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 neutrality (LRN) of money with respect to real expenditures in the U.S. over the 1947-2004 period. Real consumption and investment expenditures, as well as their broadly defined components, are examined. We also test for the effects of money on long run reallocations of GDP among durables, nondurables, and services. The time series characteristics of each variable are rigorously investigated. This is followed by application of the LRN test, introduced by Fisher and Seater (1993), to each real expenditures series. Although rejections of LRN occur in a number of studies, our results support long run neutrality of money with respect to real expenditures regardless of the level of data aggregation.

Keywords: Money, neutrality, consumption, investment

JEL Classifications: E52, E20

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. LRN is a common feature of a variety of theoretical models. 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.

Interestingly, some studies using the Fisher-Seater methodology have found that money is not long run neutral. See, for example, Fisher and Seater, Olekalns (1996), Coe and Nason (2002), and Shelley and Wallace (2003). Despite the wide acceptance of the LRN hypothesis, surprisingly little attention has been given to these contrary empirical results. Although long run neutrality of money usually characterizes theoretical macroeconomic models, in at least two papers unexpected changes in money can have long run effects on wealth. In the Obstfeld and Rogoff (1996) open economy model with monopolistic firms and sticky prices, an unanticipated increase in the money supply temporarily raises output and saving, leading to a temporary current account surplus but a permanent increase in wealth. In Williamson's (2005) limited participation model with search, monetary policy can redistribute wealth among agents, and

these real effects can persist. Rejections of LRN, then, may be viewed as lending support to modeling efforts that emphasize these distributional impacts of monetary policy.

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.

Finally, money may be long run neutral at the aggregate level, yet monetary shocks could lead to long term reallocations of output across sectors. Certainly the composition of U.S. real GDP has changed over the post WWII era. For example, the service sector has steadily increased as a percentage of GDP since 1947. Over this same time period, non-durables consumption declined as a percentage of GDP. We use the FS test to investigate whether such long run reallocations of personal consumption expenditures can, in part, be attributed to monetary shocks.

Several empirical 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. Their model is given by equations (1) and (2):

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

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

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 $q = m, y$. The long run derivative ($LRD_{y,m}$) of output with respect to a permanent change in money is given by equation (3):

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

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 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:

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

where $\alpha(L)=d(L)/[a(L)c(L)-b(L)c(L)]$ and $\gamma(L)=c(L)/[a(L)c(L)-b(L)c(L)]$. Equation (3') demonstrates that the value of $LRD_{y,m}$ 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

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

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.[1]   Standard practice is to estimate b_k for each value of k using OLS.   With T observations, 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.   Long run neutrality of money is rejected if zero lies outside the confidence intervals as k becomes large.

Previous applications of the FS methodology have examined long run effects of money on aggregate economic activity in numerous countries including the United States [see Bullard (1999) for an extensive survey].   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

Quarterly data for M2, real GDP, real personal consumption expenditures (PCE), and real private fixed investment (PFI) are used.[2]   Three broadly defined components of PCE also are examined: Durable goods (DUR), nondurable goods (NDUR), and services (SER).   In addition, we test for LRN of money with respect to two components of PFI: Nonresidential fixed investment (NRES) and residential fixed investment (RES).   All variables are logged.

The sample period is 1947:1 through 2004:4.[3]   An advantage of using a 1947-2004 sample is that it may be considered the era most relevant for contemporary policymakers.   The period includes significant monetary events potentially having long-term real consequences, including the Fed-Treasury accord and several significant episodes of anti-inflationary monetary policy identified by Romer and Romer (1989, 1990) as beginning in December 1968, April 1974, August 1978, and October 1979.

Seasonally adjusted real GDP and the real expenditures series are from the Bureau of Economic Analysis.[4]   Monthly money series are published for 1959 through the present and available from the St. Louis Federal Reserve Bank.   The M2 series is extended back to 1947 using an approach similar to that of Hetzel (1989).   First, we construct M1 using historical data previously published by the Federal Reserve.[5]   M1 is calculated as the total of currency and demand deposits.   When these observations are added to the 1959-2004 data there is no discernible break in the series, so no further adjustments are made to monthly M1.

Monthly M2 for the 1947-1958 period is created by adding time deposits and deposits at nonbank thrift institutions to the previously constructed M1 series.   Deposits at nonbank thrift institutions are available only from 1959, so this series is backcast to create observations for 1947-1958.   Again, there is no discernible break in the M2 series at 1958-1959, so no further adjustments are made to M2.   The observation for the following month is used as a proxy for end-of-quarter money.   For example, our M2 figure for the first quarter of 1959 is the value of M2 on April 1, 1959.

4. Unit Root and Stationarity Tests

As shown in Equation (3'), 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 different procedures. Both the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit-root tests are used initially. Because results of ADF tests may be affected by the choice of lag length, results of tests with the lag lengths selected by Akaike's Information Criteria (AIC), the Bayesian Information Criteria (BIC), and an LM test procedure are examined. 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. Robustness of the PP test results is assessed by varying the lags in the Newey-West serial correlation correction.

In addition, the generalized least squares unit root test designed by Elliott, Rothenberg, and Stock (1996), denoted ERS-GLS, is applied. 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 employ two tests developed by Kwiatkowski, Phillips, Schmidt, and Shin (1992), henceforth KPSS. The first, KPSS(μ), tests a null hypothesis of stationarity versus an alternative of trend-stationarity. The second, 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, the robustness of results from the KPSS and ERS-GLS tests are checked 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. The presence of a trend in these series also validates the use of the ERS-GLS and KPSS(τ) tests. All procedures indicate the presence of a unit-root in M2, real GDP, PCE, NDUR, and SER at a 5% significance level.

Test results for the DUR series are mixed. The ADF and PP tests fail to reject a unit root, while conclusions from the ERS-GLS test are sensitive to the choice of lag length. The KPSS(τ) test fails to reject a null hypothesis of trend stationarity for the durables series. The evidence regarding presence of a unit root in NRES also is mixed; the ERS-GLS test fails to reject a unit root at a 5% significance level regardless of lag length, while the KPSS(τ) test fails to reject trend stationarity. Finally the weight of evidence appears to favor trend stationarity for PFI, as only the PP tests and an ERS-GLS test with zero lags provide evidence to the contrary. All tests indicate that RES is trend-stationary.

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 included to eliminate serial correlation. The number of lags in these regressions is determined by a general-to-simple procedure in which, beginning with eight lags, the last lag is eliminated if not significant at the 5% level. The trend coefficient is significant at a 1% level for the growth rate of SER. There is no evidence of a significant trend

in the growth rates of M2 or any output series other than SER. This conclusion is supported by the results of KPSS(μ) tests which reject stationarity in favor of the trend stationary alternative only for the growth rate of 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 so that a trend is included in the tests for a unit root in 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 growth 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.[6] Further the KPSS(τ) test fails to reject a trend in SER growth. We conclude that real GDP and real personal consumption expenditures and its components are I(1) with only the growth rate of services containing a trend. Evidence is mixed for real private fixed investment and real non-residential fixed investment. Real residential fixed investment is trend stationary. These conclusions are summarized in Table I.

5. Fisher-Seater Test Results

M2 is I(1), indicating that permanent shocks to money occurred during the 1947:1 to 2004:4 period. As explained in section 2, if the money measure is integrated of order one, the long run derivative exists and long run neutrality can be tested [see equation (3)]. 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 money shocks had no permanent effects on real output in the residential fixed investment sector, long run neutrality of money with respect to RES 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.[7] 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.

All of our test results indicate that that real GDP, PCE, NDUR, and SER are I(1). Further, some tests show that DUR, PFI, and NRES are I(1), thus it is possible that these variables have also experienced permanent shocks. LRN then is directly testable for these variables using equation (5). In the case of services (SER) the trend in the growth rate would make the dependent variable in (5) non-stationary and invalidate any inferences from the FS regressions. However, a small change in the standard FS regression remedies this problem.

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). 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 1947:1 - 2004:4 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.

Figure 2a shows the b_k coefficient plot and confidence intervals for real personal consumption expenditures, while Figures 2b and 2c display these 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 14 quarters suggesting a short-run effect of monetary policy, but these effects disappear after about three years. Similarly, estimated coefficients are significantly positive for values of k less than 4 quarters for durables. None of the coefficients are significant in results for the non-durables sector. This implies 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.

Although the unit root tests are not conclusive regarding the degree of integration of PFI and NRES, the FS tests are undertaken assuming these two series are I(1). The graphs are shown in Figures 3a and 3b respectively. Again, long run neutrality of M2 cannot be rejected. No coefficients are significant for either series. If these series are instead I(0), as some unit root tests indicate, then LRN also follows since I(0) series, by definition, could not have been subject to permanent shocks. The failure to reject LRN 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.

As noted earlier, the trend in the growth rate of SER would render invalid the results from estimation of equation (5). However, it can be shown that inclusion of a trend in the FS equation does not bias estimates of the b_k coefficients.[8] This form of the FS test is given by equation (5'):

$$y_t - y_{t-k-1} = a_k + b_k(m_t - m_{t-k-1}) + \gamma_k t + e_{kt}, \tag{5'}$$

where t is the time trend and γ_k is a coefficient. This formulation allows for the possibility that some permanent shocks to SER originated from permanent shocks to money, while recognizing that money (with no trend in its growth rate) could not have caused the permanent movements in SER captured by trended growth. Results for SER using this modification of the FS test are presented in Figure 4. Again, long run neutrality cannot be rejected.

To check the robustness of the results across sample periods, the FS tests are also carried out for the restricted sample period of 1959:1 through 2004:4. This also allows us to check for possible effects of using the money data constructed for the 1947:1 through 1958:4 period and to use both M2 and M3 as money measures.[9] In no case can the neutrality of money be rejected, regardless of whether M2 or M3 is used as the money measure. Since there are no significant deviations from the results obtained using the 1947:1 through 2004:4 sample we omit detailed discussion and display of these results.[10]

Garrett has shown that estimation results using aggregated data can differ from those obtained with the disaggregated components of the data. This finding, in part, motivates our application of the FS test to the components of U.S. real GDP. However there is no evidence that LRN fails when the test is applied to the components of U.S. real GDP. Likewise the results fail to support macro models allowing for long run non-neutralities arising from distributional effects of monetary policy. We now turn to an alternative method for testing for distributional effects from money.

6. Analysis of Consumption Components as a Percent of GDP

Consumption of services has displayed substantial growth and has become an increasingly important sector of the U.S. economy during the 1947:1-2004:4 sample period. Further, as mentioned in the introductory section, consumption of services has greatly increased as a percentage of GDP while the share of non-durables consumption has declined. The long run effects of money on the shares of GDP accounted for by the components of personal consumption expenditures have not been previously investigated. Thus we ask whether monetary shocks have had contributed to the reallocation of consumption expenditures across sectors.

There are three real variables of interest: Durables consumption as a percentage of GDP (PCTDUR), non-durables consumption as a percentage of GDP (PCTNDUR), and consumption of services as a percentage of GDP (PCTSER). All variables are constructed as current dollar consumption as a percentage of nominal GDP. Plots of these series are presented in Figures 5a - 5c.

The same tests for unit-roots and trends are applied to these series as to the money and real expenditures series in section (3). Results indicate that PCTDUR has no trend. ADF and PP tests unanimously reject a unit root in the series. Further, the KPSS(μ) test fails to reject stationarity. Thus PCTDUR is stationary and, because permanent changes in the durables share are absent, money is long run neutral with respect to PCTDUR.

All test results indicate that both PCTNDUR and PCTSER contain unit roots while unit roots are rejected for differenced PCTSER and PCTNDUR. Thus, PCTNDUR and PCTSER are I(1) and subject to FS testing using equation (5) for evidence of long run monetary effects. Results of the tests are presented in Figures 6a and 6b. At all but a few small values of k, the results indicate that M2 has no real effects on the share of nondurables in GDP nor is there any evidence that money affects the percentage of GDP attributable to services. In other words, in neither case can long run neutrality of money be rejected. Monetary shocks do not appear to be a cause of the changes in the shares of non-durables and services during the post WWII period in the United States. As with the earlier findings, these results suggest that real distributional effects have been absent in U.S. monetary policy.

7. Conclusions

Using quarterly U.S. data for 1947:1 to 2004:4 and a test methodology developed by Fisher and Seater, the long run neutrality of M2 for real GDP and seven 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 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.

Endnotes

We are indebted to the anonymous referee for a number of helpful comments and insights. Remaining errors are, of course, our responsibility.

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

2. M2 rather than M1 is used as the money series because Granger-causality tests strongly suggest that the assumption of exogenous money is violated for M1.

3. Quarterly data for the real expenditures components are unavailable prior to 1947.

4. Seasonally adjusted, quantity indexes from Section 1, Table 1.1.3 of the National Income and Product Accounts available at http://www.bea.doc.gov/.

5. Our source for the historical components of M1 and M2 is Banking and Monetary Statistics 1941-1970, available at http://www.fraser.stlouisfed.org. Our estimate of M1 is the total of currency and demand deposits from Table 1.1.a, "Money Stock and Related Data, Monthly 1947-1970 (seasonally adjusted)."

6. 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.

7. As expected, an FS test using RES as the expenditures variable fails to reject neutrality.

8. Estimates of α_k and γ_k are biased in equation (5'); however, these are only nuisance parameters that are not used for inference in the FS test. A proof is available from the authors on request.

9. Information regarding the components of M3 is unavailable prior to 1959. In many cases these components did not exist prior to that time.

10. All results are available from the authors on request.

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Table I
Conclusions of Unit-Root and Stationarity Tests

Series	Conclusion
M2	Tests unanimously conclude: 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	Evidence is mixed: some suggestion of 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	Evidence is mixed: slight suggestion of an I(1) series with no trend in growth rate.
Real Non-Residential Fixed Investment	Evidence is mixed: some suggestion of an I(1) series with no trend in growth rate.
Real Residential Fixed Investment	Tests unanimously conclude: a trend-stationary series.

Figure 1
FS Test Results: M2 and Real GDP
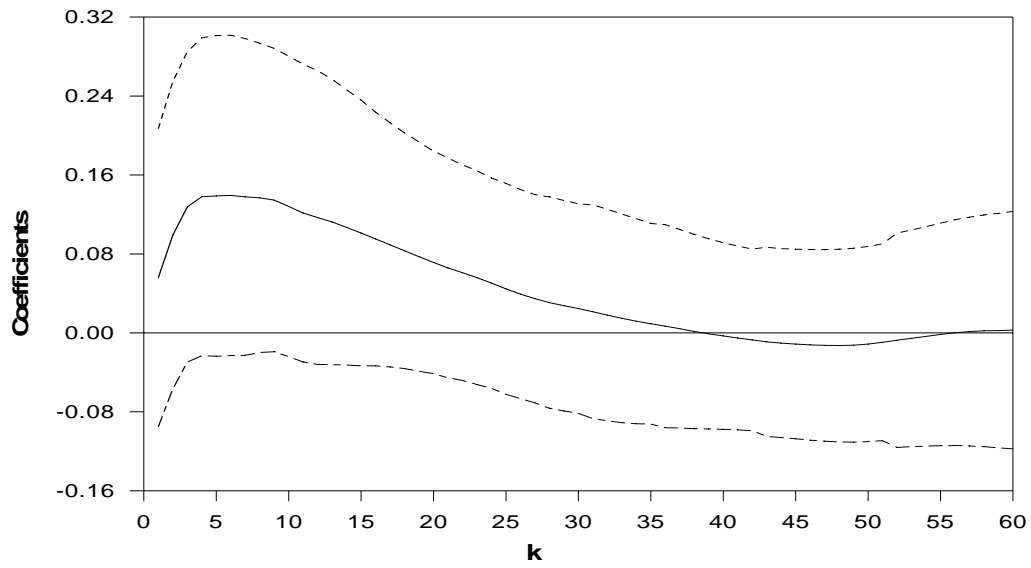
Figure 2a
FS Test Results: M2 and PCE
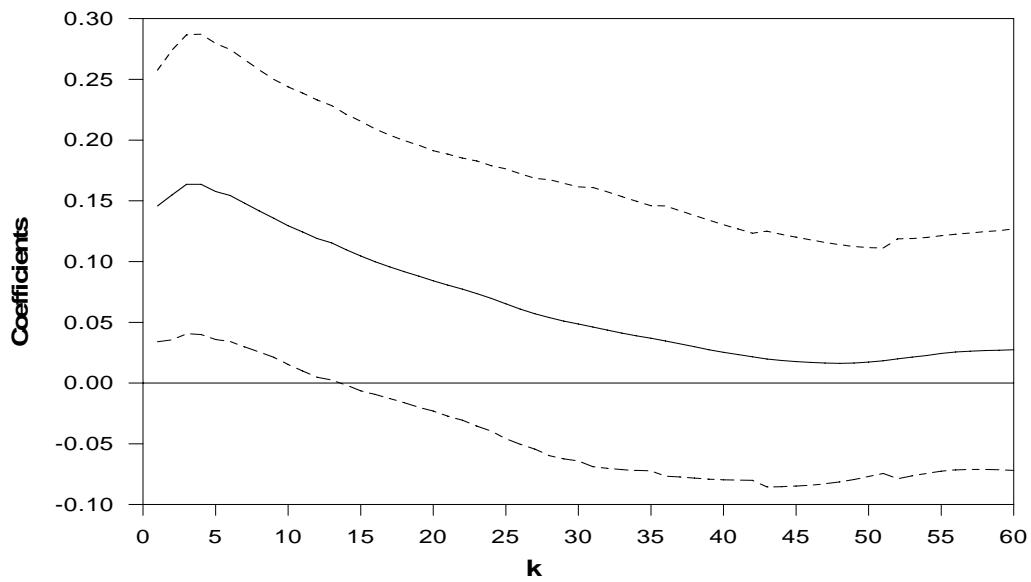
Figure 2b
FS Test Results: M2 and DUR
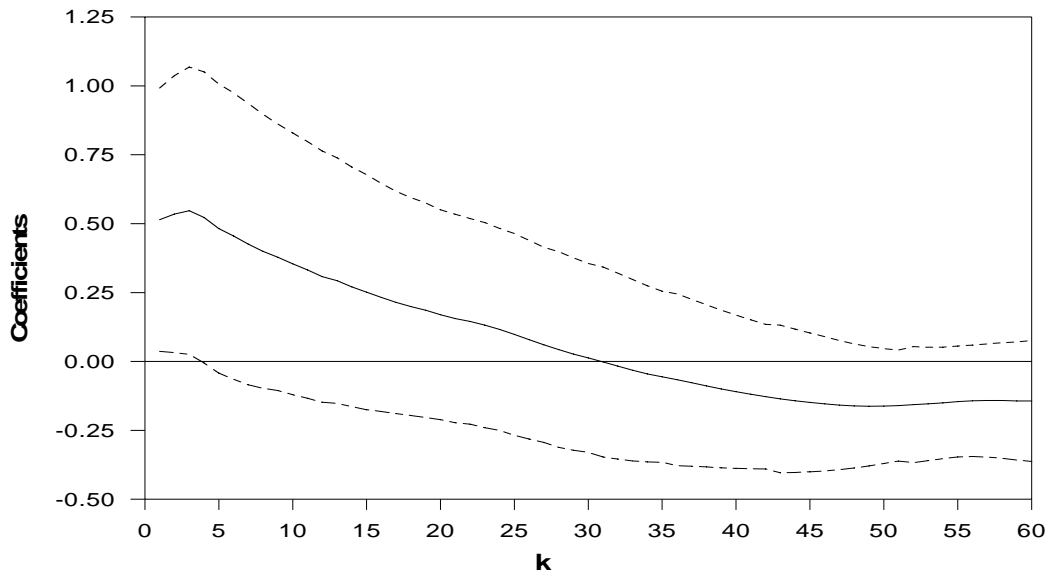
Figure 2c
FS Test Results: M2 and NDUR
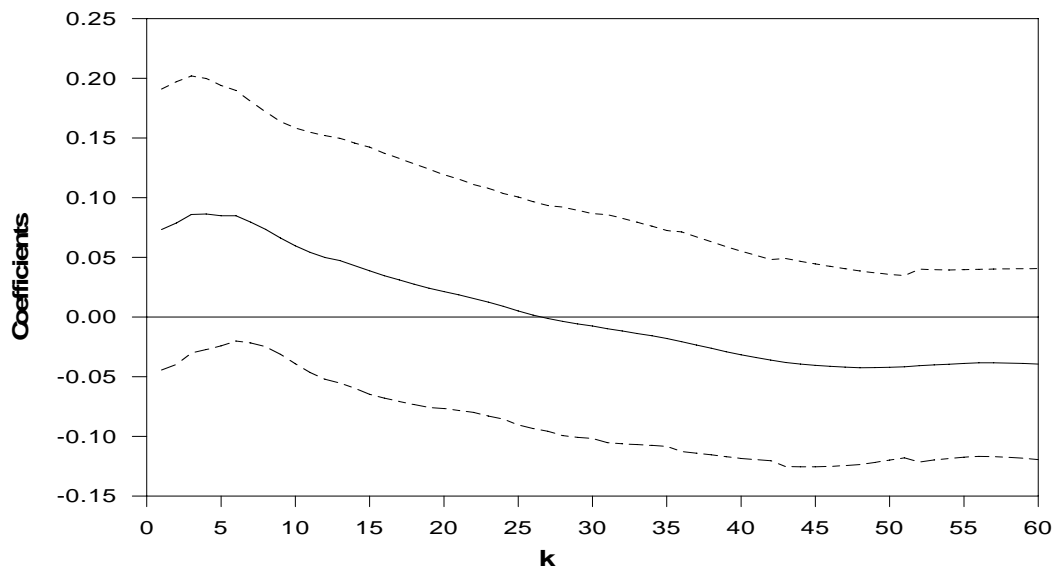
Figure 3a
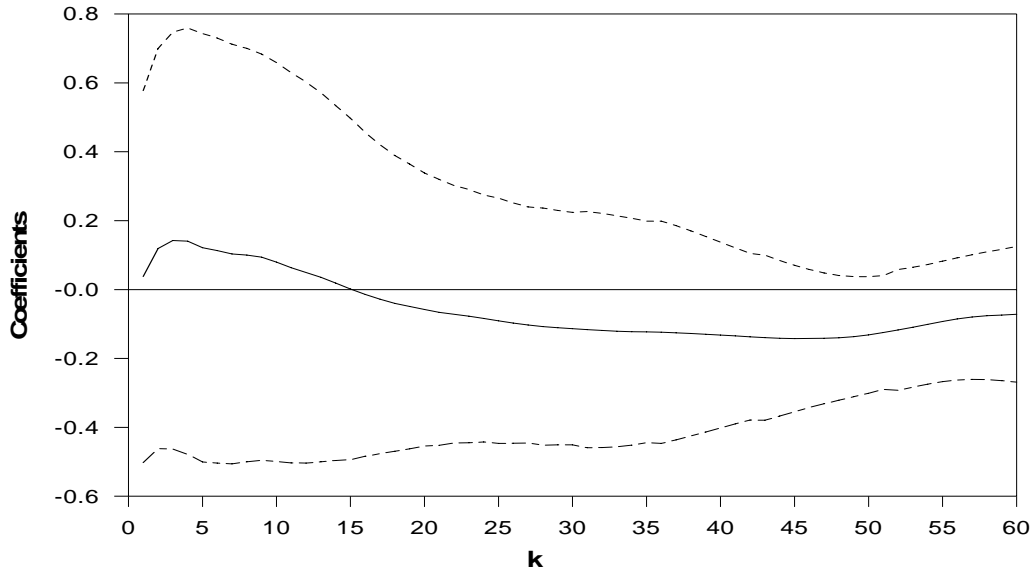**FS Test Results: M2 and PFI**

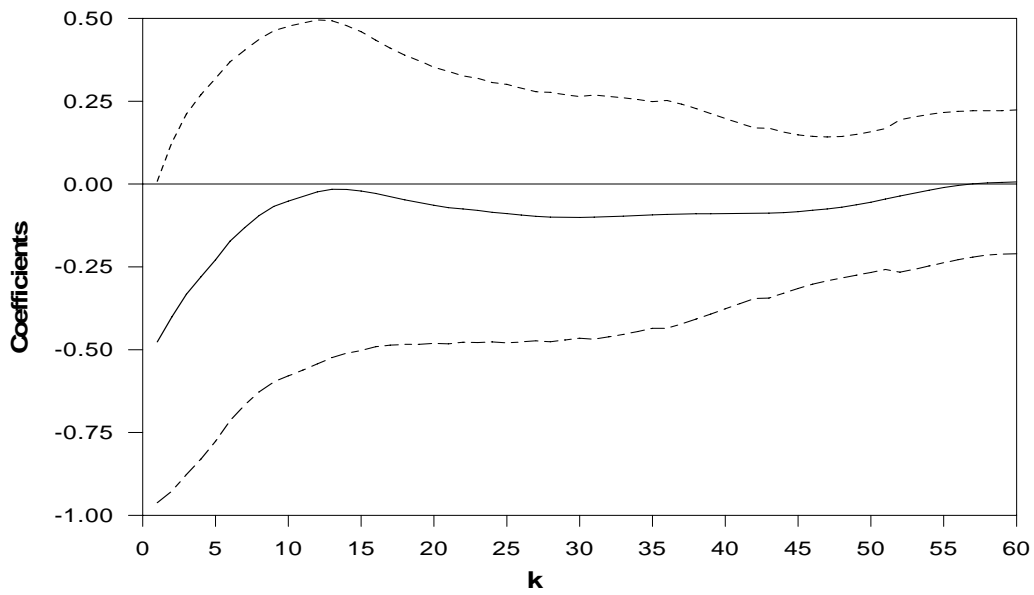**Figure 3b**
FS Test Results: M2 and NRES

Figure 4
FS Test Results: M2 and SER
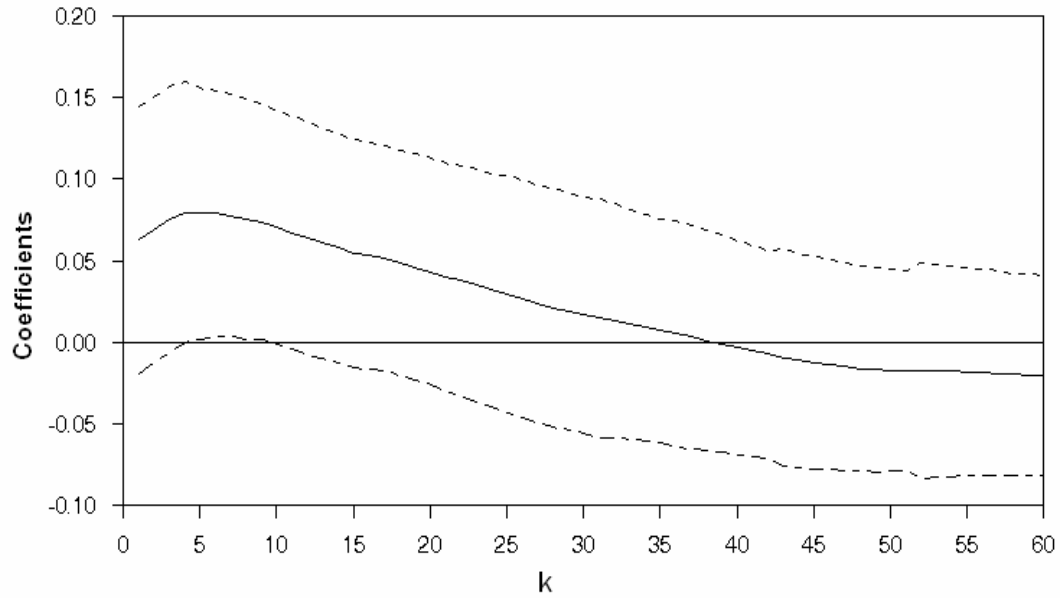
Figure 5A
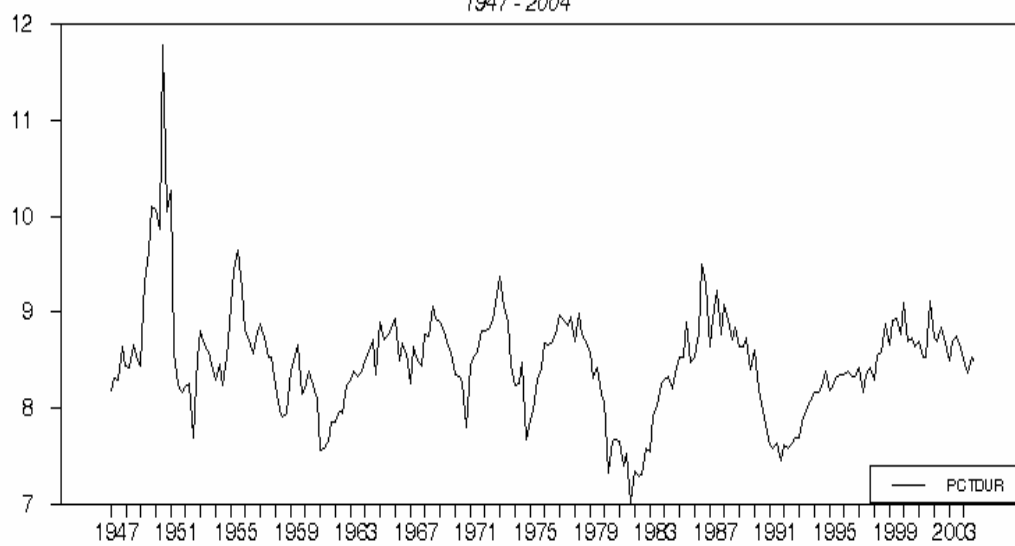

Durables Consumption as a % of Nominal GDP

Figure 5B

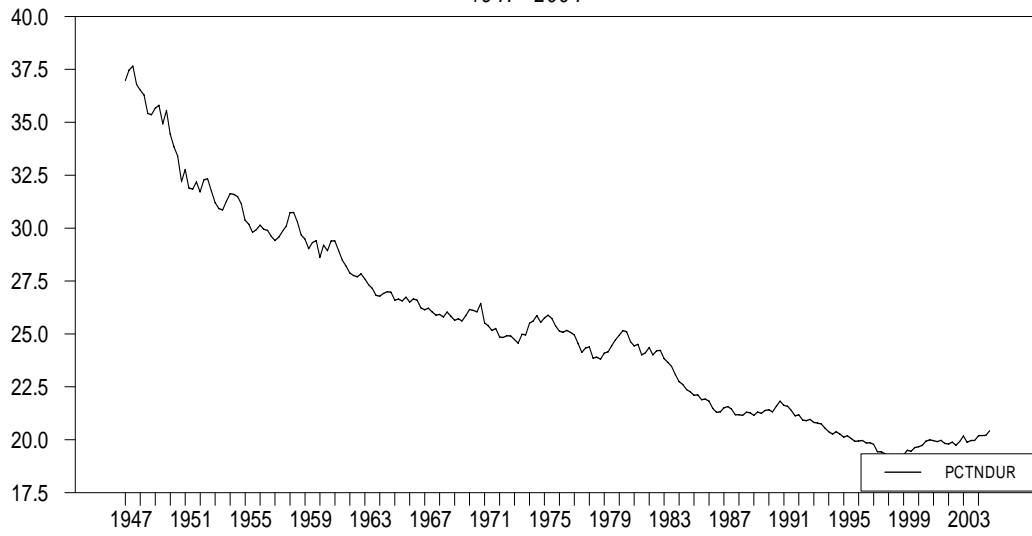**Non-Durables Consumption as a % of Nominal GDP**

1947 - 2004

Figure 5C

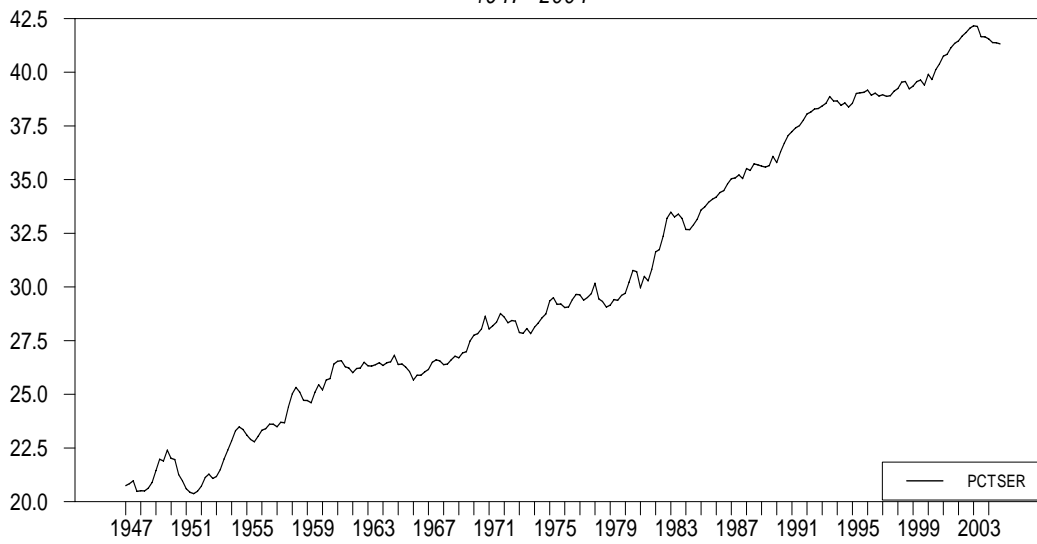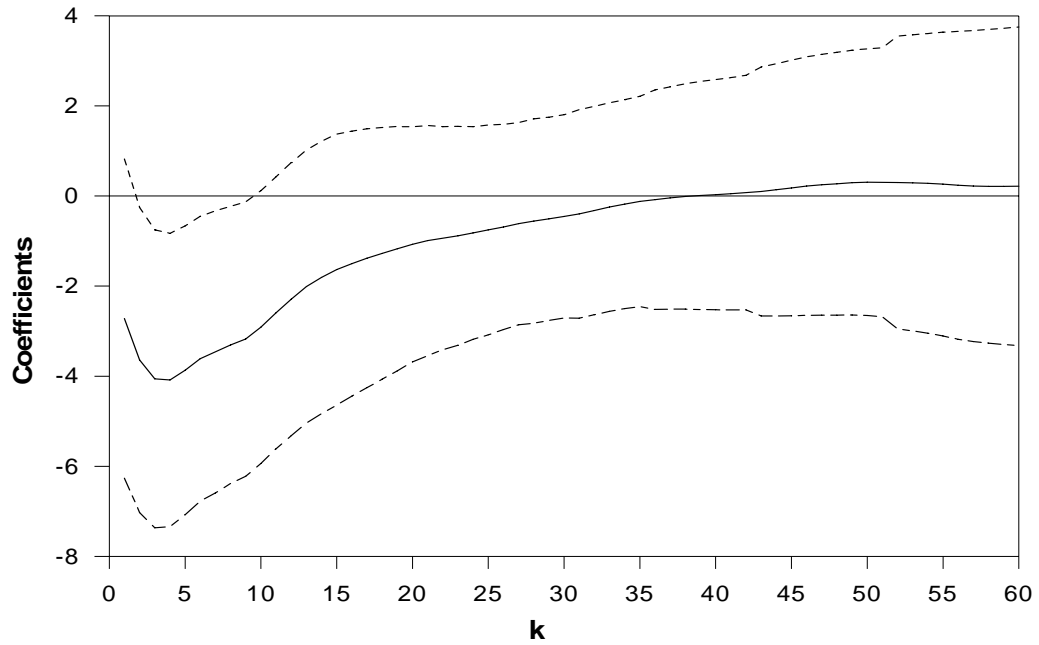**Services Consumption as a % of Nominal GDP**

1947 - 2004

Figure 6a
FS Results: M2 and PCTNDUR

Figure 6b
FS Results: M2 and PCTSER