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AN ADAPTATION OF BARRO'S MODEL FOR ANTICIPATED MONEY GROWTH TO A SAS COMPUTER PROGRAM

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The rational expectations school holds that only unanticipated money growth affects real variables. To test this hypothesis one would need a model that seperates anticipated and unanticipated money growth. Professor Robert J. Barro has proposed such a model (1977) which has gained wide acceptance among monetarist and rational expectation theorists.

The purpose of this paper is to explain Barro's justification of his model, to describe how this model was adapted to a SAS computer program and then to report on the results obtained by this program using quarterly data from 1959 (QI) to 1983 (QIII).

BARRO'S JUSTIFICATION FOR HIS MODEL

DMt = a0 + a1 DMt-1 + a2 DMt-2

+ a3 FEDVt + a4 [Ut-1 / (1 - Ut-1)]

This is Barro's sketch of his model for anticipated money growth. Notice that it contains a constant term plus four variables. Each of the variables is explained in the following:

DMt measures the average annual money growth and can be expressed algebraically as log Mt - log Mt-1. Barro used the M1 definition of money for his model. t is the measure of time period.

FEDV represents the ratio of real federal expenditures to its "normal" level. This "normal" level is defined by Barro as [log (fed)]* which equals:

a [log (fed)]t + (1-a) [log (fed)]*t-1. (1)

In other words, Barro's normal level is the log of the current real federal expenditures times a constant, a, plus

(1) Barro, 1977, p. 103.

exponentially declining values of previous normal expenditures. Using a regression of annual data from 1941-1975, Barro obtained 0.2 for the coefficient a. (2) Consequently, Barro's formula for normal federal expenditures is:

0.2 [log (fed)]t + 0.8 [log (fed)]*t-1

Taking the difference of this normal level of expenditures from the current level yields the unanticipated part of federal spending. According to rational expectations theory, this unanticipated part is the only part that has any effect on real variables since any anticipated factor is neutralized by counter active behaviors of the public.

Barro notes that federal spending can be financed by taxation or a money issue, but his formula does not attempt to distinguish the two. He assumes a constant ratio between taxation and money issue and then proceeds to establish his relationship between unanticipated federal spending and money growth.

[Ut-1 / (1 - Ut-1)] Barro includes this unemployment element in his money growth equation. He conjectures a positive relationship of unemployment to money growth for two reasons. First, the authorities might raise money growth as a counter-cyclical policy to rising unemployment. Second, as real income declines so will holdings of real balances. Barro had shown in a previous article (1976) that the optimal response to a decline in real income is to raise money growth.

Finally, Barro includes two lagged values of money growth (DMt-1 and DMt-2) to account for any "elements of serial depen-

(2) Barro, 1977, see footnote 5, p. 104.

dence or lagged adjustment" (3) that the other two independent variables, FEDV and U, might not catch.

BARRO'S ESTIMATED EQUATION

Using yearly data from 1941 to 1973, Barro obtained the following coefficients (standard errors are in parentheses):

$$DMt = \underset{(.031)}{.087} + \underset{(.15)}{.24}\, DMt\text{-}1 + \underset{(.13)}{.35}\, DMt\text{-}2 + \underset{(.015)}{.082}\, FEDVt$$

$$+ \underset{(.010)}{.027}\, [Ut\text{-}1 / (1 - Ut\text{-}1)]$$

FEDV's estimated coefficient of .08 (rounded) means that a 10% increase in real federal spending (holding constant the normal level of spending as well as the other variables in the equation) will increase money growth by 8/10 of a percentage point per year.

The unemployment coefficient of .03 likewise means that a 10% increase in the unemployment level will increase money growth by 3/10 of a percentage point per year.

The large coefficients of the lagged money variables also indicate a strong relationship.

Moreover, all of the components of Barro's equation are statistically significant, which indicates a strong positive relationship. Undoubtedly, Barro felt confident that he had hit upon an appropriate equation for anticipated money growth.

(3) Barro, 1977, p. 104.

ADAPTATION OF BARRO'S EQUATION TO A SAS COMPUTER PROGRAM

It will be helpful to have Barro's equation in front of us as we look at the computer code.

DMt = a0 + a1 DMt-1 + a2 DMt-2 + a3 FEDV

+ a4 [Ut-1 / (1 - Ut-1)]

The computer instructions based on Barro's model are given on page 2 of the accompanying program. An explanation of each step follows:

INPUT used six variables:

M1 - money supply (new M1 definition) lagged one period.

M2 - money supply (new M1) lagged two periods.

F - nominal quarterly federal expenditures.

U1 - unemployment rate expressed in percentage points.

M - money supply (new M1) current period.

P - GNP price deflator (1972 = 100).

The SAS instructions are:

LM = log (M) is the log of the current period's money supply.

LM1 = log (M1) is the log of the input value M1 which is a one period lag of the money supply.

LM2 = log (M2) is the log of the input value M2 which is a two period lag of the money supply.

M3 = lag (M2) creates a third lagged value by lagging M2.

LM3 = log (M3) is the log of this newly lagged variable.

DLM1 = LM1 - LM2 expresses the change of log Mt-1 of Barro's equation. This means the change of the log of last quarter's money supply from the previous quarter.

DLM = LM - LM1 expresses the current money growth. This is the left hand side of Barro's equation.

DLM2 = LM2 - LM3 This equation expresses the money growth of two quarters ago.

FED = (F/P) * 100 This equation converts nominal federal expenditures to a constant dollar amount. Base year is 1972.

LFED = log (FED) is the log of real federal expenditures.

F1 = lag (FED) lags the federal expenditure variable one quarter.

LLFED = log (F1) This is the log of the lagged variable F1.

LSFED = .2 * LFED + .8 * LLFED This is an approximation of Barro's normal value of federal spending. We were unable to code in SAS the repeating regress of [log (FED)]*t-1. Therefore, we rounded this value to LLFED, which is the log of last quarter's federal spending.

FEDV = LFED - LSFED Here we subtract the logged value of the approximated normal real federal expenditures from the logged value of current real expenditures to arrive at FEDV.

U = (U1) / 100 This equation converts the whole number input value for unemployment, U1, to a decimal. The input values have already been lagged one period.

UN = (U) / (1 - U) This expresses the unemployment rate as a fraction of the employment rate.

LU = log (UN) This takes the log of the previous equation. These last three steps express Barro's unemployment variable.

Lines 117 through 126 of the program are SAS instructions for calculating regression statistics. These instructions will generate the coefficients for Barro's model.

DATA

I gathered the input data from Robert J. Gordon's Macroeconomics text (Third Edition), table B-2, "Time Series Data for U.S. Economy, 1947 - 1983." The quarterly values of nominal federal expenditures are from the Federal Reserve Bulletin.

RESULTS

The calculated values for the coefficients and their variances are on the last page of the program. Although the slightly negative values for the coefficients may seem perverse, we can be sure that the SAS program is faithful to Barro's original formula. I have also double-checked the input values. Therefore, I feel confident that we can use these results in an hypothesis test.

The calculated coefficients are:

a0 = -0.0117177

a1 = -0.364166

a2 = -0.702378

a3 = 0.00897244

a4 = -0.0011202

Variances for each a value are:

VAR a0 = .0000635813	Standard error = SQRT (VAR) = .007969
VAR a1 = .919356	Standard error = .95883
VAR a2 = .898191	Standard error = .947729
VAR a3 = .000318999	Standard error = .0178578
VAR a4 = .0000072441	Standard error = .0026833

Rounding these results, I get the following version of Barro's formula. Rounded standard errors are in parentheses.

D = delta

$$D \ln M_t = \underset{(.008)}{-.012} + \underset{(.959)}{-.364}\, D \ln M_{t-1} + \underset{(.948)}{-.702}\, D \ln M_{t-2}$$

$$+ \underset{(.018)}{.009}\, FEDV + \underset{(.003)}{-.001} \ln [\, U_{t-1} / (1 - U_{t-1})]$$

HYPOTHESIS TEST

We are now ready to perform a hypothesis test on the relation of the four input variables to money growth.

H0: a1 = a2 = a3 =a4 = 0

HA: a1 ≠ a2 ≠ a3 ≠ a4 ≠ 0

The null hypothesis states that the a values equal 0, meaning that the variables do not have any significant relationship to money growth. The alternative hypothesis is the opposite: The four variables have a non-zero relationship to money growth. The test statistic we shall use is the t value.

$$t1 = \frac{-.364166}{.95883} = -.3798023$$

$$t2 = \frac{-.702378}{.947729} = -.7411166$$

$$t3 = \frac{.00897244}{.0178578} = .502358$$

$$t4 = \frac{-.0011202}{.0026833} = -.4174739$$

Each t value differs insignificantly from zero. The nearest critical value of t for a confidence interval of 10% is t = 1.645 Therefore, we must reject the alternative hypothesis and accept the null hypothesis. That is, I find no relationship between the four variables of the equation and money growth.

CONCLUSION

In Barro's original estimated equation, the coefficients represent very significant t values. Consequently, Barro was able to conclude that the independent variables in his equation had a strong bearing on money growth. However, in my adaptation of his formula to a computer program using quarterly data from 1959 to 1983, I found no such relation. How can this be? I can think of four possible reasons.

First, the computer program could be faulty in its representation of Barro's formula or in its instructions used to generate regression statistics. However, after repeated examinations, we are certain that the program accurately imitates Barro's formula (except for the expression [log (FED)]*t-1 for which we substituted an approximation. See page 5). And regarding the computer instructions for generating regression statistics, Chuang Juang is confident that they are correct. Therefore, we are certain that the computer instructions do not contain errors.

Second, I took my data over the time period 1959 - 1983, while Barro's is 1941 - 1978. However, I don't see how a few years difference in the sample period can change the conclusion so radically.

Third, and more significant, is that I used quarterly data while Barro used annual data. This could be the reason Barro's model breaks down. Perhaps quarterly changes are too soon for any kind of relationship between the four variables and money growth to materialize. However, a good case can be made that only quarterly data should be used in any rational expectations model since rational expectations theory holds that people form their expectations and engage in counter-policy behavior immediately.

Finally, we cannot overlook the possibility that Barro's model is simply perverse. He might be conjecturing a relationship where none exists, and by using such large aggregate figures as average annual data, Barro got a high correlation of data that simply coincided rather than was causally related.

RESOURCES

Barro, Robert J., "Unanticipated Money Growth and Unemployment in the United States," *American Economic Review*, March, 1977, p. 101 ff.

Gordon, Robert J., *Macroeconomics*, Third edition, Little Brown and Company, Boston, 1984.

Evans, Paul, "The Effects on Output of Money Growth and Interest Rate Volatility in the United States." *Journal of Political Economy*, April 1983, p. 204 ff.