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When Does Inflation Hurt Economic Growth?

Different Nonlinearities for Different Economies

Richard C. K. Burdekin, Arthur T. Denzau, Manfred W. Keil,

Thitithep Sitthiyot, and Thomas D. Willett

Claremont McKenna College and Claremont Graduate School

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Abstract

We show that the effects of inflation on growth change substantially as the inflation rate rises. Moreover the nonlinearities are quite different for industrial economies than for developing countries. We find that the threshold at which inflation first begins to seriously negatively affect growth is around 8% for industrial economies but 3% or less for developing countries. Marginal growth costs for developing countries then decline significantly above 50% inflation. Failure to account for nonlinearity biases downward the estimated effects of inflation on growth. Mixing industrial and developing economies together also produces unreliable results.

Key Words: Inflation, Growth, Nonlinearity.
JEL Classification: O4, E6, C1.

Contact: Richard C. K. Burdekin, Professor of Economics, Claremont McKenna College, 500 E. Ninth Street, Claremont, CA 91711. 'phone: 909-607-2884; fax: 909-621-8249; e-mail: richard.burdekin@mckenna.edu.

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Introduction

Although few economists now recommend that governments should try to engineer inflation, there is still no consensus as to when the benefits of anti-inflationary programs are likely to exceed the short-run costs. Many argue that it is not worth the transitional costs to bring down inflation rates in industrial countries from 2% or 3% to zero, especially when the upward bias of many price indices is taken into account. And in the case of developing economies it has not been uncommon for economists to judge inflation rates of from 20% to as much as 40% as being satisfactory. Negative effects of inflation on growth may well only begin to kick in after some threshold has been breached. But there has been little systematic research on where these thresholds lie and the judgments offered have varied widely.[1]

It is clearly important for policymakers to have a better-informed idea of where such inflation thresholds may lie for different economies. Sarel (1996) finds that the failure to take such thresholds into account can lead to substantial downward bias in estimates of the growth costs of inflation rates above the threshold. But, as with other studies such as Fischer (1993) and Barro (1996), Sarel groups together industrial and developing countries. Given that recent research has demonstrated that the size of the growth-depressing effects of inflation differ substantially between industrial and developing countries,[2] it seems important to allow the position of thresholds to differ also across the two groups of countries.

Another key issue is that, once the initial threshold has been passed, the marginal growth costs cannot necessarily be assumed to remain constant as the rate of inflation increases. Even if the total costs of inflation continue to climb as the inflation rate increases, after some point the marginal effects will surely begin to decline. Thus, for example, going from an inflation rate of 30% to 40% seems likely to generate more additional uncertainty than going from 130% to 140%. Fischer (1993) finds support for this view for industrial and developing country data. Using break points of 15% and 40%, Fischer finds the coefficients on inflation rates above 40% to be substantially lower than for those between 15% and 40%.[3] Fischer's thresholds are, however, picked by judgment rather than by empirical search. Meanwhile Sarel's search procedure, although allowing the initial threshold (suggested to be at 8% for his combined sample of industrial and developing countries) to be determined by the data, takes no account of the additional nonlinearity suggested by Fischer (1993).

In this paper, we follow a variant of Sarel's econometric procedure, but consider separately the data for industrial and developing countries and also allow for multiple thresholds. We isolate an 8% threshold for the industrial countries that corresponds to Sarel's findings for his combined sample, but for developing countries we identify an initial 3% threshold. Up to the 8% threshold for the industrial countries, the effects of rising rates of inflation are statistically insignificant but predominantly negative. However, for the developing countries, inflation has positive, significant, and sizable effects until the 3% threshold is reached. While inflation has negative effects after this point, developing countries clearly feature the decreasing marginal costs of inflation suggested by Fischer. Using multiple knot splines, we identify a second break at around

50%, with the coefficient for the marginal growth costs of inflation dropping by nearly three-quarters above this break. We also find some weaker evidence of a third break at around the 100% level, with the coefficient falling again by a substantial amount.

Assessing the Nonlinear Effects of Inflation on Growth

Our reduced-form model combines the effects of inflation and the first-period change in inflation with a wide range of potentially relevant determinants of growth that have been frequently used in the literature. The first-period change in inflation is included to pick up possible short-run Phillips curve effects. Other control variables -- previous period real GDP per capita, population growth, government expenditure, the black-market exchange rate premium and the terms of trade -- are included to avoid omitted variable bias.[4] The following equation is estimated over annual time-series data for 21 industrial and 51 developing countries from 1967 to 1992:

$$y = cnst + \beta_1 inf + \beta_2(inf - inf_1)*break1 + \beta_3(inf - inf_2)*break2 + \beta_4(inf - inf_3)*break3 + \beta_4 \Delta inf + \beta_5 initialGDP + \beta_6 pop + \beta_7 gov + \beta_8 blmkt + \beta_9 tot + \varepsilon$$

where:

y	=	growth rate of real GDP per capita
cnst	=	constant term
inf	=	inflation rate
inf_1	=	inflation rate where the first structural break occurs
inf_2	=	inflation rate where the second structural break occurs
inf_3	=	inflation rate where the third structural break occurs
break1	=	1 if inf > inf_1, 0 otherwise
break2	=	1 if inf > inf_2, 0 otherwise
break3	=	1 if inf > inf_3, 0 otherwise
Δinf	=	first difference of the inflation rate
initialGDP	=	log of previous period real GDP per capita
pop	=	population growth

gov	=	ratio of real government expenditure to real GDP
blmkt	=	log (1 + ratio of black-market exchange rate to official exchange rate)
tot	=	percentage change in the terms of trade
ε	=	error term

Our basic search procedure allows for up to three breaks. We define three variables -- (inf - inf_1)*break 1, (inf - inf_2)*break 2 and (inf – inf_3)*break 3 -- to capture nonlinear effects of inflation on growth. The spline function with *x* breaks has *x+1* line segments: When the inflation rate is below inf_1, the (inf - inf_1)*break1, (inf - inf_2)*break2, and (inf - inf_3)*break3 variables are all equal to zero and the effect of inflation is estimated by the coefficient on inf: (β_1). When the inflation rate is at higher levels, the coefficient on inflation is the sum of β coefficients. In order to locate the structural breaks we first allow for one break by varying the inflation rate from a low level to a high level. For the industrial countries the initial range is set from zero to 29%. With the developing countries a wider range of zero to 150% is used because of the much higher inflation rates observed in this group. Once we get approximate ranges for inf_1, inf_2, and inf_3, we then iterate across all combinations of inf_1, inf_2, and inf_3 until we get a combination for which the R^2 is maximized. While three breaks are found for the developing countries, the industrial countries evince only two breaks, however. In this latter case the (inf - inf_3)*break3 variable is set equal to zero throughout.

Results for the Industrial Countries

Using the generalized least squares (GLS) estimator with fixed effects, Figure 1 shows how the R^2 values for the industrial countries vary as progressively higher inflation rate observations are added to the sample. These R^2s reflect repeated re-estimations of

the basic equation without structural break terms. The R^2 reaches its maximum point when the inflation rate is at 8%, and starts to fall when the inflation rate passes the 8% threshold level. The R^2 rises again when the inflation rate passes the 21% level and reaches its maximum when the inflation rate is at 24%. Once the inflation rate passes the 24% level, the R^2 starts to fall. After searching over different combinations of inf_1 and inf_2, we find that a combination of 8% and 25% inflation rates yields the highest R^2. Results from t-tests indicate that these two structural breaks are statistically significant at the 1% and 5% level, respectively. As there is no evidence of a third break in this case, no inf_3 term appears in the regression results for the industrial countries.

Table 1 presents the panel estimates with fixed effects for the industrial countries.[5] The spline function results show that the relationship between inflation and growth is nonlinear. Based on our findings, when inflation is below the 8% threshold level, the estimated effect of inflation on growth is negative (-0.065) but statistically insignificant. However, when the inflation rate is above the threshold level (8%) but below the second structural break (25%), the coefficient on inflation is negative (-0.310) and significant at the 1% level. The estimated coefficient indicates that an increase in the inflation rate of 1% would lower the growth rate by about 0.3%. When the inflation rate exceeds 25%, the estimated coefficient on inflation is negative and significant with the even higher magnitude of -1.713. These results also suggest that the marginal costs of inflation for the industrial countries are rising as the inflation rate increases.

When the equation is re-estimated without the threshold effects, panel results for the linear model (misleadingly) indicate that a 1% increase in inflation would reduce growth by 0.21%, a relatively small number when compared to the spline function results

for an inflation rate between 8% and 25%. This suggests that not taking structural breaks into account will bias downward the estimated effects of inflation on growth by a factor of about 1.5.

Our empirical results also evidence a short-run Phillips curve trade-off for the industrial countries. The estimated coefficient on the first difference of inflation is positive and significant, suggesting that a 1% increase in inflation would increase growth by 0.15% in the short run. The coefficient on previous period real GDP per capita, population growth, and the ratio of real government expenditure to real GDP variables all have the expected signs and are statistically significant at the 1% level.

Results for the Developing Countries

The R^2 results shown in Figure 2 suggest three points of inflection at the inflation rates of 2.5%, 56%, and 89%. After iterating across different combinations of inf_1, inf_2, and inf_3, a combination of the inflation rates of 3%, 50%, and 102% is found to yield the highest R^2. The structural breaks at the inflation rates of 3% and 50% are both statistically significant at the 1% level. The break at 102% is not significant, however. As shown in the developing country panel estimation results in Table 2 (column 1), when the inflation rate is below the 3% threshold level, the coefficient on inflation is positive and highly significant (0.361).[6] These findings suggest that, at such low rates, higher inflation increases economic growth. However, when the inflation rate is between 3% and 50%, the coefficient of inflation is negative and significant at the 1% level. The estimated effect indicates that a 1% increase in inflation would lower growth by 0.083%. When inflation is between 50% and 102%, the estimated effect of inflation on growth is

negative (-0.023) but not significant.[7] The effect of inflation on growth becomes negative (-0.007) and significant at the 5% level when the inflation rate exceeds 102%. In contrast to the industrial countries, the results from developing countries suggest that the marginal costs of inflation are declining as the inflation rate rises.[8]

By comparison, linear estimation without any allowance for structural breaks would have us believe that an increase in the inflation rate of 1% reduces the growth rate by only 0.013%. Note that this coefficient value is well below the value implied by the spline function when the inflation rate is between 3% and 50%. As with the results from the industrial countries, when structural breaks are ignored the estimated effects of inflation on growth are biased downward substantially -- in this case by a factor of more than five.

There is no evidence of a short-run effect of inflation for developing countries. Otherwise, the coefficients on the control variables all have the expected signs and are significant at least at the 10% level -- except for the coefficient on population growth that is significant at the 11% level.

Conclusions

This paper's empirical results support the view that the effect of inflation on growth is nonlinear and that there is indeed a threshold at which inflation starts to have a negative impact on growth. While there is a nonlinear relationship between inflation and growth in both industrial and developing countries, not only do the critical inflation rates differ but also the effects of inflation on growth are quite different between the two groups of countries. Thus, the results from studies that estimate the nonlinear

relationship between inflation and growth by pooling industrial and developing countries together should be treated with caution. Furthermore, our results yield further evidence that a failure to take account of nonlinearity causes a substantial downward bias in the estimated negative effects of inflation on growth.

While a number of studies find negative inflation-growth correlations using a linear model, our analysis indicates that inflation affects growth differently depending upon the range of the inflation rate and the type of economy under consideration. These findings suggest the importance of further theoretical and empirical research to better understand the causes of these differences and to investigate whether it will prove useful to make finer distinctions than just industrial versus developing countries.[9]

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Appendix 1

Data Sources

Real GDP per capita and growth rate of real GDP per capita

Sources: International Financial Statistics (CD-ROM)

Penn World Table (Mark 5.6)

Inflation and first difference of inflation

Source: International Financial Statistics (CD-ROM)

Population growth

Source: International Financial Statistics (CD-ROM)

Ratio of real government expenditure to real GDP

Source: Penn World Table (Mark 5.6)

Black-market exchange rate premium defined as the ratio of the black-market exchange rate to the official exchange rate

Sources: World Currency Yearbook (various issues)

Percentage change in the terms of trade defined as the log of export prices minus the log of import prices

Sources: World Tables, World Bank (various issues)

Appendix 2

List of Countries

Industrial Countries

Australia	France	Japan	Spain
Austria	Germany	Netherlands	Sweden
Belgium	Greece	New Zealand	Switzerland
Canada	Ireland	Norway	United Kingdom
Denmark	Italy	Portugal	United States
Finland			

Developing Countries

Africa

Ghana	Madagascar	South Africa	Tunisia
Kenya	Mauritius	Tanzania	Zambia
Liberia	Morocco		

Asia

Bangladesh	Korea, Republic of	Nepal	Singapore
India	Malaysia	Pakistan	Sri Lanka
Indonesia	Myanmar	Philippines	Thailand

Middle East and Europe

Cyprus	Iran	Jordan	Syrian Arab Rep.
Egypt	Israel	Malta	Turkey

Western Hemisphere

Argentina	Costa Rica	Guyana	Panama
Bolivia	Dominican Republic	Haiti	Paraguay
Brazil	Ecuador	Honduras	Peru
Chile	El Salvador	Jamaica	Trinidad and Tobago
Colombia	Guatemala	Mexico	Uruguay
Venezuela			

Figure 1: Re-estimating Across Varying Industrial Country Inflation Rates

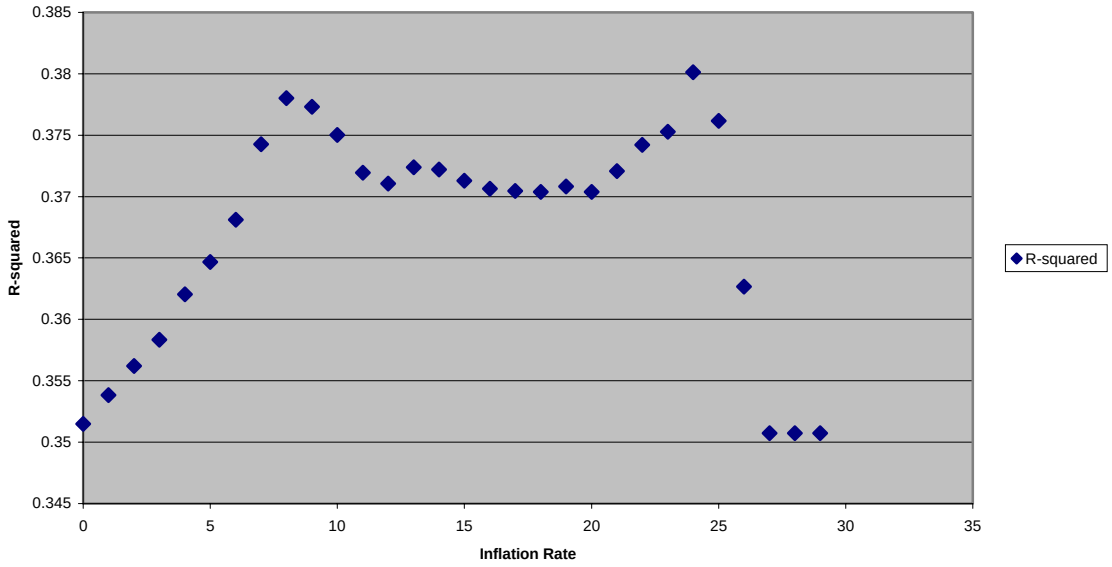

Figure 2: Re-estimating Across Varying Developing Country Inflation Rates

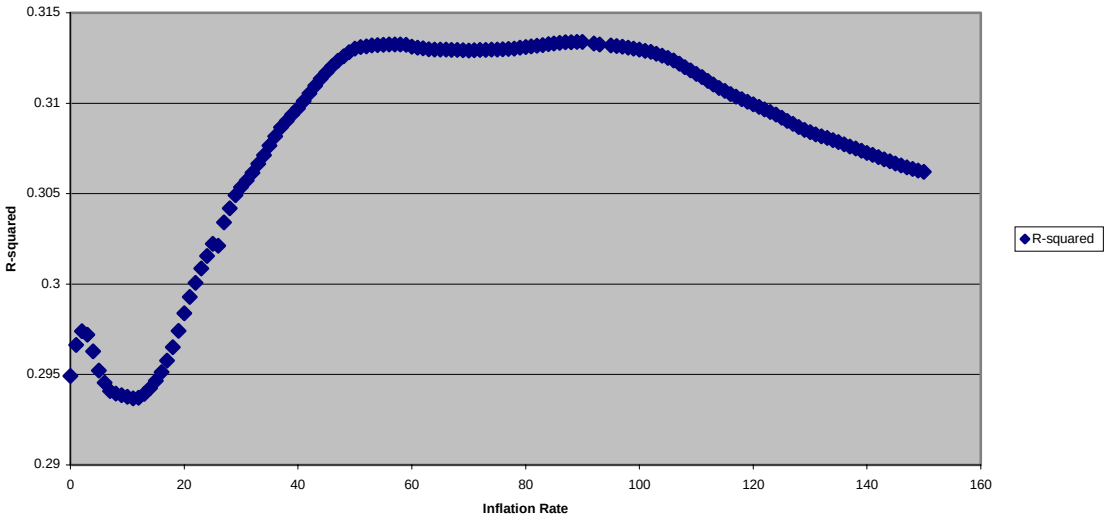

Table 1. Nonlinear Growth Equation Estimated for the Industrial Countries

Explanatory Variable	*Coefficient*
First difference of inflation	0.15 (4.13)
Log of previous period real GDP per capita	-0.029 (6.25)
Population growth	-0.92 (4.28)
Ratio of real government expenditure to real GDP	-0.0033 (4.01)
Inflation: below 8%	-0.065 (1.38)
Inflation: between 8% and 25%	-0.310 (8.17)
Inflation: above 25%	-1.713 (2.93)
Inflation: without structural breaks	-0.214 (9.01)

Notes: R^2 = 0.40; number of observations = 583; t-statistics are in parentheses.

Table 2. Nonlinear Growth Equation Estimated for the Developing Countries

Explanatory Variable	*With negative inflation rates included*	*With negative inflation rates excluded*
First difference of inflation	-0.00001 (0.05)	0.0000008 (0.04)
Log of previous period real GDP per capita	0.018 (2.36)	0.018 (2.35)
Population growth	-0.17 (1.62)	-0.16 (1.54)
Ratio of real government expenditure to real GDP	-0.0019 (3.96)	-0.0019 (3.97)
Log (1 + black-market exchange rate premium	-0.020 (2.70)	-0.032 (3.82)
Percentage change in terms of trade	0.031 (3.79)	0.032 (3.82)
Inflation: below 3%	0.361 (2.65)	6.167 (4.26)
Inflation: between 3% and 50%	-0.083 (5.68)	-0.083 (5.69)
Inflation: between 50% and 102%	-0.023 (1.43)	-0.022 (1.36)
Inflation: above 102%	-0.007 (2.26)	-0.006 (1.81)
Inflation: without structural breaks	-0.013 (5.23)	-0.013 (5.26)

Notes: $R^2 = 0.32$; number of observations = 1181.

The structural breaks at 3% and 50% inflation are both statistically significant at the 1% level. However, the third suggested break at 102% inflation is statistically insignificant.

In the last column, the initial threshold is reset to 1%.

[1] Representative studies include Fischer (1993), Barro (1996), Motley (1996), Sarel (1996), Christoffersen and Doyle (1998), Ghosh and Phillips (1998) and Kalra and Sløk (1999).

[2] See, for example, Burdekin et al. (1994; 1995) and Kim and Willett (2000).

[3] While Barro (1996), using the same breakpoints as Fischer (1993), finds that the differences in coefficients are not statistically significant, the coefficient pattern (–0.16, -0.37 and –0.23) remains suggestive of the same type of nonlinearity noted by Fischer.

[4] For industrial countries, we include only the first difference of inflation, previous period real GDP per capita, population growth, and government expenditure as our control variables since the other control variables are not statistically significant.

[5] Re-estimating the equation for the industrial countries using the pooled GLS method yields results similar to those estimated using the panel with fixed effects. The R^2s suggests that structural breaks occur when inflation is at 8% and 24%. Below 8%, the coefficient on inflation is negative (-0.045) but insignificant. The estimated effect of inflation on growth is negative and statistically significant (-0.297) when inflation is between 8% and 24%. Above 24%, the effect of inflation is negative with even higher magnitude (-1.081). These results also suggest that the marginal costs of inflation are rising as inflation rate increases. These and other sensitivity tests reported are available from the authors upon request.

[6] The results of estimating the equation using the panel method with period and region dummies are quite similar to those estimated by the basic panel method with fixed effects. In this case structural breaks are identified at the inflation rates of 3%, 50%, and 102%. Below 3%, the effect of inflation on growth is positive (0.364) and significant at the 1% level. When the inflation rate is between 3% and 50%, the estimated effect of inflation is negative (-0.058) and significant at the 1% level. The coefficients of inflation on growth are negative but statistically insignificant with the magnitudes of -0.017 and -0.004, respectively when inflation is between 50% and 102% and above 102%. These results again clearly show the marginal costs of inflation to decline as the inflation rate rises.

[7] The p-value is 0.15.

[8] Whereas Sarel (1996) actually uses the log rather than the level of inflation in his regressions, further testing showed this functional form to have little effect on our results for the industrial countries. It did increase our estimate of the first threshold for developing countries from 3% to 10%, however (see Burdekin et al., 2000). Of course one cannot take logs of negative numbers so Sarel replaced all negative inflation rates with 0.1. To check the importance of purging negative rates of inflation from the sample, we also ran a regression in levels for the developing countries with all negative inflation rates deleted. As reported in Table 2 (column 2), this had almost no effect except for the first threshold where the effects are substantial. The threshold falls to one percent and, while the coefficient remains positive and significant, it rises dramatically from 0.36 to an implausible high 6.17. This demonstrates the importance of avoiding negative rates of inflation and confirms that effects of actual deflation are quite distinct from the effects of near zero, but positive, inflation rates.

[9] Burdekin et al. (1994) suggest that the substantially higher estimates of the costs of inflation for industrial countries may result from their greater use of financial markets. They hypothesize that this leads to higher per capita income in the industrial countries, but also makes them more sensitive to the adverse effects of inflation.