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NON-NESTED SPECIFICATION TESTS AND
THE INTERMEDIATE TARGET FOR MONETARY POLICY

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Abstract

This paper deals with the problem of choosing an intermediate target for monetary policy. The proposed alternative targets are related to economic activity in non-nested models. The choice among the various alternatives is reduced to a series of tests among non-nested models. The test statistics are constructed by creating an artificial nest in an exponentially weighted combination of the null and the alternative hypotheses. Of the monetary aggregates examined in this paper, M-1 was unambiguously the aggregate most closely related to economic activity for the period 1961 through 1980.

I. Introduction

In this paper we apply a recently developed method for testing non-nested hypotheses to the process of choosing an intermediate target for monetary policy. An intermediate target should be controllable by using the instruments of the central bank. Information about the target variable should be readily available, and the variable should be reliably related to the economic objectives of the monetary authorities.¹

The Federal Reserve uses open-market operations and reserve requirements against bank deposits to control the supply of money. The Federal Reserve collects information as frequently as weekly on a subset of bank deposits and has daily access to information about reserves. Controllability and data

availability suggest alternative measures of the money supply and the monetary base as potential intermediate targets. In section II of this paper, we investigate whether each of six alternative monetary aggregates is reliably related to the economic objectives of the monetary authorities.

To begin we must define what we mean by reliably related to the economic objectives of the monetary authorities. Presumably the monetary authorities wish to pursue a policy leading to, or at least consistent with, stability of prices and real output as well as sustainable economic growth. Although monetary policy may affect prices and real output differently over different time horizons, we assume that stability of nominal output leads to stability of prices and real output.² The reliable relation is specified as a single-equation model of nominal GNP.³ This single-equation model has been used to investigate alternative intermediate targets in previous studies by Carlson and Hein (1980), Friedman and Meiselman (1963), Gambs (1980), Hafer (1981), Hamburger (1970), Higgins and Roley (1979), Levin (1974), and Schadrack (1974).

Friedman and Meiselman (1963) reported correlations between contemporaneous values of nominal income and the monetary aggregates--M-1, M-2, and M-3. They selected M-2 based on a simple ranking of the measured correlations. The differences between correlation coefficients for post-1940 data were very small. In each of the other studies, the authors compared adjusted R^2 for single-equation models of nominal income that include alternative monetary aggregates. In no case did the authors attempt to construct tests for significance between the reported statistics (adjusted R^2).

In general, there is not much difference between statistics comparing M-1 and M-2 in most of the studies. Gambs (1980) and Higgins and Roley (1979)

compare M-1 and the monetary base. In both cases adjusted R^2 is higher in M-1 models. Many of these studies include other possible targets, such as interest rates or credit aggregates.

In some of the studies, the authors report the root mean square error (RMSE) from out-of-sample predictions; see Levin (1974), Schadrack (1974), Higgins and Roley (1979), and Carlson and Hein (1980). Again, the results are mixed, and there is no attempt to test the significance of reported differences.

Both Hafer (1981) and Schadrack (1974) test for stability in the single-equation models using the Chow test. Neither can reject stability in any case using a 10 percent significance level. Similarly, tests for Granger causality reported by Hafer (1981) and Carlson and Hein (1980) cannot reject any of the proposed alternatives.⁴

These studies all have in common a simple ranking of statistics generated from non-nested models. Tests for stability and Granger causality do not eliminate any of the alternatives. Cox (1961, 1962) proposed a test statistic for comparing non-nested models. Following the suggestion of Cox, Atkinson (1970) used a combined probability density function (pdf) of the two competing models, H_0 and H_a , to choose between the two models. Each hypothesis is a special case of the combined pdf. Quandt (1974) and Pesaran (1982) summarize developments in the use of the combined pdf to choose between non-nested models.

In this paper we apply a specific form of the test suggested by Davidson and MacKinnon (1981). Suppose that the competing non-nested models are given as:

$$(1) \quad \underline{H}_0: \quad \underline{Y}_t = \underline{A}(L)\underline{X}_t + \underline{u}_t,$$

$$(2) \quad \underline{H}_a: \quad \underline{Y}_t = \underline{B}(L)\underline{Z}_t + \underline{e}_t,$$

where $\underline{A}(L)$ and $\underline{B}(L)$ are matrixes whose elements are finite polynomials in the lag operator. Both \underline{X} and \underline{Z} have some elements that are not included in each other, i.e., one is not nested in the other. The error terms \underline{u} and \underline{e} are assumed to follow:

$$\begin{aligned} E(\underline{e}) &= E(\underline{u}) = 0 \\ E(\underline{e}\underline{e}') &= \sigma^2 \underline{e}\underline{I} \\ E(\underline{u}\underline{u}') &= \sigma^2 \underline{u}\underline{I} \\ E(\underline{X}\underline{e}') &= E(\underline{Z}\underline{e}') = 0 \\ E(\underline{X}\underline{u}') &= E(\underline{Z}\underline{u}') = 0. \end{aligned}$$

The non-nested procedure requires a convex linear combination of the null hypothesis and the maximum likelihood estimate of the alternative hypothesis ($\underline{B}(L)\underline{Z}_t$):

$$(3) \quad \underline{Y}_t = (1 - \alpha) \underline{A}(L)\underline{X}_t + \alpha \underline{B}(L)\underline{Z}_t + \underline{w}_t.$$

If $\alpha = 0$, the null hypothesis is not rejected. Davidson and MacKinnon show that the maximum likelihood estimate of α is asymptotically distributed as a student's t -statistic under the assumption that the null hypothesis is true. Pesaran (1982) shows that this procedure leads to a consistent test and is asymptotically equivalent to other forms of the test when the two competing hypotheses are single-equation models (for example, see Fisher and McAleer 1981).

1 1 The Model including Alternative Monetary Aggregates

The non-nested procedure is used in this paper to test alternative hypotheses represented by six different specifications of the model of nominal GNP.⁵ Each specification includes a different measure of monetary policy. The model given in equation 4 includes current and lagged values of a monetary policy variable and a fiscal policy variable. The model is estimated using ordinary least squares:

$$(4) \quad \underline{Y}_t = \underline{c} + \sum_{i=0}^{n_j} \underline{m}_i \underline{X}_{j,t-i} + \sum_{i=0}^2 \underline{g}_i \underline{G}_{t-i} + \underline{u}_{jt},$$

where

\underline{Y} = percentage change in nominal GNP

\underline{G} = percentage change in high-employment government expenditures

\underline{X}_j = percentage change in the j^{th} monetary policy variable

\underline{u}_j = error term associated with the model including \underline{X}_j .

The six hypothesized monetary policy variables are as follows:

$\underline{H}_1: \underline{X}_1 =$ Board base (monetary base published by the Board of Governors of the Federal Reserve System)

$\underline{H}_2: \underline{X}_2 =$ St. Louis base (monetary base published by the Federal Reserve Bank of St. Louis)

$\underline{H}_3: \underline{X}_3 =$ nonborrowed base (Board base minus adjustment borrowing)

$\underline{H}_4: \underline{X}_4 =$ M-1

$\underline{H}_5: \underline{X}_5 =$ M-2

$\underline{H}_6: \underline{X}_6 =$ M-3.

The data are seasonally adjusted. The nonborrowed base is the monetary base calculated by the Board of Governors minus short-term borrowing to meet an unexpected demand for reserves. Burger (1979) compares measures of the monetary base used by the Board of Governors and the Federal Reserve Bank of St. Louis. Both measures include an adjustment for changes in reserve requirements. M-1 includes currency, demand deposits, and other checkable deposits. M-2 is a broader measure of liquid assets that includes M-1, saving deposits, small time deposits, money market mutual funds, overnight repurchase agreements (RPs), and overnight Eurodollar deposits held by U.S. residents at Caribbean branches of U.S. banks. M-3 includes M-2, large time deposits, and term RPs. A more detailed description of the Ms used in this study can be found in Simpson (1980).

A two-step procedure was used to determine the length of each distributed lag. In the first step, growth rates of nominal GNP were regressed on a constant and a distributed lag of growth rates for high-employment government expenditures. The maximum adjusted R^2 resulted from the estimation of the equation that included the current and two lagged values of government spending. In the second step, growth rates of nominal GNP were regressed on a constant, the current and two lagged values for government spending, and an unconstrained distributed lag of the monetary variable. We selected the lag length that resulted in the highest adjusted R^2 .⁶ The estimated models for each of the financial variables are shown in table 1. The joint hypothesis that the coefficients on the monetary variables were each equal to zero could be rejected at a 1 percent significance level. The exception to this was the nonborrowed base, in which case the joint hypothesis could be rejected at a 1.5 percent significance level. In every case, the sum of the

Table 1 The Spending Equation under Alternative Hypotheses
1961:1IQ - 1980:4Q

$$\text{Equation 4: } Y_t = c + \sum_{i=0}^2 g_i Y_{t-i} + \sum_{j=1}^{n_j} X_{j,t-i} + u_{jt}$$

	St. Louis base			Nonborrowed base			M-1	M-2	M-3
c	2.952 (2.07)	3.792 (2.75)	4.361 (3.18)	3.070 (2.81)	-0.032 (-0.02)	1.433 (0.89)			
g ₀	0.068 (1.33)	0.067 (1.25)	0.082 (1.56)	0.074 (1.69)	0.105 (2.22)	0.130 (2.67)			
g ₁	0.042 (0.83)	0.053 (1.01)	0.043 (0.83)	0.103 (2.38)	0.074 (1.58)	0.058 (1.18)			
g ₂	-0.110 (-2.15)	-0.116 (-2.22)	-0.119 (-2.21)	-0.114 (-2.63)	-0.105 (-2.23)	-0.107 (-2.20)			
m ₀	0.619 (2.29)	0.379 (1.59)	-0.179 (-0.89)	0.607 (4.70)	0.265 (1.75)	0.185 (1.09)			
m ₁	0.232 (0.79)	0.124 (0.46)	0.150 (0.71)	0.239 (1.77)	0.243 (1.34)	0.206 (0.91)			
m ₂	0.044 (0.15)	0.244 (1.08)	0.369 (1.74)	0.244 (1.67)	0.064 (0.29)	0.274 (1.15)			
m ₃	0.309 (1.04)		-0.046 (-0.22)	0.339 (1.80)	0.378 (1.51)	-0.021 (-0.08)			
m ₄	-0.340 (-1.36)		0.382 (2.02)	-0.529 (-2.67)	-0.617 (-2.41)	-0.462 (-1.79)			
m ₅				0.331 (1.57)	0.521 (1.89)	0.810 (3.06)			
m ₆				-0.350 (-2.07)	-0.253 (-0.91)	-0.565 (-2.16)			
m ₇					0.342 (1.78)	0.267 (1.49)			
R ²	0.213	0.165	0.167	0.448	0.326	0.298			
DW ^a	1.826	1.792	1.754	1.988	2.003	1.760			
SE ^b	3.247	3.344	3.340	2.720	3.004	3.066			

a. DW--Durbin-Watson
b. SE--Standard error of regression
NOTE: Values in parentheses are t-statistics.

coefficients on government spending was not significantly different from zero, although individual coefficients were significantly different about 50 percent of the time.

The procedure recommended by Davidson and MacKinnon can be used to test each hypothesis against each of the alternative hypotheses. They refer to the test as the joint test, or \mathcal{J} -test. The \mathcal{J} -test is conducted by estimating equation 5, which corresponds to a compound pdf of the two competing models. The null hypothesis is, for instance, model 1, including the Board base as the monetary policy variable. When $a = 0$, the combined model becomes the null hypothesis; when a goes to 1, the combined model is identical to the alternative hypothesis.

The non-nested procedure requires estimates of the parameters of the model under null and the alternative hypotheses, as well as the choice parameter. To identify the choice parameter, it is necessary to impose a priori constraints on the parameters of the alternative model. Davidson and MacKinnon do this by using the ordinary least squares estimates. This is shown in equation 5 by including the fitted values of GNP growth rates under the alternative hypothesis, $\overset{A}{Y}_j$.

$$(5) \quad \underline{Y}_t = (1 - \alpha) \left[\underline{c} + \sum_{i=0}^2 \underline{g}_i \underline{G}_{t-i} + \sum_{i=0}^{\underline{n}_j} \underline{m}_i \overset{A}{Y}_{j,t-i} \right] + \alpha \overset{A}{Y}_{j,t} + \underline{w}_{j,t}, \quad j = 2, \dots, 5, 6$$

Davidson and MacKinnon show that a conventional asymptotic \mathcal{J} -test can be used to test whether $a = 0$ in equation 2. They point out that if the alternative is true, then a should converge to 1. However, the \mathcal{J} -statistics generated from estimating equation 5 are conditioned by the truth of the null hypothesis. To test whether the alternative is true, we must reverse the

roles of the null and alternative hypotheses and calculate a conditioned by the truth of the new null hypothesis.

As is readily apparent, using a pairwise χ^2 -test may result in rejecting none, one, or both of the alternatives. Sometimes there is insufficient information to construct a model that can reject all of the alternative hypotheses; conversely, there could be insufficient information to reject any of the alternatives.

Detailed results for the pairwise χ^2 -test are shown in table 2. The null hypothesis in each case is shown in the far left column. Reading across, the table lists the estimate of a and the χ^2 -statistic for each alternative. Using a 1 percent critical region, we find that all of the hypotheses except H_4 (M-1) are rejected by at least one alternative.

Each of the higher monetary aggregates rejects each measure of the monetary base. No measure of the monetary base rejects any measure of the money supply. The results in table 2 support the Federal Reserve's decision to target the money supply rather than the monetary base.

According to criteria used in this study, the Federal Reserve should target the narrowest measure of the money supply. M-1 rejects both M-2 and M-3, and it is not rejected by either. M-2 rejects M-3, but M-3 does not reject M-2. In this particular case, a simple ranking of adjusted R^2 would have led to the same decision as an application of the non-nested test procedure. However, the non-nested procedure provides a measure of the significance of the difference between alternatives.

III. Conclusion

In this paper we have applied a procedure for comparing non-nested models

Table 2 Pairwise J-tests for H_1 through H_6

	H_a		H_1		H_2		H_3		H_4		H_5		H_6	
	H_0	α	t	α	t	α	t	α	t	α	t	α	t	
H_1 (Board base)				-1.835	-1.662	1.349*	2.995	1.111*	6.189	0.970*	4.665	0.908*	3.832	
H_2 (St. Louis base)		1.577*	2.823	--	--	1.116*	2.697*	1.092*	6.665	0.959*	4.889	0.961*	4.475	
H_3 (nonborrowed base)		2.193*	5.395	1.835*	2.774	--	--	1.018	6.721	0.966*	4.939	1.002*	5.096	
H_4 (M-1)		0.029	0.088	-0.454	-1.065	0.303	1.025	--	--	0.420	1.972	0.463	2.361	
H_5 (M-2)		0.434	1.545	0.136	0.398	0.316	1.04	0.800*	4.332	--	--	0.542	1.991	
H_6 (M-3)		0.388	1.192	0.140	0.362	0.595	2.029	0.860*	5.157	0.797*	2.885	--	--	

* This estimate of α is significantly different from zero The 0.01 critical value for the t -statistic is 2.65.

to the problem of choosing an intermediate target for monetary policy. We compared six models of economic activity based on six different monetary aggregates. The results unambiguously indicate that the model including M-1 as the monetary policy variable most closely fits the historical data.

While these results are based on historical experience, they are relevant to current debate in one respect. In this paper M-1 differs from the other aggregates in that it is the only aggregate based on the theoretical definition of money as a transaction balance. This compares with measures of the monetary base that attempt to measure the concept of outside money and broader measures of the money supply that include savings-type deposits. The results in this paper suggest that the Federal Reserve should continue to measure and target an aggregate based on the notion of money as a transaction medium.

Footnotes

1. This paper does not address an issue faced by the Federal Reserve in 1981 and 1982. That issue was one of choosing an intermediate target when regulations defining differences among the potential targets were changing.
2. Tobin (1980) and others argue that nominal GNP should be the intermediate target for monetary policy. Jordan (1982) contends that nominal GNP is and has been an intermediate objective of those who advocate monetary targets.
3. This model has its origin in papers by Friedman and Meiselman (1963) and Andersen and Jordan (1968).

4. For a discussion of Granger causality tests, see Granger and Newbold (1977), pp. 224-25. Cagan (1982) uses this framework to nest hypotheses about the appropriate intermediate target for monetary policy.
5. For an application of this procedure to data from Japan, see chapter 4 of Toida (1982).
6. The search for the best lag spanned eight lags. Batten and Thornton (1983) use a variety of tests to determine the best lag length and best degree of the polynomial in this single-equation model, including $M-1$ as the monetary variable. They suggest that the best lag length on the fiscal variable may be as long as 12. However, they, as well as Hafer (1982), also find some evidence suggesting that the fiscal variables should be excluded from the model. The evidence on the issue is mixed; the government spending variable was included on the premise that including too many variables was preferable to excluding a relevant variable. McAleer, Fisher and Volker (1982) present evidence that including too many variables does not affect the consistency of the Davidson-MacKinnon test, while omitting relevant variables may lead to inconsistent tests.

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