Evidence on the Temporal Stability of the Demand for Money Relationship in the United States

R. W. HAFER AND SCOTT E. HEIN

ECONOMISTS and policymakers are extremely interested in the temporal stability of the money demand relationship. Most economists use macroeconomic models which assume that money demand is consistently related to a number of predetermined variables. As such, evidence of instability in the relationship casts doubt on the validity of such models.

Evidence of temporal instability is likewise disconcerting to monetary policymakers. When the relationship between money demand and the variables that determine it breaks down, policymakers by definition are unsure of future money demand. Thus, projecting the linkage between the money stock and economic variables such as output, prices, and interest rates becomes even more difficult and tenuous than before.

With regard to narrowly defined money (M1), the evidence on the stability of the demand relationship has recently taken a drastic turn. Prior to the mid-1970s, the evidence supporting a stable money demand relationship in the United States was "overwhelming," to borrow Laidler's description.1 Along the same line, Laumas and Mehra provided statistical evidence that the relationship was stable under a broad range of alternative specifications.2

In 1976, however, two separate studies found evidence which suggests that the money demand relationship had broken down around 1973. Both Enzler, Johnson, and Paulus (EJP), and Goldfeld found that the traditional transaction money demand relationship significantly overpredicted post-1972 real money balances.3 Being unsuccessful in attempting to explain the decline statistically, both studies concluded that there had indeed been a downward shift in the relationship over this period.

This conclusion recently has come under attack in a number of studies which resurrect concern about the appropriate money demand specification. These studies argue that other specifications of the money demand relationship do not indicate any recent breakdown. This article provides a critical review of the existing evidence on the issue of the temporal stability of the money demand relationship. Various money demand specifications are examined in terms of their dynamic out-of-sample predictive ability over the post-1972 period and more formally through the use of the Brown-Durbin-Evans (BDE) cusum-squares tests.4 The forecasting ability of these alternatives is compared using a common sample period, data base, and means of generating post-sample predictions.


FEDERAL RESERVE BANK OF ST. LOUIS

DECEMBER 1979

RECENT EVIDENCE ON THE STABILITY OF THE MONEY DEMAND RELATIONSHIP

The basic Goldfeld equation, which posits a real adjustment lag, provides the standard of comparison for alternative money demand specifications.\(^5\) The real adjustment version of the Goldfeld specification is

\[
\ln \left( \frac{M_t}{P_t} \right) = \alpha_1 + \alpha_2 \ln y_t + \alpha_3 \ln CPR_t + \alpha_4 \ln RTD_t + \alpha_5 \ln \left( \frac{M_t}{P_{t-1}} \right) + \epsilon_t,
\]

where \( M = \) nominal M1 balances, \( P = \) the general price level (the implicit GNP deflator), \( y = \) real income (real GNP), \( CPR = \) the commercial paper rate, \( RTD = \) the rate on time deposits, \( \epsilon = \) an error term.\(^6\)

The first row of table 1 reports the coefficient estimates and summary statistics for this money demand specification. All estimates shown are for the sample period II/1955-IV/1972 and are based on the Cochrane-Orcutt (CORC) estimation technique. In addition, table 1 reports the root-mean-squared error (RMSE) of the dynamic post-sample simulations (I/1973-I/1977).\(^7\)

Although the sample period is slightly different, the results for this equation are similar to Goldfeld's. The estimated coefficients all have the anticipated sign and are significantly different from zero. These estimates reveal that more than one-third of the desired change in the money stock is completed within one quarter and that the long-run income elasticity is 0.54. The resulting large RMSE for the dynamic simulation demonstrates a marked deterioration in the relationship after 1972. A comparable simulation over the period IV/1968-IV/1972 yielded an RMSE of only 2.33 — merely one-tenth of that found for the post-1972 period.

One of the earliest rebuttals to the instability claim came from Hamburger, who contended that EJP and Goldfeld were too restrictive in their choice of asset yields hypothesized to affect money demand.\(^8\) He argued that the exclusion of long-term asset yields from the specification was both theoretically and empirically unjustified.

To support his argument, Hamburger incorporated long-term government bond yields and the common stock dividend-price ratio in estimating an altered version of the MPS (MIT-Pennsylvania-Social Science Research Council) money demand equation. The adapted specification used by Hamburger was

\[
\ln \left( \frac{M_t}{P_{t-1}} \right) = \beta_0 + \beta_1 \ln RTD_t + \beta_2 \ln DPR_t + \beta_3 \ln RGL_t + \beta_4 \ln \left( \frac{M_t}{P_{t-1}} \right) + \epsilon_t,
\]

where \( DPR = \) the dividend-price ratio on common stock, \( RGL = \) the yield on long-term government bonds, \( \epsilon = \) an error term, and other variables are as previously defined.

Estimation results for this equation are reported in the second row of table 1.\(^9\) These results, similar to

\[(i = 0, \ldots, 4)\]

\[\beta_i \]

\[\epsilon_t\]

The estimated coefficients all have the anticipated sign and are significantly different from zero. These estimates reveal that more than one-third of the desired change in the money stock is completed within one quarter and that the long-run income elasticity is 0.54. The resulting large RMSE for the dynamic simulation demonstrates a marked deterioration in the relationship after 1972. A comparable simulation over the period IV/1968-IV/1972 yielded an RMSE of only 2.33 — merely one-tenth of that found for the post-1972 period.

One of the earliest rebuttals to the instability claim came from Hamburger, who contended that EJP and Goldfeld were too restrictive in their choice of asset yields hypothesized to affect money demand.\(^8\) He argued that the exclusion of long-term asset yields from the specification was both theoretically and empirically unjustified.

To support his argument, Hamburger incorporated long-term government bond yields and the common stock dividend-price ratio in estimating an altered version of the MPS (MIT-Pennsylvania-Social Science Research Council) money demand equation. The adapted specification used by Hamburger was

\[
\ln \left( \frac{M_t}{P_{t-1}} \right) = \beta_0 + \beta_1 \ln RTD_t + \beta_2 \ln DPR_t + \beta_3 \ln RGL_t + \beta_4 \ln \left( \frac{M_t}{P_{t-1}} \right) + \epsilon_t,
\]

where \( DPR = \) the dividend-price ratio on common stock, \( RGL = \) the yield on long-term government bonds, \( \epsilon = \) an error term, and other variables are as previously defined.

Estimation results for this equation are reported in the second row of table 1.\(^9\) These results, similar to

\[(i = 0, \ldots, 4)\]

\[\beta_i \]

\[\epsilon_t\]

The estimated coefficients all have the anticipated sign and are significantly different from zero. These estimates reveal that more than one-third of the desired change in the money stock is completed within one quarter and that the long-run income elasticity is 0.54. The resulting large RMSE for the dynamic simulation demonstrates a marked deterioration in the relationship after 1972. A comparable simulation over the period IV/1968-IV/1972 yielded an RMSE of only 2.33 — merely one-tenth of that found for the post-1972 period.

One of the earliest rebuttals to the instability claim came from Hamburger, who contended that EJP and Goldfeld were too restrictive in their choice of asset yields hypothesized to affect money demand.\(^8\) He argued that the exclusion of long-term asset yields from the specification was both theoretically and empirically unjustified.

To support his argument, Hamburger incorporated long-term government bond yields and the common stock dividend-price ratio in estimating an altered version of the MPS (MIT-Pennsylvania-Social Science Research Council) money demand equation. The adapted specification used by Hamburger was

\[
\ln \left( \frac{M_t}{P_{t-1}} \right) = \beta_0 + \beta_1 \ln RTD_t + \beta_2 \ln DPR_t + \beta_3 \ln RGL_t + \beta_4 \ln \left( \frac{M_t}{P_{t-1}} \right) + \epsilon_t,
\]

where \( DPR = \) the dividend-price ratio on common stock, \( RGL = \) the yield on long-term government bonds, \( \epsilon = \) an error term, and other variables are as previously defined.

Estimation results for this equation are reported in the second row of table 1.\(^9\) These results, similar to

\[(i = 0, \ldots, 4)\]

\[\beta_i \]

\[\epsilon_t\]
Alternative Money Demand Equation Regression Results: II/1955-IV/1972

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficient</th>
<th>Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Goldfeld</td>
<td>-0.66</td>
<td>0.177</td>
</tr>
<tr>
<td>(2) Hamburger</td>
<td>-0.58</td>
<td>0.231</td>
</tr>
<tr>
<td>(3) B. Friedman</td>
<td>-0.413</td>
<td>0.100</td>
</tr>
<tr>
<td>(4) Laumas-Spencer</td>
<td>-0.286</td>
<td>0.056</td>
</tr>
<tr>
<td>(5) Garcia-Pak</td>
<td>-0.998</td>
<td>0.174</td>
</tr>
</tbody>
</table>

*All variables enter logarithmically and all equations are estimated using the Cochrane-Orcutt iterative technique. The numbers in parentheses are absolute values of t-ratios.

The Goldfeld, Friedman, and Laumas-Spencer equations contain a lagged money variable of the form \( (M_{t-1}/P_{t}) \). The Hamburger specification includes a lagged money variable of the form \( (M_{t}/P_{t}) \). The lagged money term in the Garcia-Pak equation is of the form \( (M_{t}/P_{t}) \), where \( M = M_{t} + M_{t-1} \).

The RMSE is the root-mean-squared error for dynamic extrapolation over the I/1973-I/1977 period. The error is in billions of current dollars, and the percentage error — the RMSE relative to the mean level of M1 balances over the post-sample period — is listed in parentheses.

Hamburger's equations, indicate that "long-term" yields have a significant effect on money demand. Furthermore, the equation performs quite well relative to Goldfeld's equation in post-sample simulations.

Important differences between the Goldfeld and Hamburger estimation results should be noted, however. First, Hamburger's specification implies that less than 10 percent of the change in the desired money stock occurs within a quarter, much slower than the 34 percent adjustment suggested by Goldfeld. In addition, Hamburger's specification, by excluding real income as a separate independent variable, has constrained the long-run income elasticity to be unity. This, again, is quite different from the 0.54 estimate yielded by Goldfeld's equation. Finally, while Goldfeld was criticized for excluding long-term yields from the relationship, Hamburger equally can be criticized for excluding short-term rates other than the passbook rate. This exclusion creates problems when Regulation Q prevents the commercial passbook rate from moving in step with other short-term yields. Thus, Hamburger has no good proxy in the equation to pick up movements in freely fluctuating short-term yields.

Friedman has criticized Hamburger's conclusion that long-term asset yields provide the key to understanding the recent money demand problem. Friedman's analysis considered aggregate wealth as a separate determinant of money demand. Arguing that Hamburger's dividend-price ratio variable is simply a proxy for aggregate wealth, Friedman replaced the equity yield in Hamburger's specification with aggregate household financial asset holdings and obtained a net improvement in post-sample predictive ability. Based on this it is clear that \( \Delta \ln (M_{t}/P_{t}) = \beta_1 - \beta_1 \ln RTD_t + \beta_1 \ln DPR_t + \beta_1 \ln RGL_t + \epsilon_t \) and \( \beta_1 = 1 - \lambda \). From this it is clear that \( \partial \ln (M_{t}/P_{t}) \partial \ln y_t = 1 \), so that Hamburger's equation constrains the long-run income elasticity to be unity. Hamburger's specification can be criticized further on the grounds that he includes a real rate of return when a nominal rate is appropriate.


Page 5
on this finding, he conjectured that "... Hamburger's proposed solution for the mystery of the missing money is simply a disguised story about the role of wealth in the money-demand function, and that the solution works better without the disguise."13

Were this true, however, one would also expect the inclusion of a wealth measure in a conventional equation (such as Goldfeld's) to yield more reliable post-sample forecasts. The estimated results for such a specification are reported in the third row of table 1. Although the wealth variable (measured here by household net worth) does have a significant effect on money demand, it does little to improve post-sample predictions.

These results do not support Friedman's interpretation of Hamburger's finding.14 According to this interpretation, the inclusion of a wealth variable in any specification should improve the equation's predictive ability. When incorporated in Goldfeld's equation, it did not. This suggests that the inclusion of a proxy for real wealth is not the crucial feature of Hamburger's specification. Laumas and Spencer examined the applicability of permanent income—measured as an exponentially weighted average of past values of real GNP—as the scale variable in the money demand relationship.15 The relevance of such a variable is explored in the fourth row of table 1. The estimation results of this equation are similar to Laumas and Spencer's. They imply a slow speed of adjustment (8 percent per quarter), similar to that of Hamburger's specification. On the other hand, the coefficient estimates yield a long-run permanent income elasticity that is less than unity (0.74). This specification, however, performs worse than the original Goldfeld equation over the post-sample period which suggests that permanent income, at least measured adaptively, is not a solution to the puzzle. Our findings (not detailed here) further indicate that this conclusion is insensitive to the measurement of interest rates.

Finally, Garcia and Pak have suggested that the recent problem stems from the use of an improperly measured money stock.17 They argue that the recent widespread use of repurchase agreements has led to an important understatement of "true" M1 balances.

The final equation of table 1 investigates this argument by including immediately available funds (IAF) data in the measurement of the money stock.18 In all other respects, this equation is analogous to Goldfeld's. The coefficient estimates are similar to the estimates obtained for Goldfeld's specification. The standard error of the equation, however, is larger, which suggests a poorer sample period fit. While this equation predicts post-1972 M1 balances better than the Goldfeld equation, it is unclear whether this alone justifies the conclusion that the relationship is stable.

An examination of the forecasting ability of these alternative money demand equations indicates that the inclusion of neither permanent income nor wealth in the conventional equation significantly improves post-sample forecasts. Also, while the addition of repurchase agreements to M1 improves the post-sample predictions, the significance of the improvement remains unclear. Although Hamburger's specification does a superior job in forecasting money balances, the source of the improvement is puzzling.

A CLOSER LOOK AT HAMBURGER'S FINDINGS

As noted in the previous section, Hamburger's specification performs quite well in predicting post-1972 money balances. His specification, however, differs from the conventional equation not only in its incorporation of long-term asset yields, but also in its treatment of the long-run income elasticity and its exclusion of short-term interest rates.

Consider, first, the issue of the long-run income elasticity. Hamburger's specification constrains the long-run income elasticity to be unity while the others suggest that the long-run income elasticity is signifi-

tantly less than one. Hamburger’s constraint can be tested easily by adding the natural log of real income as a separate independent variable to his original specification. This allows the long-run income elasticity to be freely estimated.19

These estimation results are reported in the second row of table 2. The estimated coefficient on real income is negative and significantly different from zero, which suggests that the long-run income elasticity is less than unity. In fact, the estimation results indicate that this parameter is 0.52—not much different from Goldfeld’s equation. Incorporation of real income into the specification yields a larger estimate of both the speed of adjustment and the short-run income elasticity on the time deposit variable. Also, the standard error of the equation is reduced slightly upon the relaxation of the income elasticity constraint. Thus, this parameter is 0.52—not much different from Goldfeld’s equation. Incorporation of real income into the specification yields a larger estimate of both the speed of adjustment and the short-run income elasticity on the time deposit variable. Also, the standard error of the equation is reduced slightly upon the relaxation of the income elasticity constraint. Thus, on empirical grounds, there is no apparent justification for Hamburger’s restriction that the income elasticity be unity.

Finally, note that the forecasting accuracy of this general specification (in terms of the RMSE) declines markedly relative to Hamburger’s original specification. This suggests that an important characteristic of Hamburger’s specification—as far as predictive ability is concerned—is the imposed income elasticity constraint.20

Unlike most other specifications, which ignore long-term asset yields, Hamburger’s equation excludes both short-term interest rates and (since nominal rates should incorporate expected inflation) short-term inflationary expectations as well. Row three of table 2 enumerates the results of adding the commercial paper rate to Hamburger’s specification. As far as sample period estimation is concerned, this short-term rate has a significant negative impact on money demand. However, the estimated coefficient on the long-term government bond yield now becomes insignificantly different from zero.

As observed when the real income variable was added, the inclusion of the commercial paper rate

---

**Table 2**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficient Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
</tr>
<tr>
<td>Hamburger</td>
<td>.458</td>
</tr>
<tr>
<td>Unconstrained Hamburger</td>
<td>-.774</td>
</tr>
<tr>
<td>Hamburger + CPR</td>
<td>.725</td>
</tr>
<tr>
<td>Unconstrained Hamburger + CPR</td>
<td>.738</td>
</tr>
</tbody>
</table>

---

*All variables enter logarithmically and all equations are estimated using the Cochrane-Orcutt iterative technique. The numbers in parentheses are absolute values of $t$-ratios.*

*The lagged term in all equations is given by $M_{t-1}/P_{t-1}.$

*The RMSE is the root-mean-squared error for dynamic extrapolation over the 1/1973-1/1977 period. The error is in billions of current dollars, and the percentage error—the RMSE relative to the mean level of M1 balances over the post-sample period—is listed in parentheses.*

---

19If real income is included in the specification as a separate variable, we have, following footnote 11,

$$\lambda \ln \left( \frac{M_t}{P_{t-1}} \right) = \beta_0 + \beta_1 \ln RTD_t + \beta_2 \ln DPR_t + \beta_3 \ln RGL_t + \beta_4 \ln y_t,$$

(where $\beta_0 (= 1 - \lambda)$ is the coefficient on the lagged variable) or,

$$\ln \left( \frac{M_t}{P_{t-1}} \right) = \frac{\beta_0}{\lambda} + \frac{\beta_1}{\lambda} \ln RTD_t + \frac{\beta_2}{\lambda} \ln DPR_t + \frac{\beta_3}{\lambda} \ln RGL_t + \frac{\beta_4}{\lambda} \ln y_t.$$

This implies that the long-run income elasticity,

$$\frac{\partial \ln \left( \frac{M_t}{P_{t-1}} \right)}{\partial \ln y_t} = \frac{\beta_4}{\beta_0} + 1,$$

where $\beta_4$ is the coefficient on the real income variable and $\lambda$ is the speed of adjustment. (Note again that Hamburger’s specification constrains $\beta_0$ to be zero, implying a long-run income elasticity of unity).

20As far as static predictive ability is concerned, Hamburger’s specification can be further improved by constraining the income elasticity to values in excess of unity. See Scott E. Hein, “Empirical Evidence on the Macroeconomic Demand for Money Relationship in the United States,” (Ph.D. dissertation, Purdue University, 1979). Hein argues that these forecasts are accurate because the specification is essentially an autoregressive process.
improves the sample period fit, but only at the expense of post-sample predictive ability. Exclusion of short-term interest rates from the specification, although empirically unjustified, is partially responsible for Hamburger's superior forecasting results.

The addition of both real income and the commercial paper rate to the basic Hamburger specification has a significant impact on both sample period and post-sample period findings, as shown in row four of table 2. The coefficients on both variables have the anticipated signs and are statistically significant. The estimated coefficient on the lagged money term is smaller than that of the original specification, which suggests a quicker speed of adjustment. Also consistent with the Goldfeld equation results, the long-run income elasticity is estimated to be 0.62. Once again, the addition of these variables produces both a decline in the sample-period standard error of the equation and a deterioration in the equation’s post-sample predictive ability. In this specification, though, the deterioration is so marked that the RMSE is larger than that of the original Goldfeld equation.

The preceding results suggest that crucial to Hamburger’s forecasting accuracy are (1) his treatment of the long-run income elasticity and (2) his exclusion of short-term interest rates, not the incorporation of long-term asset yields as he argues.21 This also explains why the substitution of a wealth variable in Hamburger's specification yields accurate post-sample predictions, while its inclusion in the Goldfeld equation does not.

AN ALTERNATIVE TEST OF TEMPORAL STABILITY

In the course of reviewing evidence on the temporal stability of the money demand relationship, this discussion like most recent literature has emphasized the relative post-1972 forecasting ability of alternative money demand specifications. This basis of comparison, however, assumes that the equation which performs best in terms of yielding the smallest post-sample RMSE is the most stable relationship.

The inappropriateness of such an assumption should be obvious. If one is concerned with the temporal stability of a given relationship, one should be concerned with the predictive ability of that specification at different points in time, not its predictive ability relative to other specifications. Evidence that a given equation’s predictions over a certain time interval are inferior to its predictions at earlier time periods (especially when such predictions are consistently to one side of the actual values) is highly suggestive of a breakdown in that relationship. A comparison of the predictive ability of any two equations over a given time period, however, will not allow one to deduce anything about the temporal stability of either equation.

In order to redirect attention to the basic issue of temporal stability, an alternative criterion to that of examining the relative forecasting ability of alternative specifications is now applied. This alternative test procedure will be used to examine the temporal stability of each specification discussed earlier.

The test used here is formulated and described in Brown, Durbin, and Evans.22 To test the hypothesis of coefficient stability statistically, the BDE test requires the calculation of the one-period-ahead forecast error of each specification. This prediction error is based on a regression over the time period 1 to r, where r = k + 1, . . . , T (k is the number of regressors, including the constant, and T is the sample size). In other words, if k is equal to, say, five, then the first one-period-ahead prediction error would be based on a regression estimated over the sample 1 to 6. The second prediction error is based on the regression estimated over the sample 1 to 7 and so on until the end of the sample (T) is reached.

The BDE statistic used, called the cusum-squares statistic, may be written as

$$S_r = \frac{\sum_{t=1}^{r} w_t}{\sum_{t=1}^{T} w_t}$$

where w_t represents the squared one-period-ahead prediction errors. The cusum-squares statistic is essentially the ratio of the squared one-period-ahead prediction errors based on the sample period k + 1 to r, to the squared one-period-ahead prediction errors based on a regression estimated over the sample period 1 to T.
Table 3

Alternative Money Demand Equation
Regression Results: 11/1955-1/1977

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficient</th>
<th>Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
<td>Income</td>
</tr>
<tr>
<td></td>
<td>(3.29)</td>
<td>(4.03)</td>
</tr>
<tr>
<td>Goldfield</td>
<td>-364</td>
<td>-1.154</td>
</tr>
<tr>
<td></td>
<td>(3.69)</td>
<td>(0.30)</td>
</tr>
<tr>
<td>Hamburger</td>
<td>347</td>
<td>-0.014</td>
</tr>
<tr>
<td></td>
<td>(3.70)</td>
<td>(0.668)</td>
</tr>
<tr>
<td>Unconstrained</td>
<td>-366</td>
<td>-0.200</td>
</tr>
<tr>
<td>Hamburger + CPR</td>
<td>-312</td>
<td>-0.014</td>
</tr>
<tr>
<td></td>
<td>(3.57)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Unconstrained</td>
<td>-253</td>
<td>-0.009</td>
</tr>
<tr>
<td>Hamburger + CPR</td>
<td>111</td>
<td>-0.004</td>
</tr>
<tr>
<td>B. Friedman</td>
<td>-137</td>
<td>-0.025</td>
</tr>
<tr>
<td></td>
<td>(2.67)</td>
<td>(2.36)</td>
</tr>
<tr>
<td>Laumas-Spencer</td>
<td>-952</td>
<td>-0.044</td>
</tr>
<tr>
<td></td>
<td>(5.15)</td>
<td>(5.14)</td>
</tr>
</tbody>
</table>

In general, short-run income elasticity declines significantly as the sample period is extended. For example, when the income elasticity is freely estimated using the Hamburger specification (inclusive or exclusive of the commercial paper rate), the estimated coefficient on the income term becomes statistically insignificant and, in the latter equation, even takes on the “wrong” sign.

Another common feature of the full sample period results is the increase in the magnitude of the coefficient on the lagged dependent variable. This phenomenon, which has been found in previous studies, indicates a slower speed of adjustment. In the Friedman specification, which incorporates the wealth variable, the lagged term coefficient becomes greater than unity, defying any meaningful interpretation within the stock-adjustment framework.

In general, many of the interest rate coefficients appear to be unstable. Although the coefficient on the commercial paper rate variable maintains its magnitude, the estimated coefficient on the commercial bank

---


of the estimations, sometimes being insignificantly small.

For the early sample period, which declines by 30 percent when commercial paper rates are included. The largest change in the estimate of the long-run income elasticity for the interest rate variables do not vary dramatically between the two sample periods. The magnitudes of Garcia-Pak's lagged term, income, and time deposit rate coefficients all appear to change little when the I/1973-I/1977 observations are included. The largest change occurs for the coefficient on the commercial paper rate which declines by 30 percent when comparing the II/1955-IV/1972 results with those for II/1955-I/1977. Given certain reservations about this specification (see footnote 18), however, these results should be interpreted cautiously.

The coefficient estimates for Goldfeld's specification appear to be as stable as Garcia-Pak's. For instance, the estimated speed of adjustment for the full sample period regression is .358 compared with .335 for the II/1955-IV/1972 period. Given the relative stability of the other estimated coefficients, it is clear that the long-run elasticities for the interest rate variables do not vary dramatically between the two sample periods. For the commercial paper rate, the long-run elasticities are .038 and .048 for the II/1955-I/1977 and II/1955-IV/1972 periods, respectively. The same measures for the time deposits variable are .140 and .119. The change in the estimate of the long-run income elasticity is slightly larger. For the early sample period this parameter was .528, compared with .430 over the full sample period. While this change may be significant, it is clearly smaller than that observed for the other specifications.

In order to carry out the cusum-squares test, it was assumed that the autocorrelation coefficient for each specification (given in table 3) was constant over the entire sample period. This assumption allows the transformation of the dependent and all independent variables to correct for serial correlation in the errors. This transformation was accomplished by subtracting the product of the estimated rho coefficient and the variable's previous value from the current value of the variable.26 Specifically, this procedure is given by the relationship

$X_t = x_t - \hat{\rho} x_{t-1}$

where $X_t$ represents the transformation of the variable $x_t$ and $\hat{\rho}$ is the estimated autocorrelation coefficient.

The statistical results for the cusum-squares tests are presented in table 4. These tests indicate that several specifications are unstable over the full sample period: Hamburger with CPR (at a significance level of 10 percent), Unconstrained Hamburger with CPR (5 percent), Friedman (1 percent), Garcia-Pak (1 percent), and Laumus-Spencer (5 percent). Perhaps the most interesting finding is that the Goldfeld specification demonstrates no structural instability using this test. Indeed, the null hypothesis of stability cannot be rejected even at the 10 percent level of significance.27

While the statistical tests reported in table 4 indicate which equations demonstrate structural instability in the regression relationships over the entire sample period, they do not locate the probable point of departure from constancy. Such information is provided by charts 1-5. In each chart, the sample cusum-squares statistic ($S_t$) is plotted against time for each specification in which the hypothesis of stability was rejected by the cusum-squares test. In addition to the

26 Such a transformation was required since the BDE tests assume that the errors are serially independent. If the serial coefficient is constant throughout the period, this transformation yields serially independent error terms. This transformation, along with the presence of a lagged dependent variable, introduces nonstochastic independent variables, violating one assumption of the BDE test. However, we know of no other stability test that adequately deals with such problems.

27 As regards the BDE tests for the Goldfeld equation, one should recall the above transformation required by the serially dependent error terms. In performing this transformation we took the rho value from table 3 (0.023). This serial coefficient was much larger than that found for the earlier sample period (0.040). When the latter estimate is used, the cusum-squares test rejects the null hypothesis at the 1 percent level.

---

### Table 4

<table>
<thead>
<tr>
<th>Equation</th>
<th>Cusum-squares</th>
<th>1%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goldfeld</td>
<td>.168</td>
<td>.233</td>
<td>.192</td>
<td>.172</td>
</tr>
<tr>
<td>Hamburger</td>
<td>.108</td>
<td>.233</td>
<td>.192</td>
<td>.172</td>
</tr>
<tr>
<td>Unconstrained Hamburger</td>
<td>.161</td>
<td>.235</td>
<td>.194</td>
<td>.173</td>
</tr>
<tr>
<td>Hamburger + CPR</td>
<td>.175</td>
<td>.235</td>
<td>.194</td>
<td>.173</td>
</tr>
<tr>
<td>Unconstrained Hamburger + CPR</td>
<td>.206</td>
<td>.236</td>
<td>.195</td>
<td>.174</td>
</tr>
<tr>
<td>B. Friedman</td>
<td>.317</td>
<td>.235</td>
<td>.194</td>
<td>.173</td>
</tr>
<tr>
<td>Garcia-Pak</td>
<td>.397</td>
<td>.233</td>
<td>.192</td>
<td>.172</td>
</tr>
<tr>
<td>Laumus-Spencer</td>
<td>.218</td>
<td>.232</td>
<td>.192</td>
<td>.171</td>
</tr>
</tbody>
</table>

Brown-Durbin-Evans Test of
Hamburger + CPR

The dashed line represents the 10 percent level of significance, the green line represents the 5 percent level.

Latest data plotted: 1st quarter

Brown-Durbin-Evans Test of
Unconstrained Hamburger + CPR

The dashed line represents the 5 percent level of significance, the green line represents the 1 percent level.

Latest data plotted: 1st quarter
Chart 3
Brown-Durbin-Evans Test of
B. Friedman

Cusum Squares

1.0

0.8

0.6

0.4

0.2

0

1956 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77

The dashed line represents the 5 percent level of significance, the green line represents the 1 percent level.

Latest data plotted: 1st quarter

Chart 4
Brown-Durbin-Evans Test of
Garcia-Pak

Cusum Squares

1.0

0.8

0.6

0.4

0.2

0

1956 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77

The dashed line represents the 5 percent level of significance, the green line represents the 1 percent level.

Latest data plotted: 1st quarter
plot of \( S_r \), each chart plots the mean value of \( S_r \) \[ i.e., E(S_r) = (r - k)/(T - k) \] and two confidence lines which, for given levels of significance, are drawn parallel to the mean value line. When the plot of \( S_r \) crosses one of these boundaries, the hypothesis of stability can be rejected at the appropriate significance level.

The charts reveal a varied picture of the timing of the possible structural shift. Chart 1—representing the \( S_r \) plot for the Hamburger with CPR specification—shows that at the 10 percent level the sample plot first intersects the statistical boundary in II/1966. At the 5 percent level the \( S_r \) plot stays within the boundary, though nearly touching the 5 percent line in III/1971.

The \( S_r \) plot for the Unconstrained Hamburger with CPR (chart 2) crosses the 5 percent boundary in III/1974. Over the period 1966-74, however, the path of \( S_r \) remains close to the 5 percent confidence band. Chart 3, the \( S_r \) plot drawn for the Friedman specification, indicates a structural shift (at the .5 percent level) in I/1966. Similar to chart 3, the \( S_r \) plot for the Garcia-Pak specification (chart 4) indicates that at the 1 percent level a shift in the underlying structural relationship occurred as early as IV/1962. Finally, the path of \( S_r \) derived from the Laumas-Spencer equation (chart 5) crosses the 5 percent confidence line in I/1970, and intersects the 1 percent line in IV/1973.

An interesting feature of these results is that the equations which indicated structural instability shifted much earlier than might have been expected. The finding of break points during the mid-1960s is at odds with much of the recent literature which suggests structural shifts later in the sample period.\(^{28}\) The results presented here do, however, tend to agree with those of Slovin and Sushka who, using a money demand equation in which demand deposits were used as the definition of money, found evidence of structural instability during the early 1960s.\(^{29}\) Their work suggests that this shift was due to changes in Regulation Q limits during this period.

\(^{28}\)Applying the Quandt log-likelihood ratio test to these equations suggests the following possible points to structural shift in the regression relationships: Hamburger with CPR, I/1975; Unconstrained Hamburger with CPR, III/1974; B. Friedman, I/1974; Garcia-Pak, IV/1967; and Laumas-Spencer, IV/1973. While these results are in general agreement with those found by others (e.g., Enzler, Johnson, and Paulus, Goldfield, Hamburger), the findings suggest that the structural instability of these models may have occurred at various times over the sample period.

In summary, these results indicate that many of the money demand specifications which have been offered as possible explanations of the missing money puzzle have actually been subject to significant structural changes over the II/1955-I/1977 sample period. A most interesting finding is that the regression coefficients on the Goldfeld specification do not change markedly when the sample period is extended to include the post-1973 period. In addition, when the autocorrelation coefficient was constrained to be 0.92, the equation did not indicate instability according to the cusum-squares test.

**SUMMARY AND CONCLUSIONS**

This article has examined the temporal stability of several alternative money demand relationships. Recent literature on money demand has drifted away from this concern and has focused too narrowly on the issue of predicting post-1972 real money balances. The formal test results presented in this article suggest that such a shift in emphasis has been misleading.

The findings in this paper indicate that, while several of the respecifications of the traditional transaction money demand relationship have yielded accurate post-1972 forecasts relative to those found for the real adjustment version of the Goldfeld specification, none of the modifications which stood up under critical review was temporally stable over the entire II/1955-I/1977 sample period. The modifications considered here included changing the measurement of the scale variable, broadening the asset range to include long-term yields, and redefining money to incorporate repurchase agreements.

The test employed in this paper (the BDE cusum-squares test) did not allow us to reject the hypothesis that the underlying relationship between the predetermined variables and real money balances, given by the conventional Goldfeld specification, was stable. In fact, the regression coefficients for the sample period including the turbulent period I/1973-I/1977 were markedly similar to those found when the sample period was ended in IV/1972. This finding indicates that the purported breakdown in this specification was overemphasized as a result of the reliance on the short-term predictive ability of the equation. In terms of policy implications, this finding suggests that long-term monetary policy prescriptions based on the assumption of a stable money demand relationship will be more reliable than previous analysis has implied.

**Appendix: Data Definitions and Sources**

| **Commercial paper rate (CPR)** — 4-6 month prime commercial paper rate. Prior to III/1974 average of most representative daily offering. After III/1974 average of midpoint of range of daily dealer closing rates. | **Price level (P)** — implicit gross national product price deflator (1972 = 100) |
| Source: Federal Reserve Bank of New York | Source: U.S. Department of Commerce, Bureau of Economic Analysis |
| **Long-term U.S. government bond yields (RCL)** | **Time deposit rate (RTD)** |
| Source: Federal Reserve Bulletin | Source: Stephen M. Goldfeld |
| **Money stock (M1)** — narrowly defined money balances (in billions of dollars), seasonally adjusted, quarterly average of monthly figures. | **Dividend price ratio on common stocks (DPR)** |
| Source: Federal Reserve Board | Source: Federal Reserve Bulletin |
| **Income (y)** — gross national product in billions of 1972 dollars at seasonally adjusted annual rates. | **Permanent income** — exponentially weighted average of past values of real gross national product. |
| Source: U.S. Department of Commerce, Bureau of Economic Analysis | Source: David E. Spencer |
| | **Household net worth (wealth)** |
| | Source: Federal Reserve Board |
| | **Immediately available funds (IAF)** |
| | Source: Garcia-Pak, “The Ratio of Currency.” |