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Author(s): Michael Dotsey
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The Use of Electronic Funds Transfers to Capture the Effects of Cash Management Practices on the Demand for Demand Deposits: A Note

MICHAEL DOTSEY*

ABSTRACT

The rapidly increasing use of more sophisticated cash management practices is a factor influencing the demand for money that is not considered in standard models of money demand. Within the framework of an inventory theoretic model of money demand, this paper provides theoretical grounds for using the number of electronic funds transfers as an indication of increasing cash management sophistication. Specifically, the demand for demand deposits is determined from the solution of a simultaneous equation system that also determines the optimal level of cash management. Therefore, the level of cash management services influences transactions costs, implying that transactions costs are endogenous. The number of electronic funds transfers is closely linked to the level of cash management services and is therefore related to transactions costs. Models of money demand that treat transactions costs as exogenous and fixed are therefore misspecified and will not perform well when transactions costs are changing. By explicitly incorporating the changing nature of transactions costs through the use of electronic funds transfers, the problems of instability and poor predictive power associated with the demand for money in the 1970's are overcome.

THIS PAPER ANALYZES THE effects of cash management techniques on the demand for demand deposits. These effects are derived from an inventory demand for money model in which cash management services are viewed as lowering transactions costs. This derivation implies that the solution of the model results in a two equation system that simultaneously determines the optimal level of cash management services and the optimal average demand deposit balances. Since the number of electronic funds transfers is related to investment in cash management services, modelling cash management in this way gives theoretical content to Kimball's [20] contention that the number of electronic funds transfers is an important variable in explaining the demand for demand deposits.

The model of the demand for demand deposits presented in this paper implies that omitting cash management innovations will produce serious misspecification and will bias regression results. These innovations allow deposit holders, especially firms, to economize on deposit balances. Therefore, the desired amount of demand deposits for any given level of transactions income and interest rates will be lower than that implied by any historical relationship. Failure to incor-

* The author is an economist at the Federal Reserve Bank of Richmond. Discussions with Robert J. Barro, James Fackler, Marvin Goodfriend, Monica Hargraves, Robert Hetzel, Robert King, Tony Kuprianov, Yash Mehra, and Mark Rush have been very helpful. Tim Rowe provided valuable research assistance. The views expressed in this paper are not necessarily those of the Federal Reserve Bank of Richmond or the Federal Reserve System and are solely the responsibility of the author.

porate cash management innovations and their effect on transactions costs will result in unstable regressions with poor predictive power over periods where innovations are taking place. In fact, much of the literature on the instability of the demand for money attributes the apparent structural shift in the demand for money to technological innovation in the management of demand deposit accounts.[1] Explicitly incorporating this process retains the stability of a demand deposit equation.

Since it is widely believed that the major effect of innovations in cash management has occurred with respect to demand deposits, the article concentrates on this variable. Total demand deposits are used since adequate data on demand deposits of nonfinancial businesses is unavailable. Both survey and econometric evidence are provided, indicating the importance of the adoption of more sophisticated cash management practices. Capturing this process by including the number of electronic funds transfers restores stability to the demand deposit equation over the extended sample and substantially improves the out-of-sample forecast errors.

The study uses annual data over the period 1920–1979. Annual data is used to avoid issues concerning lagged adjustment in money demand equations. The starting date represents the earliest date for which consistent data could be found, while the terminal date was chosen to avoid modelling the growing use of NOW accounts. This sample period is longer than samples used in most studies on money demand and provides a good deal of variability in the explanatory variables. The longer sample also provides insight into the extreme effect that cash management practices have had on the demand for demand deposits. For example, stability of the demand deposit equation cannot be rejected over the period 1920–1965, but can easily be rejected over the entire sample.

The organization of the paper is as follows. Section I presents evidence that the demand for money equation was stable over the period 1920–1965 and shows that the equation is no longer stable over the extended sample period 1920–1979. Section II develops a simple model of the impact of cash management on money demand and investigates the effects of allowing firms to influence transactions costs by investing in cash management techniques. Section III provides a summary and conclusions.

I. Stability of the Demand for Demand Deposits

A. Results for the 1920–1965 Period

In this section the demand for demand deposits is analyzed over a period when technological innovation is thought to be unimportant. Therefore, the level of cash management services is assumed to be constant, and apart from changes in the value of time, transactions costs do not change. The equation estimated is

$$\begin{aligned} \text{LNDD} = b_0 + b_1\text{LNCON} + b_2\text{LNRSAV} + b_3\text{LNRDD} \\ + b_4\text{LNRCP} + b_5\text{LNPCR} + b_6\text{LNWAGE} + e_t \quad (1) \end{aligned}$$

[1] For a few examples see Lieberman [25, 26], Kimball [20], Porter and Mauskopf [29], Simpson and Porter [32], and Judd and Scadding [17].

where DD represents real demand deposits, CON is real consumption expenditures,[2] RSAV is a weighted average of the passbook saving rate and the rate paid on money market mutual funds,[3] RDD is a competitive implicit rate paid on demand deposits derived using Klein's [21] methodology,[4] RCP is the commercial paper rate, PCR is a variable that captures the relative importance of credit use,[5] and WAGE is the real wage on average hourly earnings of production workers in manufacturing and is included to capture the effects of changes in the value of time (see Karni [19]). The letters LN in front of a variable indicate the natural logarithm of that variable.

The results of regressions over the period 1920–1965 are contained in Table I, column I. The coefficients all have the expected sign.[6] Increases in consumption imply that demand deposits will rise, but by less than one to one. At the 95 percent confidence interval, one cannot reject the hypothesis that the coefficient on LNCON is less than one, indicating economies of scale in demand deposit

[2] Although consumption and alternative scale variables such as GNP are closely correlated, the two series do exhibit some fundamental differences, most notably during the Depression and WW II. Large investment expenditures probably do not conform to the above transactions model. Also, government demand deposits are not included in demand deposit data and therefore the level of measured demand deposits may not be closely related to government spending. In a sense, investment and government spending may be demonetized. Further, in many studies of money demand, permanent income seems to be preferred to income (for a survey see Laidler [24]). Since consumption should be closely correlated with permanent income, its use is in keeping with these studies. Also Kohli [22] shows that the same concept of permanent income derived for consumption functions is appropriate for money demand studies. To see if GNP added anything above and beyond the contribution of consumption, the LN(GNP/CONS) was added to Equation (1). One could not reject the hypothesis that its coefficient was zero.

[3] The weights used are the proportion of passbook savings (money market funds) relative to the total amount of funds in both types of accounts. For most of the sample period this corresponds to the passbook rate.

[4] For a more detailed discussion of this rate see Dotsey [9]. Also, Carlson and Frew [7] indicate that there are some econometric problems in using and interpreting Klein's rate on M1 or M2 in money demand equations. These problems largely arise because of the constructed correlation between Klein's rate and the dependent variable. The actual method by which average reserve requirements are calculated can lead to spurious correlation between RDD and demand deposits similar to that outlined by Carlson and Frew. The effects of spurious correlation on the coefficients of RDD and RCP are the same as one would expect from theory, making it difficult to disentangle the two. The interpretation taken here is that RDD is a meaningful implicit rate, especially with respect to corporations, and omitting it would lead to specification bias. Also, to test the endogeneity of RDD, Granger-Sims causality tests were run. Although these tests only give necessary conditions for exogeneity, exogeneity could not be rejected.

[5] The level of demand deposits should also be sensitive to the intensity in which other mediums of exchange are used (see Barro and Santomero [3]). Therefore, the proportion of goods bought with currency and with credit are important determinants of the demand for demand deposits. No measure of currency's importance was readily available, but an analogous measure for credit was constructed. Ideally, the amount of credit extended should be used, but unfortunately data on this variable is not available over the entire sample period. To capture the relative importance of credit, the ratio of the sum of installment retail credit, noninstallment retail credit, credit outstanding on bank credit cards, credit owed to gasoline companies, and check credit, to personal consumption was used.

[6] Because of integral constraints, one should not expect an inventory model to yield elasticities of $\pm\frac{1}{2}$. For more detail see Barro [2]. Also, the inability to measure the proportion of goods purchased with currency could impart some bias to the income elasticity if the income of individuals who use only currency in transactions is growing at a different rate than those who use checks.

Table I

Regression Analysis for Demand Deposits

	I	II	III The results under 2SLS	IV The results under OLS	V
Sample Period	1920–1965	1920–1979	1920–1979	1920–1979	1920–1979
CONSTANT	−1.34 (−2.73)**	1.33 (1.71)	−1.14 (−2.63)*	−1.08 (−2.49)*	−1.24 (−2.81)**
LNCON	0.79 (10.49)**	0.31 (2.99)*	0.79 (12.29)**	0.79 (12.21)**	0.82 (11.92)**
LNRSAV	−0.24 (−13.27)**	−0.25 (−8.04)**	−0.23 (−14.85)**	−0.21 (−14.84)**	−0.23 (−14.29)**
LNRDD	0.075 (2.86)**	0.12 (2.51)*	0.077 (3.10)**	0.079 (3.18)	0.076 (3.04)**
LNRCP	−0.11 (−3.46)**	−0.11 (−1.82)	−0.10 (−3.50)**	−0.10 (−3.48)**	−0.10 (−3.52)**
LNPCR	−0.28 (−9.66)**	−0.30 (−5.69)**	−0.26 (−10.03)**	−0.26 (−9.70)**	−0.26 (−9.89)**
LNWAGE	0.36 (3.73)**	0.93 (6.17)**	0.39 (4.56)**	0.40 (4.67)**	0.36 (4.15)**
EFT			−0.013 (−12.53)**	−0.013 (−12.76)**	−0.013 (−13.38)**
TREND					−0.013 (0.73)
$\bar{R}^2$	0.9959	0.9840	0.99	0.99	0.99
D.W.[a]	1.79	0.73	1.74	1.74	1.72
S.E.E.	0.0306	0.0589	0.0287	0.0293	0.0288

Note: The numbers in parentheses are *t*-statistics. *Indicates significance at the 5 percent level. **Indicates significance at the 1 percent level.

[a] D.W., Durbin-Watson statistic.

holdings. Increases in the opportunity costs of holding demand deposits, as measured by either RSAV or RCP, cause demand deposits to fall, while a rise in the own rate causes these balances to rise. Furthermore, more intensive use of credit causes demand deposits balances to fall, while an increase in the value of time causes demand deposit balances to rise.[7]

The stability tests used were standard F-tests, the cusum of squares test proposed by Brown, Durbin, and Evans [6], and a test using varying parameter regressions suggested by Cooley and Prescott [8]. The maximum cusum of squares was 0.235, implying that stability cannot be rejected at a 5 percent confidence level.[8] These results are very similar to those obtained by Kahn [18] over a somewhat longer sample period. The Quandt log-likelihood ratio reached a minimum in 1949, and the sample was divided at that point. An F-test for equality of the coefficients over the subperiods was performed and stability could not be rejected.[9]

The test using a varying parameters regression model involves determining whether the regression coefficients are influenced by permanent disturbances. The covariance structure of the temporary and permanent disturbances, u_t and v_t, can be parameterized as $\text{cov}(u_t) = (1 - \gamma)\sigma^2\Sigma_u$ and as $\text{cov}(v_t) = \gamma\sigma^2\Sigma_v$, where Σ_u and Σ_v are assumed to be known up to scale factors.[10] Cooley and Prescott derive the asymptotic distribution of the parameter pair (γ, σ^2) and therefore allow one to test if γ is significantly different from zero. If $\gamma = 0$ can be rejected, then the regression coefficients experience permanent shifts and stability can be rejected. For the period 1920–1965, one cannot reject that $\gamma = 0$.

B. Results for the 1920–1979 Period

When the sample period is extended to 1920–1979, there is a significant change in the coefficients of the demand deposit equation.[11] These results are reported in column II of Table I. The coefficients most severely affected are those on the constant term, consumption, and the real wage rate. Also, the Durbin-Watson statistic indicates that the errors are no longer white noise, which may be a result of omitted variables. The instability of the regression can be established by

[7] The residuals from the regression in column I were analyzed using an ARIMA program. These residuals appeared to be white noise, making the chances of spurious correlation slight.

[8] Part of the maintained hypothesis is that the error variance of regressions over different subperiods are equal. When the moving regression is of length 23, the homogeneity statistic is 1.59 and has an F-distribution with 7 and 32 degress of freedom. If the moving regression is of length 15, the homogeneity statistic is 3.70 with a distribution of $F_{14,25}$. In the first case, stability cannot be rejected while in the second case it can.

[9] The F-statistic with 7 degrees of freedom in the numerator and 32 in the denominator was 2.15, which is less than the critical value at the 95 percent confidence level. Also of interest is the fact that the regression coefficients fairly quickly converge to their full sample values (see Dotsey [9]).

[10] In the tests performed in the text, the diagonal elements of Σ_u and Σ_v were taken from the variance-covariance matrix of ordinary least-squares regressions. The off-diagonal elements were set equal to zero. Cooley and Prescott indicate that this procedure does not reduce the efficiency of the estimates to any large extent.

[11] NOW and ATS accounts have not been included in the definition of demand deposits. Since these accounts were relatively unimportant, even in 1979, no significant problems can be associated with this omission. The results of regressions run with NOW and ATS added were almost identical.

examining the results of a Brown-Durbin-Evans test over the entire sample. The maximum cusum of squares statistic equals 0.668 which is well above the 5 percent critical value. (The observance of instability is in agreement with the results found in Boughton [5] and Fackler and Wheeler [12]). F-tests also confirm the rejection of stability. The point estimate for γ in the varying parameters model was 0.98 with a standard deviation of 0.14, so that almost all of the movement in the coefficients is interpreted as permanent. Furthermore, the prediction errors obtained by using the parameters from column I of Table I, show an overprediction of demand deposit balances, the overprediction becoming increasingly severe after 1974.

One possible way to correct this instability is to include a variable or group of variables that account for new cash management techniques.[12] If new methods of managing demand deposits more efficiently were being introduced, one would expect that less funds would be held for any given level of transactions income. Increases in transactions income would therefore have a smaller effect on the level of demand deposits in the presence of technological change unaccounted for. Similarly, increases in the value of time should have a smaller effect, as should increases in the own rate of interest, while decreases in these variables should have a magnified effect. The decline in the coefficient on consumption is in agreement with the above argument, but the increase in the coefficient on RWAGE is seemingly at odds with this explanation. However, correction for serial correlation causes the coefficient on RWAGE to be insignificantly different from zero. Furthermore, since the rate at which technology is adopted is likely to be endogenous, depending on the profitability of economizing on demand balances, omitting any consideration of technological progress could bias the coefficients.

II. The Use of Electronic Funds Transfers to Capture Technological Innovation

A. A Simple Model

The framework used for analyzing the potential consequences of innovations in cash management on the demand for demand deposits is an inventory model of the demand for money, where firms can influence the transactions costs of transferring funds between demand deposits and market instruments by investing in cash management services. The firm will choose the optimal level of cash management services by equating marginal benefits and marginal costs where the marginal benefit is simply the opportunity cost of holding a demand deposit multiplied by the reduction in demand deposits due to an additional unit of cash management. A linearized version of this optimization process produces a two-equation system that is recursive. This system is depicted by Equations (2)

[12] A substantial literature exists regarding the effects of more sophisticated cash management practices on the demand for money (see footnote 1). Also, surveys conducted by Greenwich Research Associates of the nation's 1,000 largest companies indicate that computerized cash balance reporting rose from 18 percent of the companies surveyed in 1976 to 63 percent in 1980.

and (3),

$$D_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 r_t + \alpha_3 a(CM_t) + e_{1t} \tag{2}$$

$$CM_t = \beta_0 + \beta_1 Y_t + \beta_2 r_t + \beta_3 MC_t + e_{2t} \tag{3}$$

where D is the average level of real demand deposit balances, Y is real transactions income, r is the opportunity cost of holding demand deposits, CM is the level of cash management services, MC is the marginal cost of using cash management services, and e_1 and e_2 are disturbance terms.

If CM_t was observable, Equation (2) could be run using two stage least squares. However, there is good reason to believe that the use of cash management services is closely related to the number of electronic funds transfers (EFT).[13] Much of the economization in demand deposit balances has resulted in investing idle balances for short periods of time, in many cases only overnight. The short-term nature of these transfers of funds necessitates that they be done in immediately available funds which are commonly transferred by wire. Also, the effective use of many of the cash management procedures instituted by firms—such as cash consolidation accounts, lock boxes, and zero balance accounts—usually require the employment of wire transfers. The number of wire transfers carried out over the Fed wire could serve as a useful indicator with regard to the intensity of the increased use of sophisticated cash management techniques.[14] For simplicity, it is assumed that EFT is related to CM by a fixed proportions technology so that EFT $= kCM$. Then for a given relationship between transactions costs, a, and cash management, say, $a(CM) = a_0 + a_1/(a_2 + CM)$, and linearizing around $CM = 0$, (2) and (3) can be rewritten as

$$D_t = \gamma_0 + \gamma_1 Y_t + \gamma_2 r_t + (\gamma_3/k)\mathrm{EFT}_t + e_{1t} \tag{4}$$

$$\mathrm{EFT}_t = k\beta_0 + k\beta_1 Y_t + k\beta_2 r_t + k\beta_3 MC_t + ke_{2t}, \tag{5}$$

where $\gamma_0 = \alpha_0 + \alpha_3 a_0 + \alpha_3(a_2/a_1)$, $\gamma_1 = \alpha_1$, and $\gamma_3 = -\alpha_3(a_1/a_2^2)$.

B. Empirical Results

The above system of equations is recursive and applying OLS to (4) will yield unbiased estimates of the coefficients if $E(e_{1t}e_{2t}) = 0$. Since e_{2t} is a shock pertaining to investment and technology while e_{1t} pertains to the demand for money, it is reasonable to conjecture that they will be uncorrelated. To check this, the equivalent of Equation (4) was run using 2SLS and compared to estimates using OLS. The results are given in Table I, columns III and IV. It is easy to see that the coefficients are extremely close (the OLS estimates are

[13] I have also examined the effect of including the value of electronic funds transfers, Dotsey [9]. The performance of this variable is similar but not as good as EFT. EFT may better indicate the degree to which technology has been adopted since a few firms making large electronic funds transfers could have a large effect on the value of electronic funds, whereas the number of transfers may serve as a more accurate indicator of the use of sophisticated cash management techniques by firms in general.

[14] Since this variable does not include the use of private wire transfers, it understates the amount of wire transfers.

within one standard error of the 2SLS estimates) and that therefore simultaneity bias is not a problem. In running 2SLS, MC_t was proxied for by an "hedonic" price of office computing and accounting equipment derived by McKee [27].

The regression results contained in Table I, columns III and IV, are interesting when compared with the results in columns I and II. The use of EFT greatly changes many of the coefficients in column III and returns the coefficients to the values presented in column I. The coefficient on EFT can be transformed into an elasticity of roughly −0.06. This would imply that from 1974 to 1979 when EFT rose from 15 million pieces to 35 million pieces that real demand deposits would have fallen approximately 9.0 percent due to cash management practices. In actuality, real demand deposits fell by almost 13.7 percent. Also, the inclusion of EFT eliminates problems of serial correlation. These results lead one to believe that the regression run over the extended sample (1920–1979) is now stable. The cusum of squares statistic is 0.176 which is within the 10 percent confidence level. Also, one can no longer reject the hypothesis that $\gamma = 0$, indicating a lack of permanent movements in the regression coefficients. However, an F-test where the sample was divided at the year 1949 (the year when Quandt's log-likelihood ratio was a minimum) rejected stability at the 5 percent level. In general, one can view these results as supporting a stable demand for money, especially given that fact that EFT is a somewhat noisy indicator of electronic funds transfers performed for cash management purposes (see footnote 14).

In order to confirm that the results concerning EFT are not merely due to spurious correlation, a time trend dummy starting in 1966 was included along with EFT. The results are included in column V of Table I. Notice that the time trend is insignificant and that the regression coefficients are almost unchanged from those reported in column IV.[15]

The final experiment is to observe the one period ahead forecast errors produced by regressions that include EFT over the period 1965–1978, and to compare their performance to that of an unaugmented regression. The results are contained in Table II. (The unaugmented regression was corrected for serial correlation, but the predicted values are calculated as $\ln y = \hat{B} \cdot \ln x$.) The inclusion of EFT reduces the average absolute error by 54 percent and the RMSE by 58

[15] Dummies taking on the value of 1 in 1974–1979, or 1 in 1966–1979 were also tried and not found to be significant when the equations were corrected for serial correlation. The trend dummy does have some explanatory power when included by itself. However, the errors are no longer white noise and the regression is no longer stable. Furthermore, a test for spurious correlation suggested by Plosser and Schwert [28] was conducted by overdifferencing the results of column IV and using an AR(2) correction for the error term. The results are:

$$\begin{aligned}\Delta\text{LNND} = \underset{(0.51)}{0.003} + \underset{(6.58)}{0.77}\Delta\text{LNCON} - \underset{(-5.19)}{0.21\Delta\text{LNRSAV}} + \underset{(2.49)}{0.079\Delta\text{LNRDD}} \\ - \underset{(-3.08)}{0.12\Delta\text{LNRCP}} - \underset{(-4.68)}{0.23\Delta\text{LNPCR}} + \underset{(1.76)}{0.28\Delta\text{LNWAGE}} - \underset{(-5.30)}{0.013\Delta\text{EFT}}\end{aligned}$$

where t-statistics are in parentheses. The corrected R^2 is 0.84, the standard error of the regression is 0.0312, the Durbin-Watson statistic is 1.92, and the values for the coefficients used for correcting for serial correlation are $\rho_1 = -0.36$ (-2.81) and $\rho_2 = -0.26$ (-2.08). All the coefficients in the first differenced regression are within one standard error of the estimates obtained in column IV.

Table II

The Logarithm of One Period Ahead Forecast Errors

	Unaugmented	With EFT
1966	−0.044	0.013
1967	−0.055	0.023
1968	−0.036	0.041
1969	−0.034	0.051
1970	−0.025	0.047
1971	−0.030	0.037
1972	−0.055	0.015
1973	−0.036	0.069
1974	−0.054	0.043
1975	−0.147	−0.057
1976	−0.192	−0.052
1977	−0.115	0.004
1978	−0.140	0.014
1979	−0.165	0.047
Average Error	−0.081	0.021
Average Absolute Error	0.081	0.037
RMSE	0.098	0.041

percent. Further, the sign as well as the size of the errors is affected. In 1975 and 1976, using EFT produces errors that do not seem to be historically large, although the errors are both negative. After 1976, the unaugmented regression continues to predict badly, while the errors using an equation with EFT are quite small.

III. Summary and Conclusions

This article develops a demand for demand deposit equation that explicitly captures the effects of investment in cash management techniques. The analysis indicates that standard models of money demand that neglect these effects are misspecified and will perform poorly when cash management technology is changing. The instability of standard models as well as their poor predictive performance is verified.

Following a suggestion by Kimball [20], the number of electronic funds transfers are used to capture endogenous changes in transactions costs brought about by more sophisticated cash management techniques. The results indicate that EFT does quite well in capturing the effects of changes in the investment in cash management services. Including EFT in a demand deposit equation returns stability to the equation and greatly improves the out-of-sample predictions.

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