Money, Income and Dynamic Lag Patterns Reconsidered

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ABSTRACT

The results of the Hsiao sequential procedure indicate that the optimal lags for both M1 and M2 substantially varied across the system and across the sample period. Also, there is no clear evidence that M2 entered the systems with shorter lags or that the optimal lag order for M2 exhibited more stability than that for M1. It appears that the issue of whether M1 or M2 entered the systems with shorter optimal lags depended largely upon what interest rates were included.

INTRODUCTION

Recent studies have shown that the inclusion of the 1980s data in the sample weakens the money-income relationship. Interest rates, not money, contain information regarding future fluctuations in income [Emery, 1996; Friedman and Kuttner, 1992, 1993]. Emery [1996] shows that the enhanced predictive content of the spread between the commercial paper and the T-bill rate on real income arises mostly from two outliers in monthly data for 1962:2 -1992:3. Once those two outliers and most of the 1980s data are removed, the paper-bill spread contains no predictive information on real income. Hafer and Kutan [1997], using both annual and quarterly data for 1960-1993, demonstrate that assuming trend stationarity on the data reestablishes the money-income relationship and reduces the importance of interest rates in predicting future variations in income. Lee [1997] contends that the failure to find the money-real income relationship is attributable to an estimation efficiency loss associated with lag length mis-specification. When the recursive lag selection procedure is used on quarterly data for 1955:1-1996:2, the optimal lag patterns for real GDP, the financial aggregates (M1 and M2) and the 3-month T-bill rate vary across the sample. Accounting for the optimal lag length for each variable in the three-variable VAR system reestablishes the money-real income causality. Lee also shows that M2 exhibits much more stability in the optimal lag order and enters the system with a much shorter lag than M1.

The purpose of this paper is to show that the optimal lag length of M1 and M2 is a system variant and that the issue of whether M1 or M2 enters the systems with shorter optimal lags largely depends upon what interest rates are included. This paper also shows that the optimal lag order for M2 does not exhibit more stability than that for M1. This paper adopts Lee=s [1997] methodology.

The paper is organized as follows. The method section extends the Hsiao [1981] sequential procedure for a five-variable system, which is an extension of the three-variable system discussed in Caines, Keng and Sethi [1981] and used by Lee [1997]. The empirical findings section reports the results of the optimal lag order of each variable for various systems and the results of the F-values and the marginal P-values based on the specifications underscored in the method section. The last section is a summary and conclusion.

METHOD

The sequential procedure introduced by Hsiao [1981], which combines the minimum final prediction error (FPE) criterion with Granger's definition of causality, is particularly suited for reducing the number of parameters to be estimated in the profligately parameterized model. The technique also provides a reasonably powerful test of exogeneity, and allows a finer specification of the system equations without using an arbitrary dampening factor or imposing spurious a priori restrictions associated with the strategy of building up a system incrementally from partial equilibrium models. According to Hsiao, the use of the minimum FPE in choosing the order of optimal lags is equivalent to applying an approximate F-test with varying levels of significance.

A variant of the following autoregressive model is used to determine the optimal

$$\Delta y_t = \alpha + \sum_{i=1}^{d} \beta_i \Delta y_{t-i} + \sum_{i=1}^{f} \gamma_i \Delta p_{t-i} + \sum_{i=1}^{h} \delta_i \Delta g_{t-i} + \sum_{i=1}^{j} \varepsilon_i \Delta r_{t-i} + \sum_{i=1}^{k} \eta_i \Delta m_{t-i}$$

lag length of each variable in the system.
where y = real income, p = implicit GNP deflator, g = federal spending, m = the financial aggregate indicated, and r = the interest rate, including the paper-bill spread, indicated. α, β_i, γ_i, δ_i, ε_i, and η_i, are coefficients to be estimated, while μ_t is a disturbance term. All the variables, except the interest rates and the spread, are estimated in natural logarithms. The procedure of specifying the optimal lag length of each variable in the system of five variables, consisting of real income, prices, federal spending, the interest rate indicated and the financial aggregate indicated, is as follows. First, compute the FPEs of y by varying the order of lags from 1 to d, where d=1,...,n. The smallest FPE is the optimal lag for y. Second, treat y as the only output of the system and p as the initial manipulated variable. Compute and compare the FPEs. The smallest FPE is the optimal lag for p. Third, repeat the second step with g as the manipulated variable while controlling for the optimal lags for y and p. The smallest FPE is the optimal lag for g. Fourth, repeat the third step with r as the manipulated variable while controlling for the optimal lags for y, p and g. The smallest FPE is the optimal lag for r. Fifth, repeat the fourth step with m as the manipulated variable while controlling for the optimal lags for y, p, g and r. The smallest FPE is the optimal lag for m.

FINDINGS

The correct specification and estimation of the model require determining whether or not each time series contains an integrated component. According to Perron [1989, 1997] and Zivot and Andrews [1992], the standard augmented Dickey-Fuller tests are not appropriate for the variables with apparent structure changes, possibly due to the oil shocks. This paper adopts the Perron=s [1997] method, which examines the stationarity of the variables with a structure change. The variables examined are RGNP, M1, M2, P, G, the 3-month T-bill rate (tb), the 3-month commercial paper rate (rp), and the spread between the commercial paper and the T-bill rate (rt). The estimated statistics of the variables in first differences are greater than the finite sample critical value of -5.59 at the 5% level. Consequently, the null hypothesis of nonstationarity is rejected in favor of the alternative hypothesis of stationarity at the 5% level for the variables in first differences.

Table 1 reports the FPEs for one-dimensional autoregressive processes based on the first differenced data. The smallest FPE of rgnp for the 1959:1-1979:3 sample period is .8917E-04 with 7 lags, while it is .3813E-03 with 1 lag for the full sample period.[1]

TABLE 1
The FPE of Fitting a One-dimensional Autoregressive Process for Real Income in First Differences

Order of lags	1959:1-1979:3 FPE(E-04)	1959:1-1990:4 FPE(E-03)
1	.9655	.3813*
2	.9442	.3821
3	.9562	.3848
4	.9652	.3876
5	.9457	.3889
6	.9420	.3905
7	.8917*	.3895
8	.8976	.3925
9	.9087	.3951
10	.9210	.3981
11	.9196	.4005
12	.9306	.4031
13	.9410	.4061
14	.9703	.4091
15	.9313	.4099

* denotes the smallest FPE. prices, federal spending, the T-bill rate and the paper rate are not fitted individually, because those variables are controlled variables in the determination of the relationship between real income and financial aggregates.

Table 2 presents the smallest FPEs for the three-, four- and five-variable systems for the two sample periods. In the three-variable system, the smallest FPEs for manipulated variables m1 and m2 are .6466E-04 with 6 lags and .5834E-04 with 5 lags for the sample period 1959:1-1979:3. For the full sample, their respective smallest FPEs are .3373E-03 with 7 lags and .3120E-03 with 1 lag. In the four-variable system, the smallest FPEs for m1 and m2 are .6028E-04 with 6 lags and .5548E-04 with 13 lags for the sample period 1959:1-1979:3, but for the full sample period, they are .3362E-03 with 1 lag and .3118E-03 with 1 lag. In the five-variable system, the smallest FPEs for manipulated variables m1 and m2 are .4067E-04 with 15 lags and .4531E-04 with 13 lags for the sample period 1959:1-1979:3, whereas for the full sample they are .3164E-03 with 3 lags and .2910 with 1 lag when rgnp, p, g and tb are controlled. With rp, however, m1 and m2 have the smallest FPEs of .4506E-04 with 13 lags and .4056E-04 with 15 lags for the sample period 1959:1-1979:3 and of .3333E-03 with 1 lag and .3123E-03 with 3 lags for the full sample. When the paper-bill spread (rt) is included, the optimal lag lengths for m1 and m2 are 11 and 13 with their respective FPEs of .3974E-04 and .4394E-04 for the 1959:1-1979:3 sample period. For the full sample, the optimal lag for m1 and m2 are 7 and 1 with their respective FPEs of .3267E-03 and .3051E-03. Overall, as illustrated in the five-variable systems, the optimal lag lengths for m1 and m2 are influenced by the different type of interest rates included and, to some extent, by the sample period.[2]

TABLE 2
The Optimal Lags of the Manipulated Variable and the FPE of the Controlled Variable

Controlled Variable	Manipulated Variable	Optimum Lag of Manipulated Variable	FPE (E-04)
Sample period 1959:1-1979:3			
A. Three-variable system (real income, prices, financial aggregates)			
rgnp(7) w/ p(5)	m1	6	.6466
rgnp(7) w/ p(5)	m2	5	.5834
B. Four-variable system (real income, prices, federal expenditures, financial aggregates)			
rgnp(7) w/ p(5),g(3)	m1	6	.6028
rgnp(7) w/ p(5),g(3)	m2	13	.5548
C. Five-variable system (real income, prices, federal expenditures, interest rates, financial aggregates)			
rgnp(7) w/ p(5),g(3),tb(15)	m1	15	.4067
rgnp(7) w/ p(5),g(3),tb(15)	m2	13	.4531
rgnp(7) w/ p(5),g(3),rp(14)	m1	13	.4506
rgnp(7) w/ p(5),g(3),rp(14)	m2	15	.4056
rgnp(7) w/ p(5),g(3),rt(12)	m1	11	.3974
rgnp(7) w/ p(5),g(3),rt(12)	m2	13	.4394
Sample period 1959:1-1990:4			
A. Three-variable system (real income, prices, financial aggregates)			
rgnp(1) w/ p(1)	m1	7	.3373
rgnp(1) w/ p(1)	m2	1	.3120
B. Four-variable system (real income, prices, federal expenditures, financial aggregates)			
rgnp(1) w/ p(1),g(1)	m1	1	.3362
rgnp(1) w/ p(1),g(1)	m2	1	.3118
C. Five-variable system (real income, prices, federal expenditures, interest rates, financial aggregates)			
rgnp(1) w/ p(1),g(1),tb(15)	m1	3	.3164
rgnp(1) w/ p(1),g(1),tb(15)	m2	1	.2910
rgnp(1) w/ p(1),g(1),rp(9)	m1	1	.3333
rgnp(1) w/ p(1),g(1),rp(9)	m2	3	.3123
rgnp(1) w/ p(1),g(1),rt(7)	m1	7	.3267
rgnp(1) w/ p(1),g(1),rt(7)	m2	1	.3051

Note: Parentheses denote the order of lags.

Table 3 illustrates the F-statistics for m1 and m2 with their respective marginal P-values for the two sample periods.[3] In Table 3, the inclusion of the 1980s data and onward has marginally weakened or deteriorated the predictive content of m1 on real income, regardless of the system. However, the same thing cannot be said about the predictive content of m2 on real income. The P-values in the four-variable system and the five-variable systems with tb and rt are either marginally or substantially increased, while the other three P-values have marginally decreased or unchanged. In spite of this, m2 Granger causes real income, regardless of the system. This paper thus concludes that the difference in predictive content between M1 and M2 arises due to the de-emphasis of M1 as an intermediate target by the Federal Reserve in 1982 because of the apparent break in the process generating the velocity of M1 [McMillin, 1991]. In the 1970s, the Federal Reserve put increased emphasis upon M1 and M2 as intermediate targets for monetary policy.

TABLE 3
F-Statistics for Financial Aggregates with Varying Optimal Lags of Each Variable

Equations	1959:1-1979:3		1959:1-1990:4	
	F-statistics	P-values	F-statistics	P-values
A. Three-variable system (real income, prices, financial aggregates)				
rgnp w/ p,m1	3.14^c	.009	1.20	.308
rgnp w/ p,m2	4.63^c	.001	6.36^c	.010
B. Four-variable system (real income, prices, federal expenditures, financial aggregates)				
rgnp w/ p,g,m1	5.65^c	.001	1.43	.233
rgnp w/ p,g,m2	2.30^b	.021	6.09^b	.015
C. Five-variable system (real income, prices, federal expenditures, interest rates, financial aggregates)				
rgnp w/ p,g,tb,m1	2.78^b	.015	3.59^b	.016
rgnp w/ p,g,tb,m2	1.70	.126	2.74^a	.101
rgnp w/ p,g,rp,m1	2.52^b	.022	0.02	.886
rgnp w/ p,g,rp,m2	2.13^a	.052	2.42^a	.070
rgnp w/ p,g,rt,m1	2.29^b	.033	1.18	.319
rgnp w/ p,g,rt,m2	1.49	.180	3.01^a	.085

Notes: [a,b,c]Statistically significant at the 10%, 5%, and 1% levels, respectively. See Table 2 for The optimal lag length of each variable according to the system and the sample period.

SUMMARY AND CONCLUSION

This paper extended the Hsiao sequential procedure for a five-variable system. Using this procedure, the optimal lag length of each variable for the various systems was determined. The results indicate that the optimal lags for both M1 and M2 substantially varied across the system and across the sample period.[4] Also, there is no clear evidence that M2 entered the systems with shorter lags or that the optimal lag order for M2 exhibited more stability than that for M1. It is thereby concluded that whether M1 or M2 entered the systems with shorter optimal lags largely depended upon what interest rates were included in the systems.

One plausible explanation of this owed to developments relating to banking deregulation and financial renovation in the late 1970s, which altered the interest rate characteristics of M1 balances and M2 balances. For instance, at year-end 1978 virtually all M1 balances earned no explicit interest, but by year-end 1983 one-fourths of M1 balances earned interest. The share of M1 balances paying market interest rates had continuously increased over time. The case of M2 balances was more dramatic. At year-end 1978 about 18% of M2 balances earned no interest, but by year-end 1983 more than 60% of M2 balances received market interest rates. These new interest rate properties of M2 balances as well as M1 balances had a more immediate and powerful impact on the economy. Stated differently, not only financial innovation and deposit deregulation had altered the interest rate properties of the money supply, but they also created the uncertainty surrounding the stability of the optimal lags of M1 and M2 and of the money-income relationship.

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ENDNOTES

1. The adequacy of the lag specification of the variables in the model is further tested using likelihood ratio tests by over-fitting the lags.

1. Adding error-correction terms in the systems varies slightly the optimal lag length of m1 and m2. But the overall conclusion stills holds. There is no conclusive evidence that m2 has shorter optimal lags and exhibits more stability. It appears that the optimal lags for m1 and m2 still are influenced by the different type of interest rates included.

1. We considered a different ordering of the variables, but results were similar to the ones reported in this paper.

1. To draw a conclusion about Lee's findings, this paper adopts only Lee's method of analysis, thereby not considering cointegration tests. Moreover, the choice of the subsample periods is based on the Federal Reserve's change in operating procedures in 1979:4, which is consistent with the subsample periods in Friedman and Kuttner [1992, 1993].