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Commentary

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Robert J. Barro's article, "Inflation and Growth," presents the results of regressions of per capita output growth on inflation across countries and over time. He finds that there is a statistically significant negative slope coefficient estimate in these regressions; the estimate usually lies between −0.02 and −0.04. As far as I can tell, Barro wants to interpret these results as follows. Suppose a central bank can choose between two different monetary policies. The first monetary policy induces an average inflation rate of 5 percent per year, whereas the second monetary policy induces an average inflation rate of 15 percent per year. Barro argues that his regressions imply that growth will be on average 0.3 percent higher per year in the first monetary policy regime.

Of course, the problem with this interpretation is obvious: Growth and inflation are both endogenous variables. Given this endogeneity, can we really view this negative coefficient as being an opportunity for the monetary authorities to influence growth rates?

My discussion has three parts. In the first part I set up and calibrate a simple macroeconomic model. In the model, monetary policy has no effect on growth. Yet, because of endogeneity bias, regressions of growth on inflation produce coefficient estimates on the order of −0.024. This indicates that the quantitative magnitude of Barro's estimates are entirely consistent with classical models of money in which monetary policy has no effect on long-run growth. In the second part of my discussion, I assess Barro's attempts to eliminate this endogeneity bias with instrumental variables. I conclude that these attempts are not very convincing. I summarize my conclusions in the third part.

A CALIBRATED CLASSICAL MODEL

Consider a world with many countries. Within each country, individuals are identical and have homothetic preferences over consumption streams. Let k_{t-1} denote capital at the end of period $(t\text{-}1)$. It produces period t output y_t according to the production function:

$$(1) \qquad y_t = Ak_{t-1}.$$

In this formula, A is the marginal productivity of capital; it is constant over time. Output in period t gets split into consumption and investment as follows:

$$(2) \qquad y_t = c_t + i_t,$$

$$(3) \qquad k_t = k_{t-1}(1\text{-d}) + i_t.$$

In these formulas, c_t is period t consumption, i_t is period t investment, and d is the depreciation rate of capital, which is constant over time.

In addition to the above physical constraints, individuals within each country face a cash-in-advance constraint on consumption. The central bank in each country prints money so that the money supply grows at a constant rate. It distributes the money through lump-sum transfers to individuals in the economy.

In this environment, there is a classical dichotomy: Central banks are not able to influence the growth rate of real output. Instead, the growth rate of real output, which is constant over time, is determined by the parameters governing preferences and by the technology parameters A and d, which might be indirectly affected by government fiscal policy. Prices are then determined through money market equilibrium:

$$(4) \qquad P_t = M_t^s / C_t,$$

where C_t is equilibrium consumption, and M_t^s is the money supply in period t.

This gives rise to the following relationship between inflation and growth across countries. Let $\pi^j = \ln P^j_{t+1} - \ln P^j_t$ be the inflation rate in country j, let $\mu^j = \ln M^j_{t+1} - \ln M^j_t$ be the money growth rate in country j, and let $g^j = \ln Y^j_{t+1} - \ln Y^j_t$ be the growth rate of real output in country j. Then money market clearing says that

$$\pi^j = \mu^j - g^j, \tag{5}$$

or equivalently

$$g^j = -\pi^j + \mu^j. \tag{6}$$

In keeping with the spirit of monetary neutrality, assume that μ^j and g^j are stochastically independent across countries; otherwise, it is trivial to match any covariation across countries in output growth and inflation with a classical model. Suppose, as in Barro's article, an econometrician has data across countries on g^j and π^j, but not on μ^j. He runs a regression of g^j on π^j. The regression coefficient is given by

$$\mathrm{Cov}(g^j,\pi^j)/\mathrm{Var}(\pi^j) = -\mathrm{Var}(\mu^j)/\{\mathrm{Var}(\mu^j) + \mathrm{Var}(g^j)\}, \tag{7}$$

where all moments are calculated across countries.

Thus even though monetary policy has no effect on long-run growth rates in this model, there is a negative correlation between inflation and output growth. This is because of the usual classical effect: When output growth is high, relatively little money is chasing a lot of goods. Hence the growth of goods prices will be low, so inflation will be low.

The predictions of a classical model are certainly consistent with the *sign* of Barro's regression estimates. Can a classical model also replicate the *magnitude* of Barro's estimates? Clearly, the quantitative predictions of a classical model depend on the cross-country moments $\mathrm{Var}(\mu^j)$ and $\mathrm{Var}(g^j)$. I calibrated these parameters using data on p. 153 of Barro's *Macroeconomics.* I found that in his sample of 79 countries, the sample variance of output growth equals 0.000265, whereas the sample variance of money growth equals 0.0107. Using these estimates, we see that the prediction of the calibrated model for the slope coefficient b is

$$b_{\mathrm{pred}} = -0.000265/(0.0107 + 0.000265) = -0.024. \tag{8}$$

Thus when the model is calibrated to accord with data on money and output growth, one obtains slope coefficients in regressions of growth on inflation that are quantitatively similar to those obtained by Barro. When viewed in this light, his coefficient estimates appear to be evidence in favor of the long-run neutrality of money growth.[1]

In Table 1, I report how the calibrated

Table 1

Quantitative Performance of a Classical Model*

Slope Coefficients in Regressions of Δy on Δp in Inflation-Based Subsamples

Inflation Range	Predicted	Estimated
[0, ∞)	−0.024	−0.35 (0.140)
[0, 10%]	−0.296	−0.224 (0.120)
[10%, 25%]	−0.116	−0.058 (0.088)
[25%, ∞)	−0.020	−0.085 (0.044)

Conditional Means of Inflation and Growth†

	Fast Growers	Slow Growers
Predicted mean inflation	0.085	0.109
Estimated mean inflation	0.091	0.119

Slope Coefficient in a Regression of Inflation on Growth

Predicted	−1.000	
Estimated	−1.600	(1.015)

* All variables were estimated using data on inflation and output growth from 79 countries (p. 153 of Barro's *Macroeconomics*). Standard errors are consistent in the presence of heteroskedasticity.

The predictions are generated from a classical model in which Δy and Δm are assumed to have independent distributions given by their empirical distribution functions in the same data set.

† Fast growers grow faster than the median country, whereas slow growers grow slower than the median country.

[1] Barro's estimates are based on pooled cross-sectional regressions. The predictions of the classical model for these types of regression estimates will be influenced by the relative magnitudes of the within-country variance of output growth and money growth.

model does in terms of matching various aspects of the empirical joint distribution of inflation and output growth across countries. I calculate this empirical distribution using the data from Barro's textbook. The calibrated model basically matches all of the features of interest of the empirical distribution. Table 1 serves to underscore that there is no need to abandon the classical model to explain cross-country data on inflation and output growth.

INSTRUMENTS?

Barro is certainly aware of the endogeneity problem described previously. He attempts to deal with it by using instruments that satisfy two conditions: They are *demonstrably* correlated across countries with inflation and *plausibly* uncorrelated across countries with the error term in his growth regressions. He discards a measure of central bank independence because it does not satisfy the first requirement. He finds two instruments, lagged inflation and previous colonial status, that are both demonstrably correlated with inflation. The question is whether they are plausibly uncorrelated with the error term in the growth regressions.

For both instruments, it seems that the answer to this question must be no. Suppose one believes that inflation is possibly correlated across countries with the error term in the growth regression (as the preceding section argues and as Barro seems to feel might be a problem). Presumably, within a given country, inflation is a stationary process. Then if inflation averaged over 1971–80 is correlated across countries with unexplained growth differentials, so should inflation averaged over 1965–70 be correlated.

The previous colonial status regressor is more interesting. Colonial status, however, presumably affects a country's ability to grow in ways other than through inflation (or through the other explanatory variables). For example, recent theoretical work by Tamura (1995) suggests that being part of a larger language network might lead a country to grow faster. If Tamura's reasoning is right, being under British or French rule may tie a country into a wider language-economic network than that of a country under Spanish or Portuguese rule and therefore lead to higher growth in the British and French colonies.

CONCLUSION

Barro argues that his regression estimates indicate that central banks can have an effect on long-run growth rates through monetary policy. In the first part of this commentary, I discuss the predictions of a classical model for the slope coefficient in a regression of growth on inflation. I show that the sign of this coefficient is generally negative because high growth tends to generate low inflation. More important, I demonstrate that the data on relative magnitudes of the variances of output growth and money growth across countries imply that this classical effect is quantitatively consistent with the estimates Barro obtained. In the second part of my discussion, I argue that Barro's attempts to deal with endogeneity bias through appropriate choice of instruments are unconvincing.

My analysis indicates that the coefficient estimates obtained by Barro are quantitatively consistent with a simple classical model of money and growth. Given my results, I would recommend that policymakers *not* view lower long-run growth as a penalty of inflationary monetary policy. Moreover, given the scarce amount of time available to economic theorists, I would recommend that they not spend it trying to build models that predict large growth consequences for monetary policy.

REFERENCES

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