Long Run Effects of Money On Real Consumption and Investment in the U.S.

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Abstract

This paper tests for long run effects of money on real expenditures in the U.S. over the 1959-2002 period. Real consumption and investment expenditures, as well as their broadly defined components, are examined. We also test for effects of money on long run reallocations of consumption expenditures among durables, nondurables, and services. The time series characteristics of each variable are rigorously investigated. This is followed by application of the long run neutrality test, introduced by Fisher and Seater (1993), to each real expenditures series. Results support long run neutrality of both M2 and M3 with respect to real expenditures for all examined levels of data aggregation.

JEL Classifications: E52, E20
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1. Introduction.

Long run neutrality of money (LRN) is the hypothesis that a permanent, unanticipated change in the money supply has no long run effect on any real variable. Under LRN, changes in the money supply may or may not have short run real effects. Fisher and Seater (1993) introduced a method of testing the long run neutrality proposition that requires only an assumption that the money supply is exogenous in the long run. This paper applies the Fisher-Seater (henceforth FS) approach to U.S. quarterly real consumption and investment expenditures and to their broadly defined components. There are no published studies using the FS methodology to test for long run effects of money on individual sectors of the U.S. economy. Previous studies have applied the FS test to aggregate output, with the weight of evidence generally in favor of long run neutrality.

Tests of long run neutrality of money with respect to disaggregated or sectoral series are important for several reasons. First, Garrett (2003) demonstrates that estimated coefficients and results of statistical inference can vary across different levels of data aggregation. This implies that results of tests of LRN using disaggregated data can differ from results based on aggregate data. Second, Coe and Nason (2002, 2004) demonstrate that the FS test has relatively low power. Failure to reject long run neutrality at the sectoral level then could be viewed as corroboration for aggregate findings in favor of long run neutrality. Alternatively, failure to reject neutrality at the aggregate level may be due to the low power of the test. It is possible that application of the FS test to sectoral data may uncover significant long run effects of money that are not revealed when using aggregate measures of output, especially if the effects are concentrated in only a few sectors. Third, it is possible for money to be long run neutral at the aggregate level, yet monetary shocks could lead to long term reallocations of output across sectors. For example, the service sector has steadily increased as a percentage of GDP since 1959. Over this same time period, non-durables consumption declined as a percentage of GDP. We investigate whether these long run reallocations of personal consumption expenditures can, in part, be attributed to monetary shocks.

Several studies have shown that the short run effects of monetary shocks can differ among disaggregated groups or sectors. For example, Carlino and DeFina (1998, 1999) find that the short-run effects of monetary policy differ across U.S. states and regions depending on manufacturing's share of output in the region. Gertler and Gilchrist (1994) show that small manufacturing firms are more affected by negative monetary shocks than are large manufacturing firms. Ganley and Salmon (1997) find differing reactions to monetary shocks in sectors of the U.K. economy, with the largest response in the construction sector, the smallest response in the agricultural sector, and significant but widely varied responses among the various manufacturing sectors.

Two studies of short run sectoral responses to monetary shocks are particularly relevant for this paper. Raddatz and Rigobon (2003) conclude that monetary policy has significant effects on interest-sensitive sectors of the U.S., especially consumer durables and residential investment. However, they find that monetary policy has little effect on investment in equipment & software and virtually no effect on investment in structures by firms. Dale and Haldane (1995) show that changes in money lead changes in real corporate expenditures, while changes in credit lead changes in real personal expenditures in the U.K. Results of these studies suggest that the household sector and the business sector significantly differ in their short run responses to monetary shocks. This paper extends these analyses by asking if these differences persist over the long run.

2. Fisher-Seater Methodology.

Fisher and Seater begin with a two variable, log-linear ARIMA model that is stationary and invertible. The model is given by equations (1) and (2):

$$a(L)\Delta^{\langle m \rangle} m_t = b(L)\Delta^{\langle y \rangle} y_t + u_t \qquad (1)$$

$$d(L)\Delta^{\langle y \rangle} y_t = c(L)\Delta^{\langle m \rangle} m_t + w_t. \qquad (2)$$

In these equations, m_t and y_t are log money and log output respectively, $a_0 = d_0 = 1$, and u_t and w_t are mean zero, i.i.d. vectors of errors. The notation $\langle q \rangle$ refers to the order of integration of variable q = m, y.[1] The long run derivative ($LRD_{y,m}$) of output with respect to a permanent change in money is given by equation (3):

$$LRD_{y,m} = \lim_{k \to \infty} \frac{\partial y_{t+k} / \partial u_t}{\partial m_{t+k} / \partial u_t} \qquad (3)$$

Equation (3) shows that the long run derivative is the limit of the long run elasticity of output with respect to money. The LRD is not defined for cases in which the $\lim_{k \to \infty} (\partial m_{t+k} / \partial u_t) = 0$. Therefore, a necessary condition for testing long run neutrality is that there have been permanent shocks to the money supply. Money therefore must be at least first order integrated, or I(1), to apply the FS test. Equation (3) also shows that if there have been no permanent shocks to real output, then the $\lim_{k \to \infty} (\partial y_{t+k} / \partial u_t) = 0$, and the

[1] We substitute the money and output symbols, m and y respectively, for the more general notation used by FS. Otherwise their notation is used throughout the discussion.

LRD is equal to zero. Therefore, if real output is I(0), long run neutrality cannot be rejected.

For $\langle m \rangle \geq 1$, FS show that equation (3) can be written as:

$$\mathrm{LRD}_{y,m} = \frac{(1-L)^{\langle m \rangle - \langle y \rangle}\gamma(L)\big|_{L=1}}{\alpha(L)}; \tag{3′}$$

where $\alpha(L)$ and $\gamma(L)$ are functions of the coefficients from equations (1) and (2).[2] Equation (3′) demonstrates that the value of $\mathrm{LRD}_{y,m}$ depends on $\langle m \rangle - \langle y \rangle$, the difference in orders of integration of (log) money and (log) real output. The unit-root tests, reported below, suggest that money is I(1) while the output series are at most I(1), thus we consider only the case of $\langle m \rangle - \langle y \rangle = 0$. In this instance equation (3′) reduces to

$$\mathrm{LRD}_{y,m} = \frac{\gamma(1)}{\alpha(1)} = \frac{c(1)}{d(1)}. \tag{4}$$

Imposing the restriction that money is exogenous in the long run, FS demonstrate that c(1)/d(1) can be consistently estimated as b_k from the OLS regression in equation (5)

$$y_t - y_{t-k-1} = a_k + b_k(m_t - m_{t-k-1}) + e_{kt}, \tag{5}$$

with k taking on values of one through a predetermined upper limit.[3] Standard practice is to estimate b_k for each value of k using OLS. The 95-percent confidence intervals then are constructed for the b_k's from a t-distribution with T/k degrees of freedom using standard errors corrected for serial correlation by the Newey-West procedure.[4] Long run neutrality of money is rejected if zero lies outside the confidence intervals as k becomes large.

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[2] $\alpha(L)=d(L)/[a(L)c(L)-b(L)c(L)]$ and $\gamma(L)=c(L)/[a(L)c(L)-b(L)c(L)]$.

[3] We set the upper limit for k at 59. This allows examination of changes up to 15 years.

[4] T is the total number of observations.

Previous applications of the FS methodology have examined long run effects of money on aggregate economic activity in several countries including the United States.[5] Fisher and Seater originally rejected long run neutrality of money for the U.S. However, Boschen and Otrok (1994), find that long run neutrality cannot be rejected for the U.S. when allowance is made for the anomalous behavior of the economy during the Great Depression. Coe and Nason (2002) reject the proposition for the U.S. using M2 as the money measure, but not when using the monetary base.

3. The Data.

We use quarterly data for M2, M3, real GDP, real personal consumption expenditures (PCE), and real private fixed investment (PFI).[6] We examine three broadly defined components of PCE: Durable goods (DUR), nondurable goods (NDUR), and services (SER). In addition, we test two components of PFI: Nonresidential fixed investment (NRES) and residential fixed investment (RES). All variables are logged.

The sample period is 1959:1 through 2002:4. Although forty-four years may be considered a short time period for testing a long run proposition, precedent is provided by Fisher and Seater in their use of 55 monthly observations of German hyperinflation data. In addition, Boschen and Otrok include a separate analysis of the post-depression era, 1940-1992, using annual data. Our sample period allows the use of quarterly data, thus increasing the degrees of freedom for our tests.[7]

[5] Bullard (1999) provides an extensive survey.
[6] All aggregate series were obtained from the Federal Reserve Bank of St.Louis database. Monthly M2 and M3 series are converted to quarterly figures by taking the end of quarter value. The real expenditures series are the chain-type quantity indexes obtained from the BEA's NIPA Tables 7.4 and 7.6.
[7] Quarterly sectoral series are unavailable from the primary source, the National Income and Product Accounts, prior to 1947.

Furthermore, extension of the sample to years prior to 1959 requires splicing of money series either from different sources or constructed using different methodologies. It is possible that such splices in the monetary data could affect the results of the FS test. An additional advantage of using a 1959-2002 sample is that this may be considered the era most relevant for contemporary policymakers. The sample includes significant monetary events potentially having long-term real consequences. For example, Romer and Romer (1989, 1990) conclude from readings of the minutes of the Federal Open Market Committee that significant episodes of anti-inflationary monetary policy were begun in December 1968, April 1974, August 1978, and October 1979.

4. Unit Root and Stationarity Tests.

As shown in Equation (3') above, identification of the orders of integration of the money and real expenditures series is critical for tests of long run neutrality. It is widely recognized that conclusions regarding orders of integration may vary depending on the test method employed. We check the robustness of our conclusions by employing several test methods. We first use both the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit-root tests. Because results of ADF tests may be affected by the choice of lag length, we examine results of tests with lag length selected by Akaike's Information Criteria (AIC), the Bayesian Information Criteria (BIC), an LM test procedure, and a general-to-simple (GS) method. The LM test procedure includes the minimum number of lagged differences needed to eliminate serial correlation from the residuals of the test equation as indicated by a series of LM tests. The GS method estimates a test equation with a predetermined maximum number of augmenting lags, then iteratively drops the last lagged value if it is not significant at a 10% marginal significance level. Robustness of the PP test results is examined by including various lags in the Newey-West serial correlation correction.

In addition, we apply the generalized least squares unit root test designed by Elliott, Rothenberg, and Stock (1996). We denote this test by ERS-GLS. This test has been shown to have more power against the trend-stationary alternative than either the ADF or the PP unit root tests. Finally, we apply two tests developed by Kwiatkowski, Phillips, Schmidt, and Shin (1992), henceforth, denoted KPSS. The first, denoted KPSS(μ), tests a null hypothesis of stationarity versus an alternative of trend-stationarity. The second test, denoted KPSS(τ), offers an alternative to most unit root tests because it tests a null hypothesis of trend-stationarity versus an alternative of a unit root. Again, we check the robustness of results from the KPSS and ERS-GLS tests by considering various lag lengths in the Newey-West serial correlation corrections.

Plots of all series exhibit upward movement through time, and the KPSS(μ) test rejects stationarity in favor of a possible trend in all cases. Therefore, a trend is included in the ADF and PP tests of all logged series. All tests indicate the presence of a unit-root in M2, M3, real GDP, PCE, NDUR, and SER at a 5% significance level. There is strong evidence of a unit-root in the DUR series, with only the 6-lag version of the ERS-GLS test providing evidence to the contrary. Similarly, there is strong evidence of a unit-root in the NRES series, with only the 2-lag version of the ERS-GLS test indicating trend-stationarity. RES appears trend-stationary, with only the PP tests providing evidence to the contrary. Evidence for PFI is mixed with failure to reject a unit root by the PP and

ADF tests, rejection of trend-stationarity in favor of a unit root by the KPSS(τ) tests, but rejection of a unit root by the ERS-GLS tests.[8] The results for PFI may be mixed because the series is made up of a trend-stationary RES component and an integrated NRES component. Since the unit root test results indicate that NRES is I(1) and RES is I(0), PFI must contain a unit root since it is the sum of I(1) and I(0) processes.

Next the growth rate of each integrated series is tested for the presence of a trend. We run OLS regressions of each series on a constant, a trend, and lagged values of the differenced series. The lagged dependent variables are intended to eliminate serial correlation. We select the number of lags in these regressions by the same GS method used above in the ADF tests. The tests fail to reject a trend in the growth rate of SER. There is no evidence of a significant trend in the growth rates of M2, M3, or any output series other than SER.

Finally, each integrated series is tested for the presence of a second unit root. Specification of these tests is based on the results of the OLS tests for a trend in each growth rate. A trend is included in the test equations for the growth rate of services. All other test equations are specified without a trend. All versions of the ADF and PP tests reject unit-roots for M2 and for all first-differenced output series, including the growth rate of SER. The ERS-GLS tests also reject a unit root in the growth rate of SER.[9] Further the KPSS(τ) test fails to reject a trend in SER. We conclude that all of the real output series are I(1) and only the growth rate of services contains a trend. The test results for the growth rate of M3 are somewhat mixed. However, all PP tests, as well as

[8] The ADF tests fail to reject a unit root; however, the test statistics are very close to the 5% critical value.
[9] The ERS-GLS test is used only for a series with a potential trend. The test is not appropriate for discriminating between a simple random walk and a stationary series. Likewise, the KPSS(τ) test is applied only to a series with a possible trend.

the LM and BIC versions of the ADF test, reject a unit root in M3 growth. We conclude that the weight of evidence supports stationarity of M3 growth. Conclusions from this section are summarized in Table 1.

Table 1
Conclusions of Unit-Root and Stationarity Tests

Series	Conclusion
M2	Tests unanimously conclude: an I(1) series with no trend in growth rate.
M3	Weight of evidence suggests an I(1) series with no trend in growth rate.
Real GDP	Tests unanimously conclude: an I(1) series with no trend in growth rate.
Real Personal Consumption Expenditures	Tests unanimously conclude: an I(1) series with no trend in growth rate.
Real Consumption of Durables	Weight of evidence suggests an I(1) series with no trend in growth rate.
Real Consumption of Non-Durables	Tests unanimously conclude: an I(1) series with no trend in growth rate.
Real Consumption of Services	Tests unanimously conclude: an I(1) series with a trend in growth rate.
Real Private Fixed Investment	Weight of evidence suggests an I(1) series with no trend in growth rate.
Real Non-Residential Fixed Investment	Weight of evidence suggests an I(1) series with no trend in growth rate.
Real Residential Fixed Investment	Weight of evidence suggests a trend-stationary series.

5. Fisher-Seater Test Results.

Both M2 and M3 are I(1), indicating that permanent shocks to these series occurred during the 1959:1 to 2002:4 sample.[10] As described in section (2), the LRD then exists and long run neutrality can be tested. Residential fixed investment is found to be trend-stationary, that is I(0), indicating that this series has not been subject to permanent shocks. Because the money shocks had no permanent effects on real output in the residential fixed investment sector, long run neutrality of money with respect to RES

[10] M1 is not included among the money series because Granger-causality tests strongly suggest that the assumption of exogenous money is violated for M1.

cannot be rejected. This result depends strictly on the finding that RES is trend-stationary, so is not affected by the low power of the FS test. This result is particularly interesting given the finding of Raddatz and Rigobon that monetary policy, through its influence on interest rates, has particularly strong short run effects on this sector.

The remaining real expenditures series are I(1). Therefore, these variables have experienced permanent shocks, possibly arising from permanent money shocks; therefore, LRN is directly testable by using equation (5). Unfortunately, the trend in the growth rate of services would make the dependent variable in (5) non-stationary for FS tests using this series. This would make inference from FS regressions for the services sector invalid; therefore, we exclude SER from the present analysis. However, an alternative method of analyzing the service sector is presented in section (5).

In Figure 1, we first present the graph of the b_k coefficients and the 95% confidence intervals when the (k+1) difference of log real GDP is the dependent variable in equation (5). Results using M2 and M3 as the money measures are very similar so only the former are reported.[11] As can be seen from the graph, the confidence intervals contain zero at all values of k, hence long run neutrality of M2 with respect to real GDP cannot be rejected for the 1959:1 - 2002:4 period. This result is consistent with the findings of Boschen and Otrok for the U.S. using annual data for the post-Great Depression period.

[11] Results for M3 are available from the authors on request.

Figure 1
FS Test Results: M2 and Real GDP

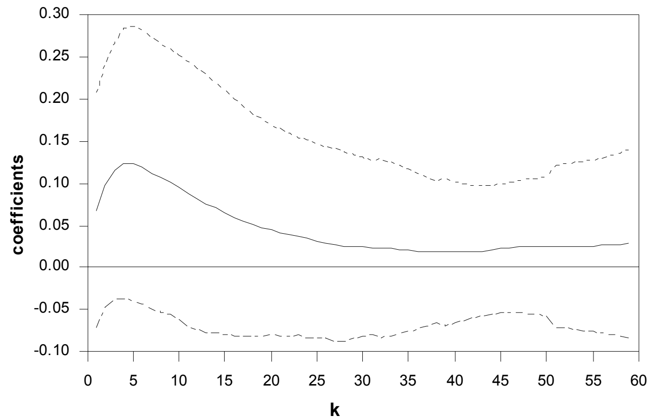


Figure 2a displays the results for real personal consumption expenditures and Figures 2b and 2c display results for the DUR and NDUR components of PCE. Again the long run neutrality of M2 cannot be rejected. Note in the graph for PCE that the estimated coefficients are significantly positive for values of k less than 12 quarters suggesting a short-run effect of M2 changes, but the short-run effects disappear after about three years so that there is no evidence of a long run effect. This same pattern occurs in the results for durables. None of the coefficients are significant in results for the non-durables sector. This suggests that short run non-neutrality of money may exist in the consumption sector and that this non-neutrality may result from the effects of money on durables consumption, a result consistent with the conclusion of Raddatz and Rigobon that the durables sector in the U.S. is particularly susceptible to monetary policy shocks.

Figure 2a
FS Test Results: M2 and PCE

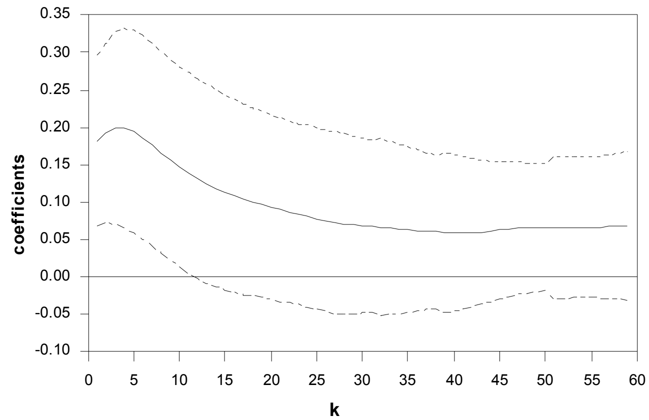


Figure 2b
FS Test Results: M2 and DUR

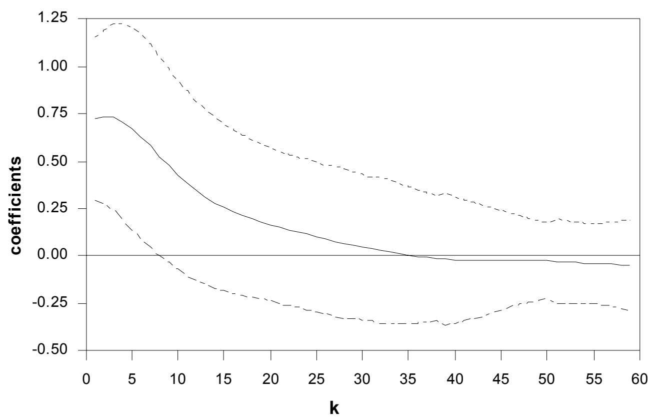


Figure 2c
FS Test Results: M2 and NDUR

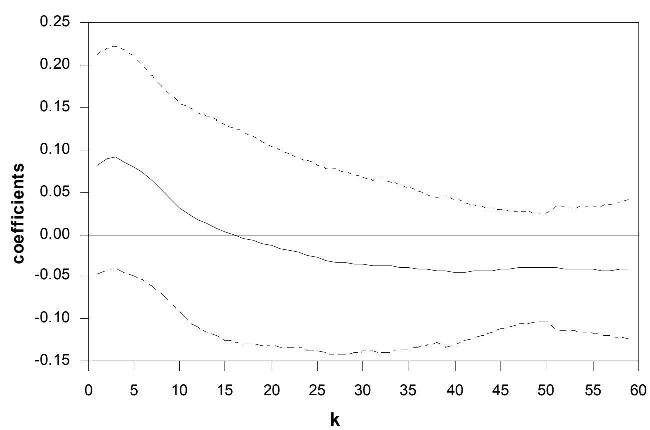


Figure 3a shows the results for private fixed investment. Results for non-residential fixed investment, the integrated component of PFI, are presented in Figure 3b. Again, long run neutrality of M2 cannot be rejected. No coefficients are significant for either series. Failure to reject LRN in this sector is consistent with results from the studies by Dale and Haldane and by Raddatz and Rigobon who find little or no short run effect of monetary shocks on fixed investment by firms. Short run effects of monetary shocks should exist in order for long run effects to be present in a series.

Figure 3a
FS Test Results: M2 and PFI

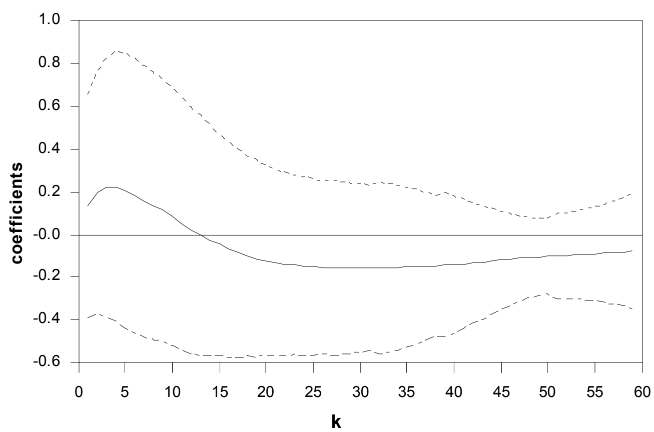
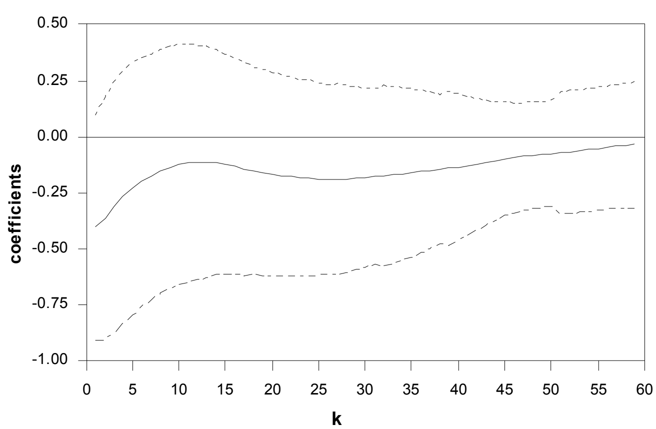


Figure 3b
FS Test Results: M2 and NRES

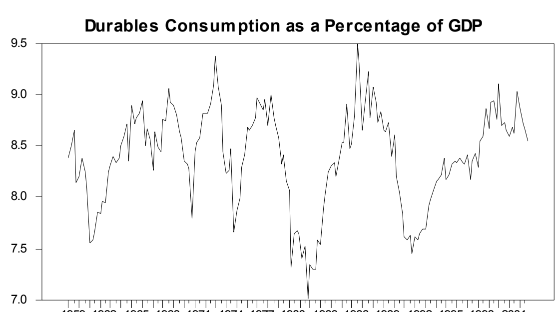


5. Analysis of Consumption Components as a Percent of GDP.

The trend in the growth rate of SER required us to omit the service sector from the set of FS tests conducted in section (4). This is unfortunate because services has displayed tremendous growth and become an increasingly important sector of the U.S. economy during the sample period. Further, as mentioned in the introductory section, consumption of services has greatly increased as a percentage of GDP at a time when consumption of non-durables has declined. However, we can investigate the long run effects of money on the components of personal consumption expenditures measured as percentages of GDP. This allows us to draw some inference regarding the effects of money on the service sector and allows us to investigate the question of whether monetary shocks have had any effect on the reallocation of consumption expenditures across sectors.

There are three real variables of interest: Durables consumption as a percentage of GDP (%DUR), non-durables consumption as a percentage of GDP (%NDUR), and consumption of services as a percentage of GDP (%SER). All variables are constructed as current dollar consumption as a percentage of nominal GDP.[12] Plots of these series are presented in Figures 4a - 4c.

Figure 4A



[12] The nominal consumption and GDP data were obtained from the Federal Reserve Bank of St.Louis.

Figure 4B

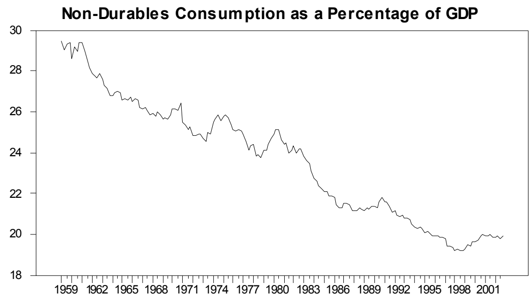
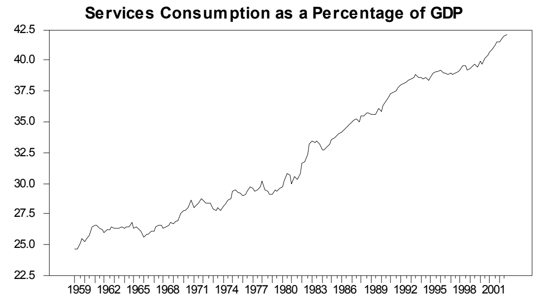


Figure 4C



The same series of tests for unit-roots and trends are applied to these series as to the money and real consumption series in section (3). Results clearly indicate that %DUR is stationary; therefore, money is long run neutral with respect to %DUR. The results also show that both %NDUR and %SER contain unit roots. Unit roots and trends are rejected for differenced %SER and %NDUR. Both %NDUR and %SER then are I(1) and subject to FS testing for evidence of long run monetary effects. Results of the tests are presented in Figures 5a and 5b. In neither case can long run neutrality of money be rejected. Thus it appears that monetary shocks are not a cause of the long run reallocation of consumption expenditures away from non-durables and toward services.

Figure 5a
FS Results: M2 and %NDUR

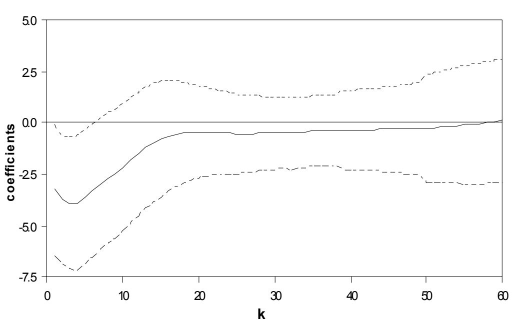
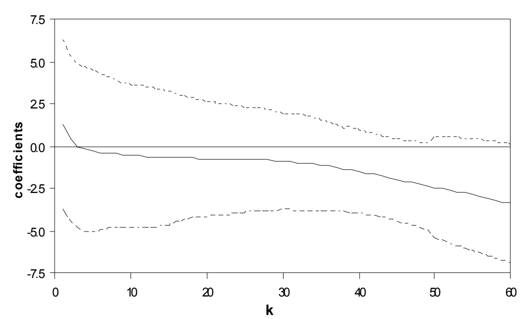


Figure 5b
FS Results: M2 and %SER



6. Conclusions.

Using quarterly U.S. data for 1959:1 to 2002:4 and a test methodology developed by Fisher and Seater, the long run neutrality of M2 and M3 for real GDP and six disaggregated real expenditures series cannot be rejected. There is some evidence of short run effects of money on total and durable goods personal consumption expenditures but these effects disappear within three years. Although some studies have found significantly different short-run effects of monetary shocks on household versus business expenditures, money appears to have no significant effect on either type of expenditures over the long run. In addition, we find no evidence that the long run reallocation of consumption expenditures from non-durables to services has been due to monetary shocks. We conclude that long run neutrality of money with respect to real GDP and its major consumption and investment components is a proposition that holds for recent U.S. history.

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