	-0.87	-0.24	0.19	-0.17
Log of inflation	-0.82	-0.32	0.23	-0.25
Standard deviation of inflation	-0.86	-0.35	0.14	-0.19
Log of standard deviation of inflation	-0.84	-0.58	0.20	-0.26

Table 3: Simple Regressions on the Level of Income, 22 OECD Countries

Dependent Variable: log GDP per capita in 1985			
Constant	7.24 (0.35)*	8.81 (0.18)*	7.39 (0.35)*
Log inflation	-0.83 (0.13)*		-0.68 (0.16)*
Log inflation volatility		-1.02 (0.27)*	-0.40 (0.24)
$\overline{R}^2$	0.65	0.39	0.68
s.e.e.	0.22	0.30	0.22

Note:
In all the following tables, an asterisk denotes significance at the 5 per cent significance level. $\overline{R^2}$ is the R-bar-squared statistic and s.e.e. is the standard error of the residuals.

Table 4: Simple Regressions on the Level of Income, 62 Countries

Dependent Variable: log GDP per capita in 1985				
Constant	6.71 (0.67)*	7.95 (0.13)*	7.00 (0.54)*	8.08 (0.50)*
Log inflation	-0.68 (0.26)*		-0.39 (0.21)	-0.39 (0.18)*
Log inflation volatility		-1.80 (0.28)*	-1.68 (0.29)*	-0.50 (0.33)
LDC dummy				-1.20 (0.24)*
$\overline{R}^2$	0.09	0.39	0.42	0.58
s.e.e.	0.94	0.77	0.75	0.64

Table 5: Simple Regressions on Income Growth, 22 OECD Countries

Dependent Variable: Growth of GDP per capita 1960-85			
Constant	0.046 (0.016)*	0.032 (0.006)*	0.047 (0.017)*
Log inflation	0.006 (0.006)		0.007 (0.008)
Log inflation volatility		0.004 (0.010)	-0.0002 (0.012)
$\bar{R}^2$	0.01	-0.04	-0.04
s.e.e.	0.010	0.010	0.010

Table 6: Simple Regressions on Income Growth, 62 Countries

Dependent Variable: Growth of GDP per capita 1960-85			
Constant	0.0007 (0.011)	0.021 (0.003)*	0.001 (0.011)
Log inflation	-0.009 (0.004)*		-0.008 (0.005)
Log inflation volatility		-0.007 (0.006)	-0.005 (0.006)
$\bar{R}^2$	0.05	0.01	0.04
s.e.e.	0.016	0.016	0.016

Table 7: Growth Model with Inflation, 22 OECD Countries

Dependent Variable: log GDP per capita in 1985				
Constant	8.64 (2.21)*	7.64 (1.38)*	10.61 (2.05)*	8.47 (1.54)*
Log investment/ GDP	0.28 (0.39)	-0.11 (0.25)	0.24 (0.34)	-0.08 (0.25)
Log SCHOOL	0.77 (0.29)*	0.50 (0.19)*	0.49 (0.27)	0.44 (0.19)*
Log(n + g + δ)	-1.08 (0.76)	-0.32 (0.49)	0.07 (0.78)	-0.02 (0.55)
Log inflation		-0.74 (0.13)*		-0.65 (0.15)*
Log inflation volatility			-0.86 (0.32)*	-0.31 (0.26)
$\bar{R}^2$	0.24	0.71	0.44	0.72
s.e.e.	0.33	0.20	0.28	0.20

Table 8: Growth Model with Inflation, 22 OECD Countries

Restricted Regressions

Dependent Variable: log GDP per capita in 1985

Constant	8.72 (0.47)*	7.46 (0.36)*	8.63 (0.41)*	7.56 (0.37)*
Log investment/ GDP	0.28 (0.33)	-0.13 (0.22)	0.10 (0.30)	-0.15 (0.22)
Log SCHOOL	0.77 (0.28)*	0.50 (0.18)*	0.50 (0.27)	0.44 (0.19)*
$\text{Log}(n + g + \delta)$	-1.05 (0.37)*	-0.38 (0.26)	0.61 (0.37)	-0.30 (0.27)
Log inflation		-0.74 (0.13)*		-0.67 (0.15)*
Log inflation volatility			-0.74 (0.30)*	-0.24 (0.23)
$\bar{R}^2$	0.28	0.73	0.44	0.73
s.e.e.	0.32	0.20	0.28	0.20
p-value for test of restriction	0.97	0.89	0.34	0.55
Implied α	0.14 (0.15)	-0.09 (0.17)	0.06 (0.18)	-0.11 (0.19)
Implied β	0.37 (0.12)*	0.36 (0.11)*	0.31 (0.14)*	0.34 (0.12)*

Table 9: Growth Model with Inflation, 62 Countries

	Dependent Variable: log GDP per capita in 1985			
Constant	7.71 (1.45)*	6.83 (1.44)*	8.73 (1.50)*	7.78 (1.51)*
Log investment/ GDP	0.60 (0.21)*	0.52 (0.20)*	0.52 (0.21)*	0.46 (0.20)*
Log SCHOOL	0.84 (0.12)*	0.84 (0.11)*	0.79 (0.12)*	0.79 (0.11)*
Log(n + g + δ)	-1.58 (0.48)*	-1.54 (0.46)*	-1.03 (0.54)	-1.08 (0.53)*
Log inflation		-0.33 (0.14)*		-0.30 (0.14)*
Log inflation volatility			-0.51 (0.25)*	-0.43 (0.25)
$\overline{R}^2$	0.74	0.76	0.75	0.77
s.e.e.	0.50	0.48	0.49	0.47

Table 10: Growth Model with Inflation, 62 Countries

Restricted Regressions				
Dependent Variable: log GDP per capita in 1985				
Constant	8.05 (0.19)*	7.28 (0.37)*	8.06 (0.19)*	7.35 (0.36)*
Log investment/ GDP	0.63 (0.17)*	0.56 (0.17)*	0.48 (0.18)*	0.43 (0.18)*
Log SCHOOL	0.84 (0.12)*	0.84 (0.11)*	0.79 (0.12)*	0.80 (0.11)*
$\text{Log}(n + g + \delta)$	-1.47 (0.12)*	-1.40 (0.13)*	-1.27 (0.16)*	-1.22 (0.16)*
Log inflation		-0.33 (0.14)*		-0.30 (0.13)*
Log inflation volatility			-0.47 (0.24)*	-0.41 (0.23)
$\bar{R}^2$	0.74	0.76	0.76	0.77
s.e.e.	0.50	0.48	0.49	0.47
p-value for test of restriction	0.81	0.75	0.65	0.77
Implied α	0.25 (0.06)*	0.23 (0.06)*	0.21 (0.07)*	0.19 (0.07)*
Implied β	0.34 (0.05)*	0.35 (0.05)*	0.35 (0.05)*	0.36 (0.05)*

Table 11: Convergence Regressions, 22 OECD Countries

Dependent Variable: log difference GDP per capita 1960-85				
Constant	2.76 (1.20)*	3.76 (1.26)*	3.43 (1.50)*	4.15 (1.50)*
Log investment/ GDP	0.33 (0.17)	0.19 (0.18)	0.32 (0.18)	0.19 (0.19)
Log SCHOOL	0.23 (0.15)	0.26 (0.14)	0.21 (0.15)	0.25 (0.14)
Log(n + g + δ)	-0.86 (0.34)*	-0.66 (0.34)	-0.67 (0.42)	-0.54 (0.41)
Log GDP per capita in 1960	-0.40 (0.07)*	-0.54 (0.10)*	-0.43 (0.08)*	-0.55 (0.11)*
Log inflation		-0.25 (0.14)		-0.24 (0.15)
Log inflation volatility			-0.15 (0.20)	-0.10 (0.19)
$\bar{R}^2$	0.65	0.69	0.64	0.68
s.e.e.	0.15	0.14	0.15	0.14
Implied speed of adjustment λ	0.020 (0.005)*	0.031 (0.009)*	0.023 (0.006)*	0.032 (0.010)*
Long-run inflation elasticity θ		-0.47 (0.20)		-0.43 (0.22)
Long-run inflation volatility elasticity ϕ			-0.35 (0.43)	-0.18 (0.34)

Table 12: Convergence Regressions, 22 OECD Countries

Restricted Regressions

Dependent Variable: log difference GDP per capita 1960-85

Constant	3.55 (0.63)*	4.34 (0.72)*	3.86 (0.69)*	4.47 (0.75)*
Log investment/ GDP	0.40 (0.15)*	0.22 (0.17)	0.34 (0.16)*	0.21 (0.17)
Log SCHOOL	0.24 (0.14)	0.27 (0.13)	0.21 (0.14)	0.25 (0.14)
$\text{Log}(n + g + \delta)$	-0.64 (0.17)*	-0.50 (0.18)*	-0.55 (0.19)*	-0.45 (0.19)*
Log GDP per capita in 1960	-0.40 (0.07)*	-0.55 (0.10)*	-0.44 (0.08)*	-0.56 (0.10)*
Log inflation		-0.25 (0.14)		-0.24 (0.14)
Log inflation volatility			-0.18 (0.17)	-0.12 (0.17)
$\bar{R}^2$	0.66	0.70	0.66	0.70
s.e.e.	0.15	0.14	0.14	0.14
p-value for test of restriction	0.44	0.58	0.75	0.80
Implied α	0.38 (0.13)*	0.21 (0.15)	0.35 (0.14)*	0.20 (0.16)
Implied β	0.23 (0.11)*	0.26 (0.11)*	0.21 (0.12)	0.25 (0.11)*
Implied speed of adjustment λ	0.021 (0.005)*	0.032 (0.009)*	0.023 (0.006)*	0.033 (0.009)*
Long-run inflation elasticity θ		-0.48 (0.19)*		-0.43 (0.21)
Long-run inflation volatility elasticity ϕ			-0.41 (0.36)	-0.21 (0.29)

Table 13: Convergence Regressions, 62 Countries

Dependent Variable: log difference GDP per capita 1960-85

Constant	2.71 (1.04)*	2.39 (1.01)*	2.39 (1.19)*	1.95 (1.16)
Log investment/ GDP	0.38 (0.13)*	0.35 (0.13)*	0.40 (0.13)*	0.36 (0.13)*
Log SCHOOL	0.34 (0.09)*	0.35 (0.09)*	0.33 (0.09)*	0.35 (0.09)*
Log(n + g + δ)	-0.74 (0.31)*	-0.75 (0.30)*	-0.83 (0.35)*	-0.87 (0.34)*
Log GDP per capita in 1960	-0.32 (0.07)*	-0.34 (0.07)*	-0.30 (0.08)*	-0.32 (0.07)*
Log inflation		-0.20 (0.09)*		-0.20 (0.09)*
Log inflation volatility			0.10 (0.17)	0.13 (0.17)
$\bar{R}^2$	0.40	0.44	0.39	0.43
s.e.e.	0.31	0.30	0.31	0.30
Implied speed of adjustment λ	0.015 (0.004)*	0.017 (0.004)*	0.014 (0.004)*	0.015 (0.004)*
Long-run inflation elasticity θ		-0.57 (0.26)*		-0.63 (0.29)*
Long-run inflation volatility elasticity ϕ			0.33 (0.62)	0.41 (0.57)

Table 14: Convergence Regressions, 62 Countries

Restricted Regressions

Dependent Variable: log difference GDP per capita 1960-85

Constant	2.76 (0.55)*	2.51 (0.55)*	2.65 (0.60)*	2.36 (0.59)*
Log investment/ GDP	0.39 (0.11)*	0.36 (0.11)*	0.41 (0.12)*	0.38 (0.11)*
Log SCHOOL	0.34 (0.09)*	0.35 (0.09)*	0.33 (0.09)*	0.35 (0.09)*
Log(n + g + δ)	-0.72 (0.11)*	-0.71 (0.11)*	-0.75 (0.12)*	-0.74 (0.11)*
Log GDP per capita in 1960	-0.32 (0.07)*	-0.34 (0.07)*	-0.30 (0.08)*	-0.32 (0.07)*
Log inflation		-0.20 (0.09)*		-0.20 (0.09)*
Log inflation volatility			0.08 (0.16)	0.11 (0.16)
$\bar{R}^2$	0.41	0.45	0.40	0.44
s.e.e.	0.31	0.30	0.31	0.30
p-value for test of restriction	0.95	0.89	0.80	0.68
Implied α	0.37 (0.09)*	0.34 (0.09)*	0.39 (0.10)*	0.36 (0.09)*
Implied β	0.32 (0.07)*	0.34 (0.07)*	0.32 (0.07)*	0.33 (0.07)*
Implied speed of adjustment λ	0.015 (0.004)*	0.017 (0.004)*	0.014 (0.004)*	0.016 (0.004)*
Long-run inflation elasticity θ		-0.57 (0.26)*		-0.61 (0.28)*
Long-run inflation volatility elasticity ϕ			0.28 (0.57)	0.33 (0.52)

Appendix A: The Data

In the following table, "Group" refers to the country classification: 1 for OECD and 2 for LDCs. Level of GDP/adult is GDP per working-age population." Growth of GDP/adult" is average growth of GDP per adult over the 1960-85 period. "Growth of Pop." is growth of the working-age population averaged over the 1960-85 period." I/Y" is investment as a percentage of GDP, and SCHOOL is the percentage of the working-age population in secondary school, both averaged over the 1960-85 period. The"Inflation Rate" is the average annual rate of change of the CPI over the 1960-85 period. The "Std. Dev. of Inf." is the standard deviation of the annual inflation rate for the 1960-85 period. All the data except SCHOOL and the inflation variables are from the Summers-Heston (1988) data base. Data on SCHOOL is taken from Mankiw, Romer and Weil (1990). The inflation rate and its standard deviation are from the International Monetary Fund's International Financial Statistics (IFS) data base.

Table A1

			Level of GDP/Adult		Growth of GDP/ Adult	Growth of Pop.			Inflation Rate	Std. Dev of Inf.
No.	Country	Group	1960	1985			I/Y	SCHOOL		
1	Australia	1	8440	13409	1.9	2.0	31.5	9.8	6.5	4.2
2	Austria	1	5939	13327	3.3	0.4	23.4	8.0	4.8	1.8
3	Belgium	1	6789	14290	3.0	0.5	23.4	9.3	5.4	2.8
4	Canada	1	10286	17935	2.2	2.0	23.3	10.6	5.6	3.3
5	Denmark	1	8551	16491	2.7	0.6	26.6	10.7	7.6	2.7
6	Finland	1	6527	13779	3.0	0.7	36.9	11.5	7.8	3.9
7	France	1	7215	15027	3.0	1.0	26.2	8.9	7.1	3.4
8	Germany	1	7695	15297	2.8	0.5	28.5	8.4	3.8	1.6
9	Greece	1	2257	6868	4.6	0.7	29.3	7.9	9.9	8.1
10	Ireland	1	4411	8675	2.7	1.1	25.9	11.4	9.3	5.3
11	Italy	1	4913	11082	3.3	0.6	24.9	7.1	9.3	6.0
12	Japan	1	3493	13893	5.7	1.2	36.0	10.9	6.2	3.9
13	Netherlands	1	7689	13177	2.2	1.4	25.8	10.7	5.3	2.3
14	New Zealand	1	9523	12308	1.0	1.7	22.5	11.9	8.4	4.9
15	Norway	1	7938	19723	3.7	0.7	29.1	10.0	6.7	3.0
16	Portugal	1	2272	5827	3.8	0.6	22.5	5.8	12.5	8.3

Table A1 (*continued*)

No.	Country	Group	Level of GDP/Adult 1960	Level of GDP/Adult 1985	Growth of GDP/ Adult	Growth of Pop.	I/Y	SCHOOL	Inflation Rate	Std. Dev of Inf.
17	Spain	1	3766	9903	3.9	1.0	17.7	8.0	10.3	4.9
18	Sweden	1	7802	15237	2.7	0.4	24.5	7.9	6.8	3.0
19	Switzerland	1	10308	15881	1.7	0.8	29.7	4.8	4.1	2.1
20	Turkey	1	2274	4444	2.7	2.5	20.2	5.5	18.8	17.9
21	United Kingdom	1	7634	13331	2.3	0.3	18.4	8.9	8.1	5.2
22	United States	1	12362	18988	1.7	1.5	21.1	11.9	5.2	3.3
23	Bangladesh	2	846	1221	1.5	2.6	6.8	3.2	10.9	11.8
24	Burma	2	517	1031	2.8	1.7	11.4	3.5	6.1	9.9
25	Colombia	2	2672	4405	2.0	3.0	18.0	6.1	15.9	7.6
26	Costa Rica	2	3360	4492	1.2	3.5	14.7	7.0	11.0	14.2
27	Dominican Republic	2	1939	3308	2.2	2.9	17.1	5.8	7.8	8.0
28	Ecuador	2	2198	4504	2.9	2.8	24.4	7.2	11.4	8.8
29	El Salvador	2	2042	1997	-0.9	3.3	8.0	3.9	7.0	6.9
30	Guatemala	2	2481	3034	0.8	3.1	8.8	2.4	5.4	5.8
31	Haiti	2	1096	1237	0.5	1.3	7.1	1.9	6.9	6.0
32	Honduras	2	1430	1822	1.0	3.1	13.8	3.7	5.4	4.0
33	Hong Kong	2	3085	13372	6.0	3.0	19.9	7.2	6.1	4.7
34	India	2	978	1339	1.3	2.4	16.8	5.1	7.2	6.2
35	Indonesia	2	879	2159	3.7	1.9	13.9	4.1	32.4	35.6
36	Ivory Coast	2	1386	1704	0.8	4.3	12.4	2.3	7.2	6.3
37	Jamaica	2	2726	3080	0.5	1.6	20.6	11.2	11.5	9.0
38	Kenya	2	944	1329	1.4	3.4	17.4	2.4	7.8	6.0
39	Malaysia	2	2154	5788	4.0	3.2	23.2	7.3	3.6	3.9
40	Mexico	2	4229	7380	2.3	3.3	19.5	6.6	16.8	18.5
41	Morocco	2	1030	2348	3.4	2.5	8.3	3.6	6.1	4.4
42	Nigeria	2	1055	1186	0.5	2.4	12.0	2.3	10.6	9.3
43	Pakistan	2	1077	2175	2.9	3.0	14.9	3.0	7.3	6.1

Table A1 *(continued)*

No.	Country	Group	Level of GDP/Adult 1960	Level of GDP/Adult 1985	Growth of GDP/ Adult	Growth of Pop.	I/Y	SCHOOL	Inflation Rate	Std. Dev of Inf.
44	Panama	2	2423	5021	3.0	3.0	12.2	11.6	3.9	3.8
45	Paraguay	2	1951	3914	2.8	2.7	26.1	4.4	9.1	7.9
46	Peru	2	3310	3775	0.5	2.9	12.0	8.0	38.3	46.4
47	Philippines	2	1668	2430	1.5	3.0	14.9	10.6	11.4	9.0
48	Singapore	2	2793	14678	6.9	2.6	32.2	9.0	3.8	5.9
49	South Africa	2	4768	7064	1.6	2.3	21.6	3.0	7.7	4.7
50	Sri Lanka	2	1794	2482	1.3	2.4	14.8	8.3	6.8	6.0
51	Syrian Arab Republic	2	2382	6042	3.8	3.0	15.9	8.8	7.1	6.5
52	Thailand	2	1308	3220	3.7	3.1	18.0	4.4	5.6	5.7
53	Trinidad and Tobago	2	9253	11285	0.8	1.9	20.4	8.8	8.4	5.6
54	Tunisia	2	1623	3661	3.3	2.4	13.8	4.3	5.3	3.4
55	Venezuela	2	10367	6336	-2.0	3.8	11.4	7.0	5.7	5.3
56	Zambia	2	1410	1217	-0.6	2.7	31.7	2.4	9.6	7.3
57	Burkina Faso	2	529	857	1.9	0.9	12.7	0.4	6.2	7.6
58	Congo, Peop. Rep. of	2	1009	2624	3.9	2.4	28.8	3.8	6.9	4.3
59	Egypt	2	907	2160	3.5	2.5	16.3	7.0	7.4	5.9
60	Sierra Leone	2	511	805	1.8	1.6	10.9	1.7	14.0	16.3
61	Somalia	2	901	657	-1.3	3.1	13.8	1.1	14.6	16.7
62	Sudan	2	1254	1038	-0.8	2.6	13.2	2.0	13.2	11.8

Appendix B:

An Optimal Growth Model with Costs of Inflation

This appendix nests costs of inflation on the level of efficiency within an optimal version of the neoclassical growth model to verify whether the form of our estimated equations is robust to the specific version of the growth model used. A version of the Sidrauski model with money and growth in technology is used for this purpose. The idea is to check whether working with deeper structural parameters like the rate of time preference and the elasticity of intertemporal substitution would lead to a modification of our functional form. We abstract from human capital to focus on the aggregate relationship between the savings rate and per capita income.[1]

Contrary to the main body of the text, lowercase letters for variables will now refer to per-capita values rather than to per- efficiency units. Consumers are assumed to maximize the discounted present value of utility from consumption and real balances:

$$\int_0^{\infty} e^{-\rho t} U(c, m)\, dt \qquad 0 < \rho < 1, \tag{B1}$$

where ρ is the rate of time preference, *U(...)* is the utility function, and *c* and *m* are consumption per capita and real balances per capita respectively. Output per capita, *y*, is given by

$$y = Z^{1-\alpha} k^{\alpha} \qquad 0 < \alpha < 1, \tag{B2}$$

where Z is the level of technology, *k* is the per-capita capital stock and α is the share of capital in income. Technology grows exogenously at rate *g*, but is also influenced by the rate of inflation, π. Thus,

$$Z_t = Z_0 e^{gt} \pi^{\theta}. \tag{B3}$$

Maximization of the utility functional is subject to the budget constraint which, in per-capita terms, is given by

1. An alternative interpretation is that we lump together physical and human capital.

$$\dot{k} = y - c - (n+\delta)k - \dot{b} + (i - \pi - n)b - \dot{m} - (n+\pi)m - x, \tag{B4}$$

where n is the population growth rate, b is the real stock of government bonds per capita, δ is the rate of depreciation, i is the nominal interest rate on bonds, and x represents taxes net of transfers. The specific form of the utility function used is of the popular constant relative risk aversion type:

$$U(\ldots) = \frac{1}{1-\omega}(c^{\gamma}m^{1-\gamma})^{1-\omega} \tag{B5}$$

$$\omega > 0, 0 < \gamma < 1,$$

where ω is the degree of relative risk aversion (inverse of the elasticity of intertemporal substitution) defined over the composite good $c^{\gamma}m^{1-\gamma}$.

The solution to the optimization problem yields the following Euler equation for the optimal choice of b:

$$r = i - \pi = \rho + n + [1 - \alpha(1-\omega)]\frac{\dot{c}}{c} - (1-\omega)(1-\alpha)\frac{\dot{m}}{m}, \tag{B6}$$

where r is the real interest rate on bonds. This is a version of the familiar positive relationship between the real interest rate and the rate of growth of consumption in consumption-based asset return models. The difference here is that the real interest rate is now also inversely related to the rate of growth of real balances. Now, along a balanced growth path, consumption in efficiency units will be constant and therefore per capita consumption, real balances, income and so forth will grow at the exogenous rate of technical progress g:

$$\frac{\dot{c}}{c} = \frac{\dot{k}}{k} = \frac{\dot{y}}{y} = \frac{\dot{m}}{m} = g. \qquad \text{(B7)}$$

Given this steady-state condition, the equation for the real interest rate becomes

$$r = \rho + n + \omega g, \qquad \text{(B8)}$$

which is a function of the rate of time preference, the rate of population growth, the rate of technical progress and the elasticity of intertemporal substitution, but is independent of inflation. This is identical to the steady-state real interest rate in a model without money.

The Euler equation for the optimal choice of k is

$$\alpha Z^{1-\alpha} k^{\alpha-1} = r + \delta, \qquad \text{(B9)}$$

which is just the usual marginal product condition. After rearrangement, the Euler equation for the optimal choice of m yields:

$$m = c\left(\frac{1-\gamma}{\gamma}\right)\left(\frac{1}{i}\right), \qquad \text{(B10)}$$

which is a demand for money function relating real balances positively to consumption (and hence income) and negatively to the nominal interest rate. Given an exogenous nominal money supply, M, growing at rate μ, it is easy to see that real balances will be constant in the steady state so that the rate of inflation, π, is given by the quantity-theoretic relation:

$$\pi = \mu - g - n. \tag{B11}$$

The steady-state levels of the capital stock and income per capita are given by

$$k = Z\left(\frac{\alpha}{r+\delta}\right)^{\frac{1}{1-\alpha}} \tag{B12}$$

$$y = Z\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}}. \tag{B13}$$

Thus, unlike the real interest rate, both k and y will be affected by inflation through its effect on Z. However, the steady-state savings rate will be unaffected by inflation since it is unaffected by the level of technology. To verify this, note that the savings rate, s, is defined by

$$s = \frac{\dot{k} + (n+\delta)k}{y}. \tag{B14}$$

Now dividing top and bottom by k, substituting g for the growth rate of k, and substituting for the capital output ratio implicit in equation (B9) yields:

$$s = \frac{\alpha(n+g+\delta)}{r+\delta}. \tag{B15}$$

Thus the savings rate is independent of inflation.

Using equation (B15) to substitute out for $r+\delta$ in equation (B13) gives the solution for the steady-state level of income per capita:

$$y = Zs^{\frac{\alpha}{1-\alpha}}(n+g+\delta)^{-\frac{\alpha}{1-\alpha}}. \tag{B16}$$

This can be written in logarithmic form as:

$$ln\left(\frac{Y}{L}\right) = ln(Z_0) + gt + \theta ln(\pi) + \frac{\alpha}{1-\alpha} ln(s) - \frac{\alpha}{1-\alpha} ln(n+g+\delta), \tag{B17}$$

which is the same as equation (12) in the main body of the text, when β is set to 0. Thus, we arrive back at the basic functional form of the estimated equation.[2]

In summary, nesting a negative effect of inflation on the level of macroeconomic efficiency within the neoclassical growth model leads to the following predictions: (i) inflation will have a negative effect on the levels of income, capital and consumption; (ii) there will be no effect of inflation on the real interest rate or the savings rate. In order to affect the latter variables, inflation would have to affect the growth rate of technology, not just its level. In the above model, a negative effect of inflation on the rate of technical progress would mean that inflation would unambiguously depress real rates of return. The effect on the savings rate would, however, be ambiguous, depending among other things on the degree of relative risk aversion.

2. While the optimal growth model produces the same basic estimation equation as the Mankiw/Romer/Weil model used in the text, it could be argued that the latter model is more general, since it does not require the same assumption of a closed economy.

Figure 1: Inflation and Growth in Income per Capita
22 OECD Countries

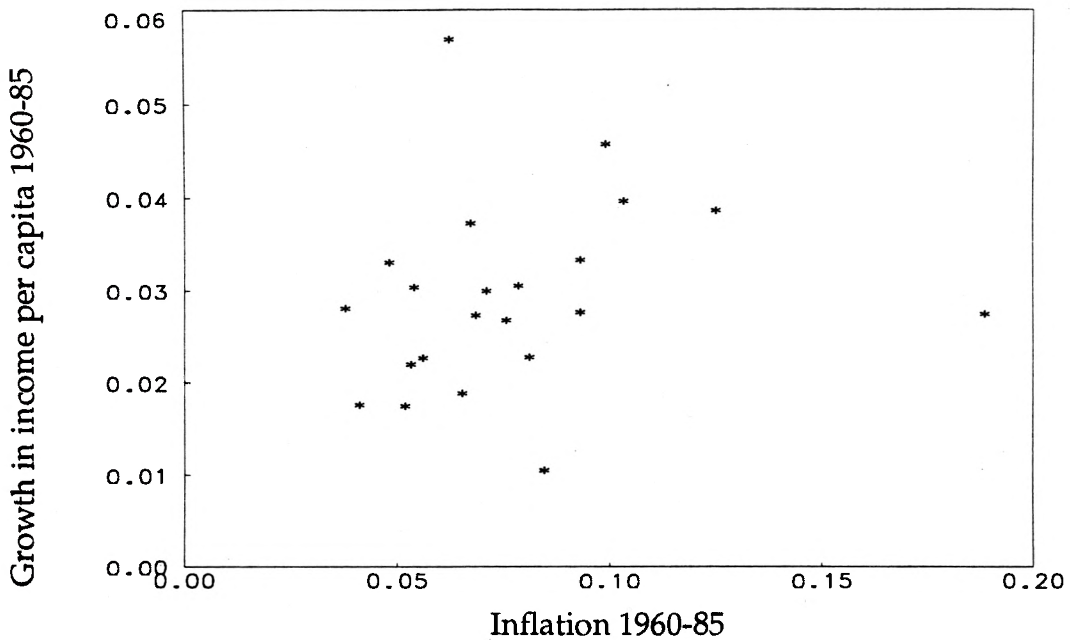


Figure 2: Inflation and Growth in Income per Capita
62 Countries

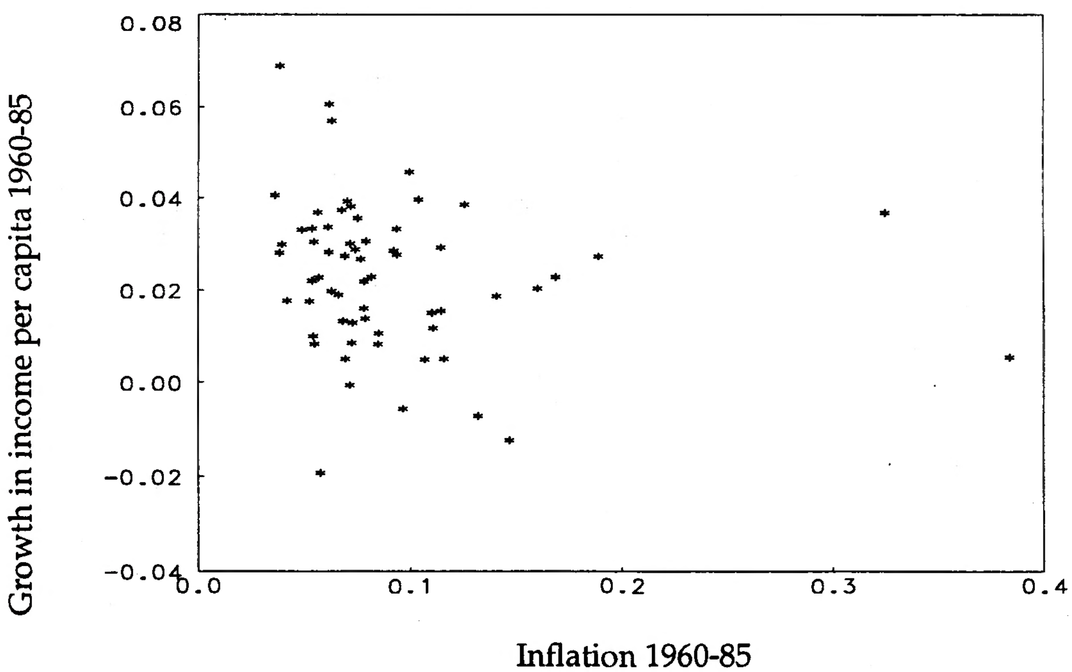


Figure 3: Inflation Volatility and Growth in Income per Capita
22 OECD Countries

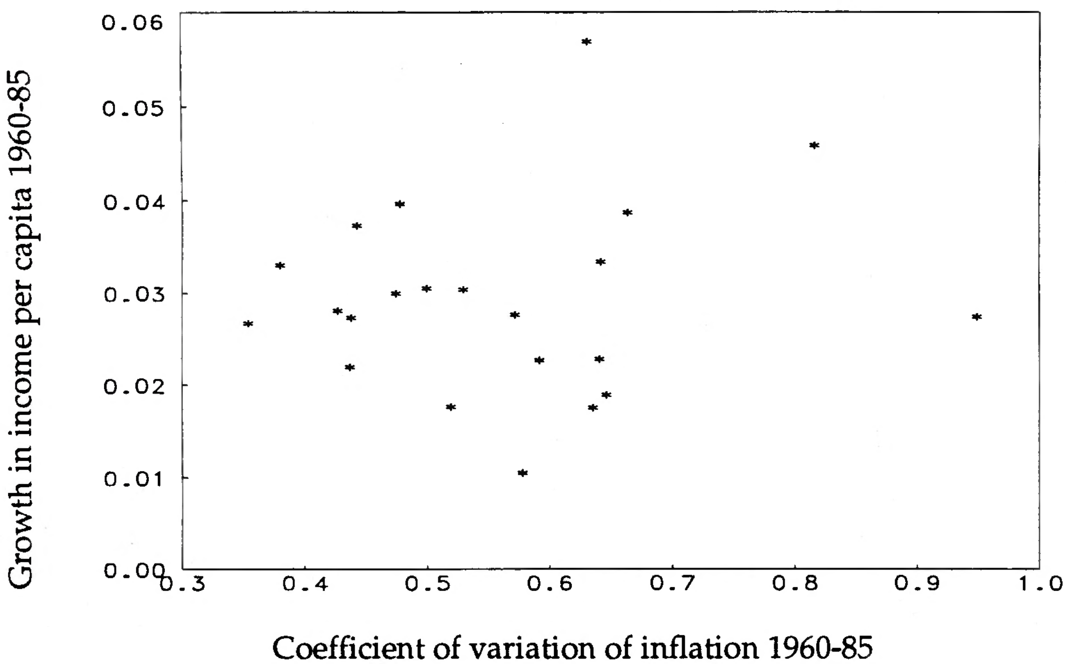


Figure 4: Inflation Volatility and Growth in Income per Capita
62 Countries

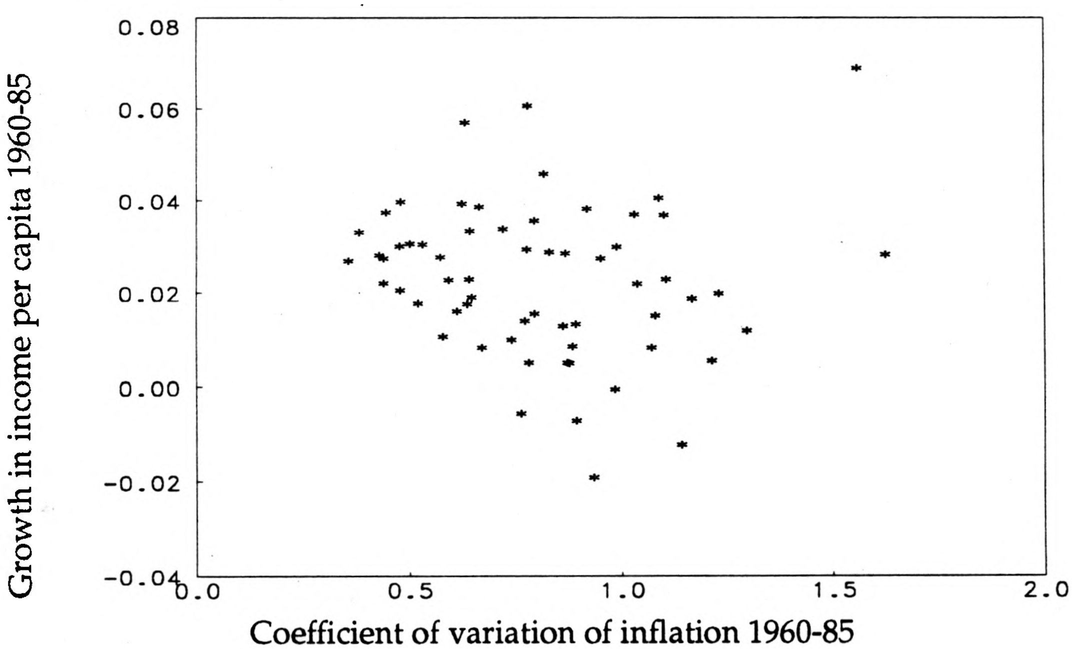


Figure 5: Inflation and the Level of Income per Capita
22 OECD Countries

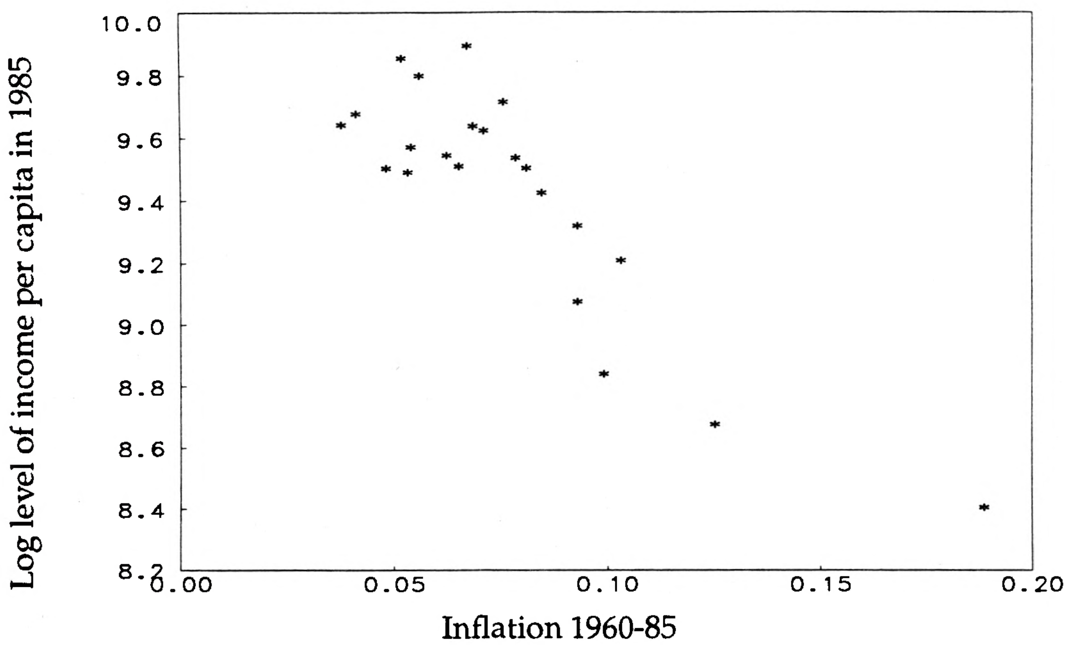


Figure 6: Inflation and the Level of Income per Capita
62 Countries

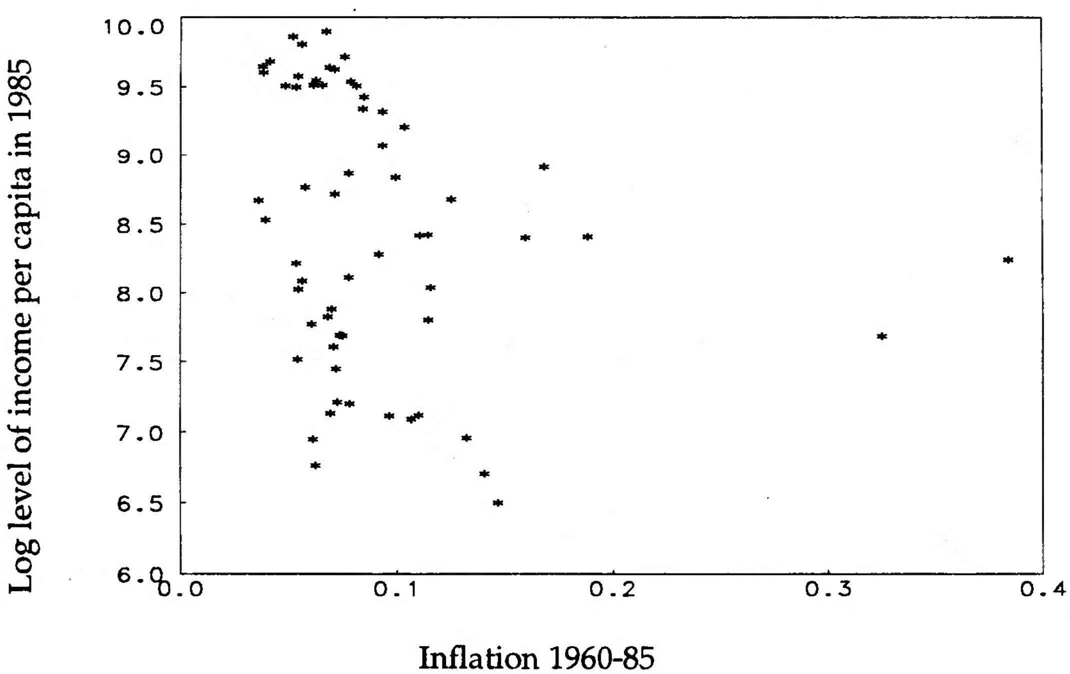


Figure 7: Inflation Volatility and the Level of Income per Capita
22 OECD Countries

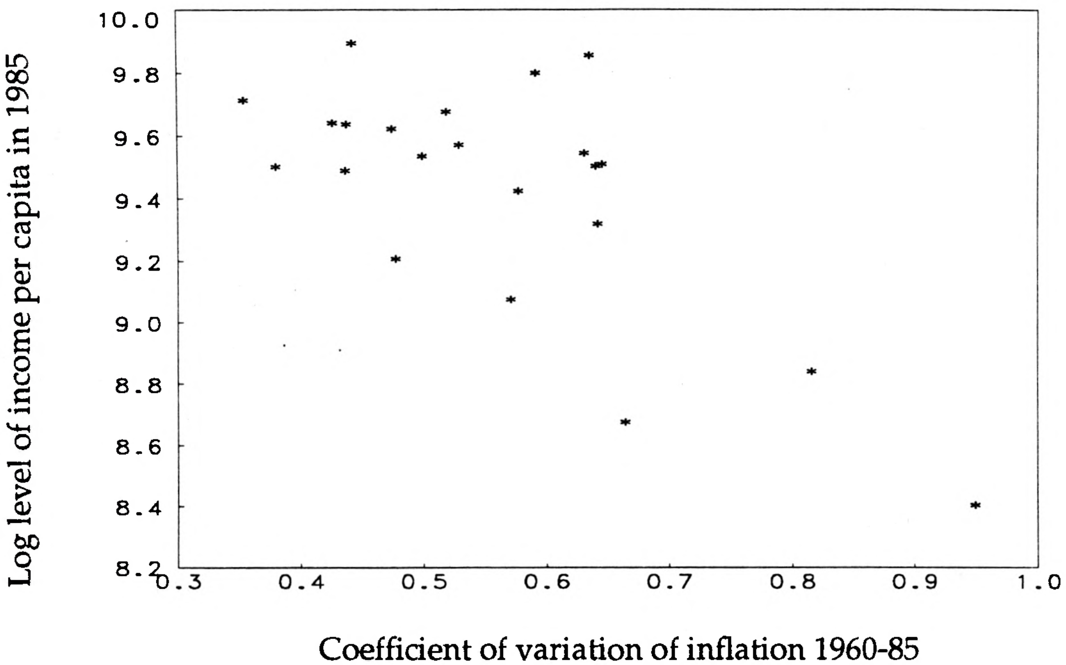


Figure 8: Inflation Volatility and the Level of Income per Capita
62 Countries

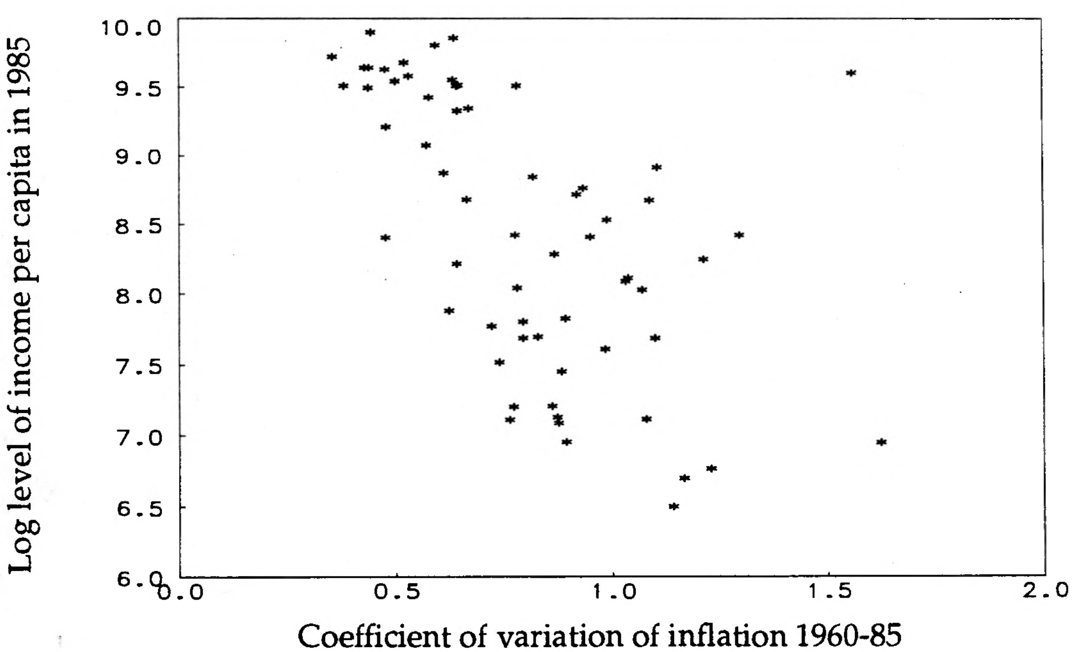


Figure 9: Log of Inflation and the Level of Income per Capita
22 OECD Countries

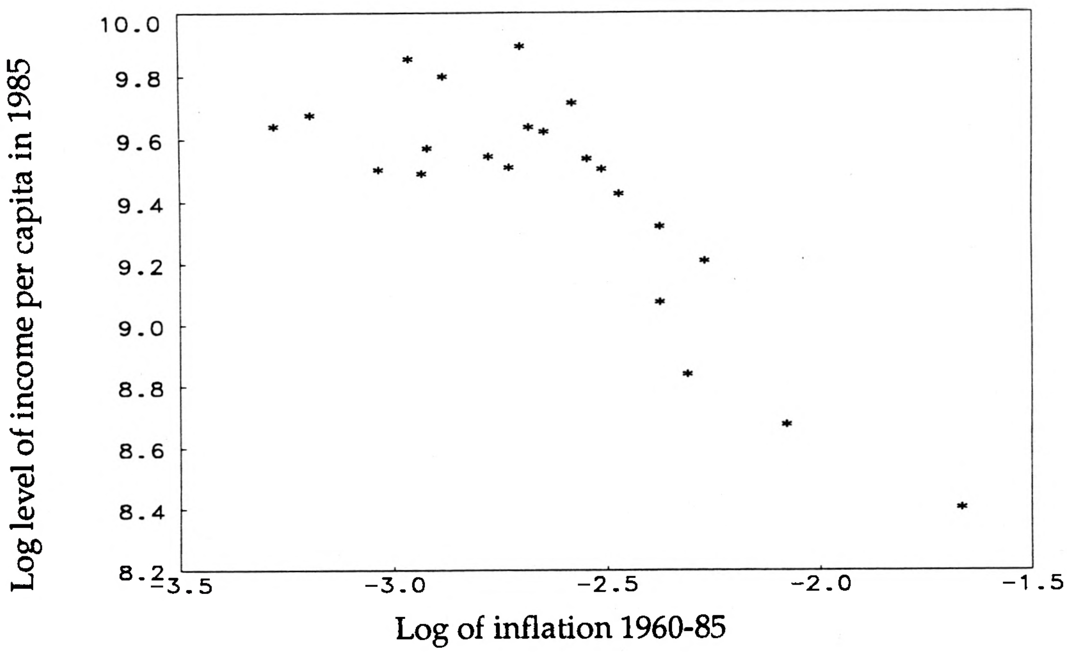


Figure 10: Log of Inflation and the Level of Income per Capita
62 Countries

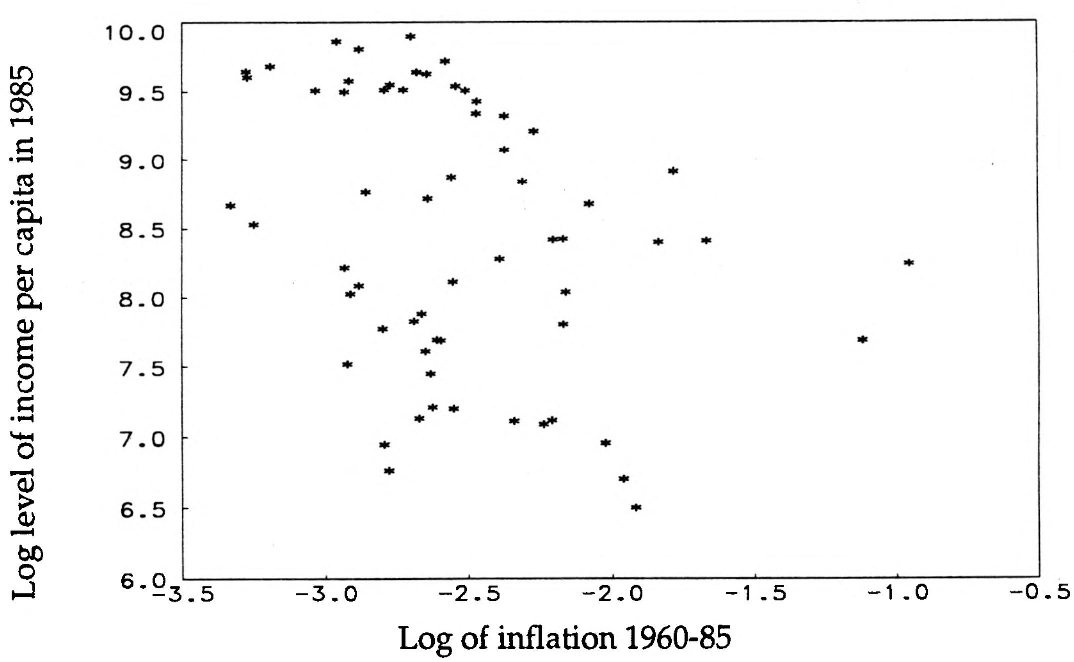


Figure 11: Log of Inflation and the Level of Income per Capita
Conditional on Variables Determining Growth

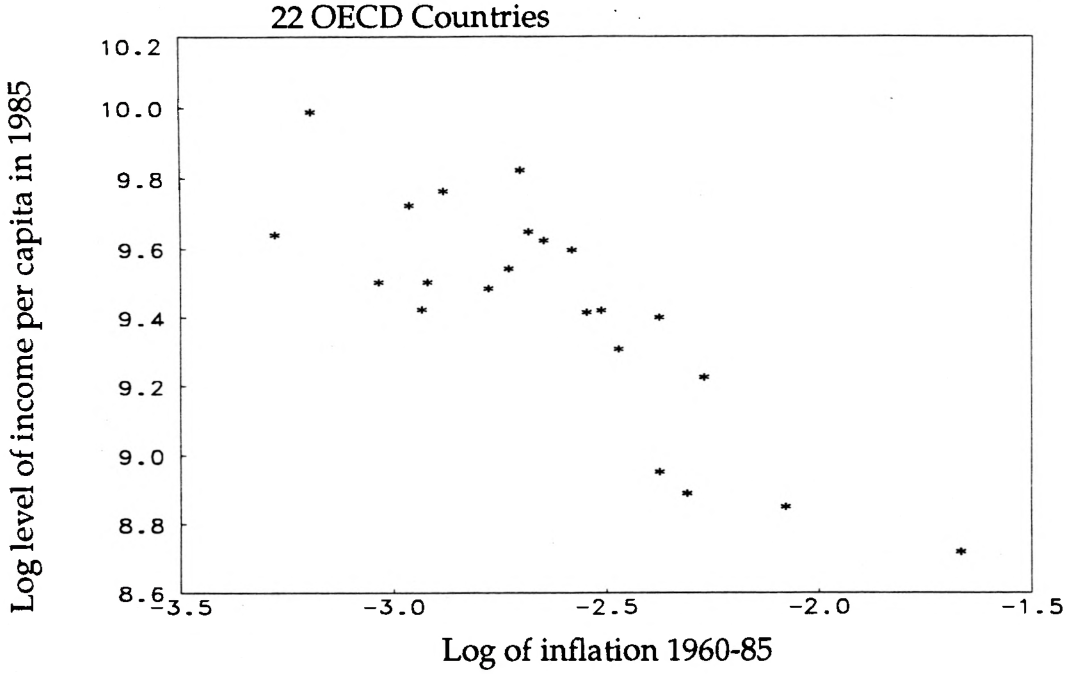


Figure 12: Log of Inflation and the Level of Income per Capita
Conditional on Variables Determining Growth

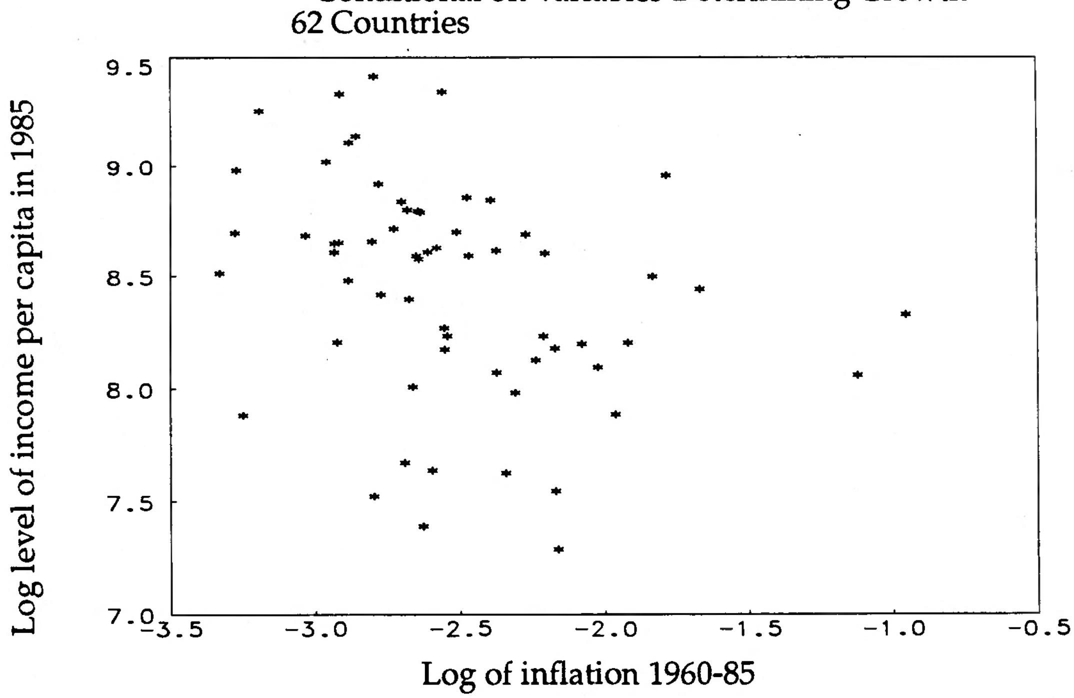


Figure 13: Log of Inflation and the Growth of Income per Capita
Conditional on Variables Determining Growth
22 OECD Countries

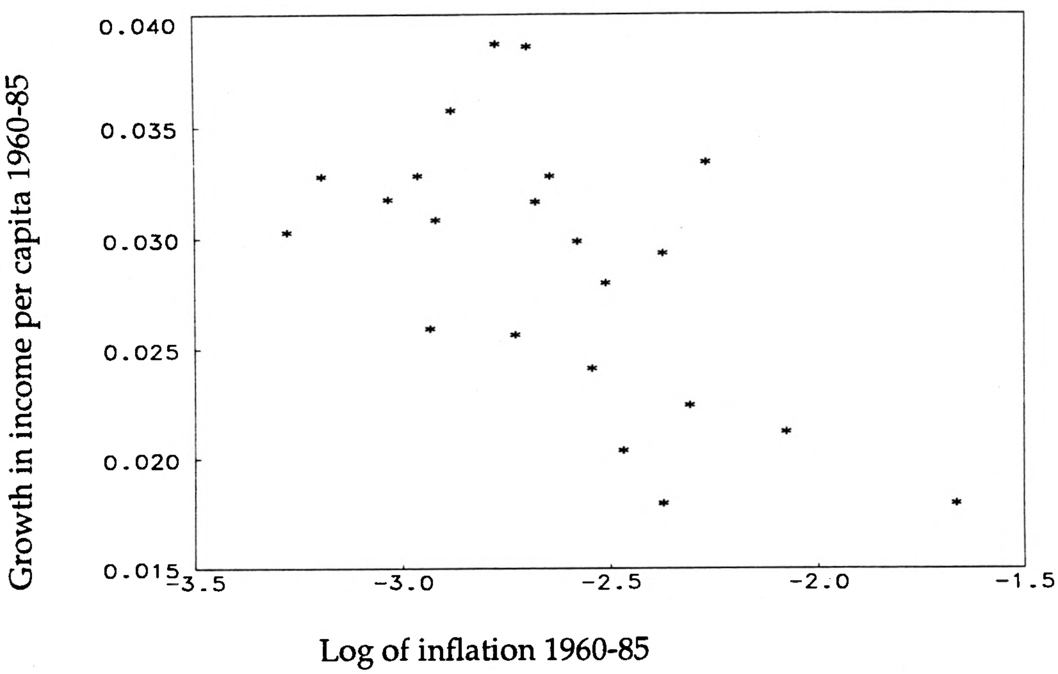
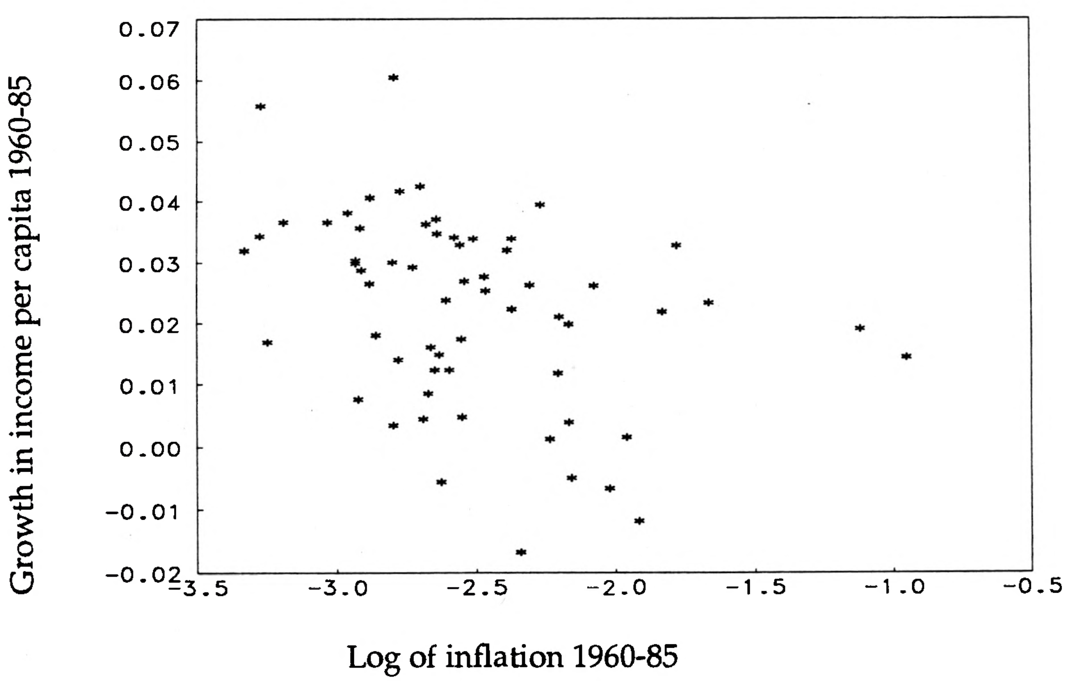


Figure 14: Log of Inflation and the Growth of Income per Capita
Conditional on Variables Determining Growth
62 Countries



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