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LIQUIDITY FUNCTIONS IN THE AMERICAN ECONOMY[1]

BY MARTIN BRONFENBRENNER AND THOMAS MAYER

This study analyzes liquidity functions (demand for money) in the American Economy. Total money holdings and idle balances are treated as alternative variables. In Part I an aggregative liquidity function is analyzed twice, once using interest rates and wealth as independent variables and once using last year's idle balances as a third independent variable. Very good fits were obtained in both cases.

In Part II the liquidity function is disaggregated by major holders. Only one independent variable, the rate of interest, is used. Most emphasis is on year-to-year changes. Estimates obtained in this way are compared to those of a naive model. Finally the elasticity of the liquidity functions at various levels of interest rates is analyzed. Neither the data nor theoretical considerations give any reason for expecting a liquidity trap.

I. INTRODUCTION

THE KEYNESIAN SYSTEM of aggregative economics rests, in its empirical aspects, on three major statistical foundations. One is the consumption function or propensity to consume, relating consumption to disposable income. The second is the investment function or marginal efficiency of capital, relating investment to interest rates. The third is the liquidity function, or liquidity preference, relating money holdings to interest rates.[2]

In the generation since the first appearance of the *General Theory*, none of these three functions has been left in the simplified form in which Keynes presented it. The consumption function has received until recently the lion's share of attention; three developments have dominated post-Keynesian research. One has been the addition of supplementary variables (including lags and ratchet effects). Another has been segmentation of the Keynesian

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[2] Compare Lawrence R. Klein, "The Empirical Foundations of Keynesian Economics," in K. K. Kurihara (ed.), *Post-Keynesian Economics* (New Brunswick: Rutgers University Press, 1954), p. 277: "Three accepted pillars of the Keynesian system are (1) the propensity to consume, (2) the marginal efficiency of capital, and (3) liquidity-preference."

aggregates. A third has been the drawing of distinctions between short- and long-run functions. The goal has been greater empirical realism, as measured by the goodness of statistical fit. Paradoxically, however, in the consumption-function case, one result has been the development of a rival theory as aggregative as Keynes's own, and with as few independent variables.[3]

Turning to liquidity functions, we hope in this study to improve their statistical fits to American data, operating along the lines just mentioned for the consumption function. In the first section, additional variables are added to the Keynesian pair (money stock and interest rates) for the entire American economy. In the second section, only the two Keynesian variables are used, but attention is concentrated on shorter time periods and on sub-groups within the American economy. Both sections are concerned with five fundamental questions of liquidity theory:

1. Is there a definite observable liquidity function, i.e., a relation between money holdings and interest rates?
2. Assuming this function to exist, what is its interest-elasticity?
3. Assuming this function to exist, what is its stability over time?
4. If shifts over time are observed, what are their causes, i.e., what other variables are important?
5. Does the liquidity function appear to impose an observable floor to interest rates?

II. NOTES ON THE LITERATURE

Before we present our own results, a brief resume of some earlier work appears worthwhile. Many of the earliest attempts to quantify the Keynesian liquidity function took the indirect form of establishing a positive correlation between interest rates and the velocity of circulation of money.[4] For the United Kingdom, however, A. J. Brown computed from British data as early as 1939, and by surprisingly "modern" methods, what appears to be the first true statistical liquidity function in the economic literature.[5]

[3] Milton Friedman, *A Theory of the Consumption Function* (Princeton: Princeton University Press, 1957), esp. ch. 3. Friedman has also applied similar methods to the liquidity function in a paper which appeared only after the present article was completed ("The Demand for Money: Some Theoretical and Empirical Results," *Journal of Political Economy*, August, 1959, pp. 327-352).

[4] For the United Kingdom, Kalecki, "The Short-Term Rate of Interest and the Velocity of Cash Circulation," *Review of Economic Statistics* (May, 1941), pp. 97-99; Kalecki, *Theory of Economic Dynamics* (New York: Rinehart, 1954), p. 76 f.; for the United States, J. N. Behrman, "The Short Term Interest Rate and the Velocity of Circulation," *Econometrica*, (April, 1948), pp. 185-190 and 370.

[5] A. J. Brown, "Interest, Prices, and the Demand Schedule for Idle Money," (originally published in 1939), in Thomas Wilson and P. W. S. Andrews (ed.) *Oxford Studies in the Price Mechanism* (Oxford: Oxford University Press, 1951), pp. 32-41.

More influential, at least in America, has been a later and simpler study by James Tobin.[6] Tobin defined idle balances somewhat arbitrarily as the difference between total deposits and the quotient of total debits and the maximum (1929) velocity of circulation.[7] (The Tobin method makes idle balances zero by definition in 1929.) He then plotted idle balances against interest rates, with no other variables entering the relations, and obtained, for the period ending in 1945, excellent graphical representations of Keynesian liquidity functions—not linear, as in the Brown study, but roughly hyperbolic, as had been assumed in many presentations of the Keynesian system.[8] For subsequent years, unfortunately, the fit was much less good, even when Tobin's method was refined by deflating deposit figures for price changes.

Much subsequent work avoids arbitrary classifications of balances as active or idle.[9] It relates *total* money or deposit holdings to interest rates, income, and other variables, without distinguishing active from idle elements. This assumes a single liquidity function of the type:

$$M = L(Y, r, a)$$

rather than such standard neo-Keynesian formulations as

$$M = L_1(Y) + L_2(r) \qquad \text{or} \qquad M = L_1(Y, r, b) + L_2(r, c)$$

where the L_1 are separate functions of disparate mathematical forms, and

[6] James Tobin, "Liquidity Preference and Monetary Policy," (originally published in 1947) in Arthur Smithies and J. Keith Butters (ed.) *Readings in Fiscal Policy* (Homewood, Illinois: Richard D. Irwin, 1955), pp. 245-47. A Tobin-type liquidity function has even found its way into an elementary text, Paul T. Homan, Albert G. Hart, and Arnold W. Sametz, *The Economic Order* (New York: Harcourt Brace and Company, 1958), pp. 488-490. For Great Britain, A. M. Khusro has fitted a Tobin-type function in his "Investigation of Liquidity Preference," *Yorkshire Bulletin of Economic and Social Research* (January, 1952), p. 3 f., before passing to further complexities.

[7] A similar definition had been used earlier by James W. Angell, *Investment and Business Cycles* (New York: McGraw-Hill, 1941), pp. 339-340.

[8] For example, Oscar Lange, "The Rate of Interest and the Optimum Propensity to Consume," (originally published 1938), in Gottfried Haberler, (ed.) *Readings in Business Cycle Theory* (Philadelphia: Blakiston, 1944,), p. 173; Franco Modigliani, "Liquidity Preference and the Theory of Interest and Money," (originally published 1944) in Friedrich A. Lutz and L. W. Mints (ed.), *Readings in Monetary Theory* (Philadelphia: Blakiston, 1951), pp. 199, 201, and 203.

[9] A good bibliography through 1955 is found in Hans Brems, "A Solution of the Keynes-Hicks-Hansen Non-Linear Employment Model," *Quarterly Journal of Economics* (May, 1956), pp. 306-308. (This also includes references to Scandinavian literature.) See also H. F. Lydall, "Income, Assets, and the Demand for Money," *Review of Economics and Statistics* (February, 1958), pp. 1-14, as an example of a cross-section rather than a time-series study.

where *a*, *b*, and *c* are collections of other exogenous variables which may overlap or even coincide.

L. R. Klein's successive macroeconomic models of the American economy illustrate the development of ideas regarding liquidity functions. In his Cowles Commission study of 1950, Klein made an idiosyncratic distinction between active and idle balances; he identified the former with demand and the latter with time deposits.[10] To explain the behavior of time deposits measured in current prices over the period 1921-41, his independent variables were corporate bond yields current and lagged one year, a negative time trend, and the prior year's volume of time deposits, a ratchet term. The equation is linear.[11] In his 1955 study with A. S. Goldberger, Klein utilizes the insights of Tobin and others in separating idle from active balances more meaningfully.[12] He also introduces a distinction between household and business balances. His explanatory variable for households is the difference between the current value of the long-term interest rate and a "minimum possible" rate which he takes as two per cent. His money figures are now deflated; his equation is now a logarithmic straight line; ratchet and trend terms have both disappeared.[13] For business balances Klein applies a similar method, using the aggregate wage bill rather than a national income aggregate as his basis for separating idle from active balances. Here his explanatory variables are the amount of price change in the current year, the short-term interest rate, and business idle balances lagged one year; his equation is linear.[14]

III. THE AGGREGATE FUNCTION

Our aggregative study covers the period 1919–56 inclusive. In the major portion of the study the dependent variable (X_1) is the logarithm of an estimate of deflated[15] idle balances computed *a la* Tobin with minor modifications. To derive it, private GNP (i.e., total GNP minus government

[10] Lawrence R. Klein, *Economic Fluctuations in the United States, 1921-1941* (Cowles Commission Monograph No. 11; New York: John Wiley and Sons, 1950), p. 132 f.

[11] *Ibid.*, pp. 105, 110.

[12] L. R. Klein and A. S. Goldberger, *An Econometric Model of the United States, 1929-1952* (Amsterdam: North-Holland Publishing Company, 1955), pp. 23-28. A preliminary presentation is also found in Klein, "Empirical Foundations of Keynesian Economics," *op. cit.*, pp. 315, 318.

[13] Klein and Goldberger, *op. cit.*, pp. 53, 64, 92, 107-8.

[14] *Ibid.*, pp. 53, 65, 92, 108.

[15] The deflator used is the Department of Commerce GNP deflator. See *Survey of Current Business* (July, 1959), Table 41, p. 25.

purchase of goods and services)[16] was divided by private money holdings.[17] The resulting velocity estimate has its maximum value of 4.022 in 1926 (not 1929). GNP for each year was then divided by this maximum velocity figure to obtain an estimate of active balances, and by subtracting these active balances from total balances we obtained an estimate of idle balances.[18]

As independent variables we chose three which had been suggested by economic theory, by earlier studies, or by promising two-way scatter diagrams reproduced as Figures 1–3.[19] The first of these is the interest rate. Just as it is possible to measure the price of strawberries either in fresh or frozen form, it is legitimate to measure either the cost liquidity for a long or short term by using a long or a short term interest rate.[20] We chose to use the short rate here and used the 4–6 months commercial paper rate. Besides being available readily, this rate is nearly free of risk and apprecia-

[16] A series for private GNP from 1919 to 1928 inclusive in 1939 prices may be found in J. W. Kendrick, "National Productivity and Its Long Term Projection," in Conference on Research in Income and Wealth, *Studies in Income and Wealth*, Vol. XVI, Princeton: Princeton University Press, 1954, Table 4, p. 82 f. For 1929 and subsequent years we used the (not entirely comparable) Department of Commerce series, *Survey of Current Business* (July, 1957), Table 40, p. 25 f. Undeflated deposit series are from Federal Reserve Board, *Banking and Monetary Statistics* (Washington, 1943), Table 9, p. 34 f., supplemented by *Economic Report of the President* (1957), p. 165, and *Federal Reserve Bulletin* (December, 1957), p. 1376.

[17] These are defined as currency outside banks plus demand deposits other than Government or interbank deposits. Time deposits were excluded because they bear substantial interest. Liquidity functions are designed to measure, among other things, the influence of interest rates on interest-free money holdings. Inclusion of interest-bearing components in money holdings would muddy the waters. (Insofar as some American banks paid nominal interest on demand deposits until the early thirties, inclusion of these deposits muddies them slightly.)

[18] Since idle balances are zero by definition in 1926, X_1 for 1926 should be $-\infty$. For convenience in calculation, we used the value of 0.1 (billion dollars) for 1926 idle balances, yielding an X_1 of -1.0000 for 1926. It should be noted that this method of isolating idle balances assumes that transactions balances are a linear function of income. While this is an oversimplification (Cf. William J. Baumol, "The Transactions Demand for Cash: An Inventory Theoretic Approach," *Quarterly Journal of Economics*, November, 1952, pp. 545-556) it is hoped that it does not create too serious an error.

[19] In addition to the variables used, the following three variables were tried and rejected because of poor fit: lagged interest rates, lagged national wealth, and the rate of change of the price level. The last named series has, however, been used by A. J. Brown, *op. cit.*, and later by Phillip Cagan in modified form as the major explanation of the behavior of the money supply in several European hyperinflations, "The Monetary Dynamics of Hyperinflation," in Milton Friedman (ed.) *Studies in the Quantity Theory of Money* (Chicago: University of Chicago Press, 1956, pp. 35, 37.) (Cagan's explanatory variable is not the *observed* but the *expected* rate of price changes.)

[20] This means that the liquidity function here analyzed differs somewhat from that of Keynes, who apparently used the long-term rate exclusively.

tion factors, and it is also more sensitive to economic changes than are longer term rates.

The second independent variable used is the logarithm of national wealth, more specifically Dr. Goldsmith's series on total national wealth in 1929 prices.[21] Government-owned wealth was not excluded, but rather used as a proxy for the government securities omitted from the wealth of the private sector.[22] The fourth variable used, a ratchet, is the logarithm of prior year idle balances.

An alternative presentation departs from the Angell-Tobin model by using the logarithm of *total* private deposits as X_1 and the logarithm of its lagged value as X_4. In this model an additional variable, X_5, the logarithm of private GNP, has been added.

Figures 1-3 show the arithmetic relationship of the dependent variable with each of the independent variables separately.

In Figure 1, using only the interest rate, a roughly hyperbolic function fits the data quite well over the period 1919–46,[23] but an entirely different

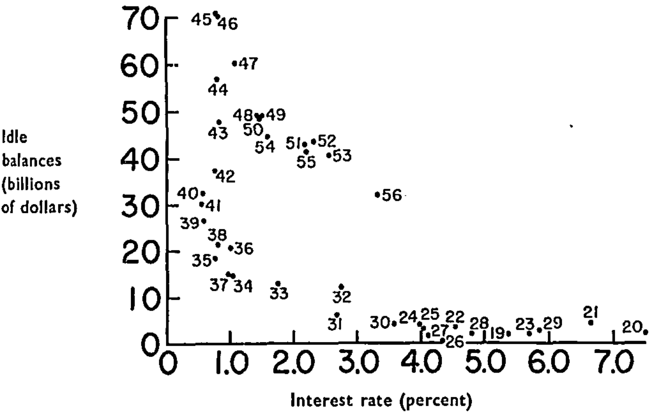

FIGURE 1. Idle balances and interest rates 1919-1956.

[21] To save space the description of statistical sources and details of the methods used have been omitted here, but mimeographed copies of this material are available upon application to Mr. Mayer.

[22] An alternative procedure would have been to subtract Government wealth from Goldsmith's estimate and to add back Treasury estimates of non-bank holdings of Government securities.

[23] Compare Tobin, *op. cit.*, Charts 2-5, pp. 244-246, covering periods 1922-1941, 1922-1944, and 1942-1945 for various areas of the United States. The roughly hyperbolic fits to the arithmetical data naturally suggest double-logarithmic straight lines.

function fits the subsequent observations. The scatter diagram of idle balances and national wealth (Figure 2) suggests three separate functions: a horizontal line, 1919-30, a vertical line, 1930-45, and a *slightly* downward

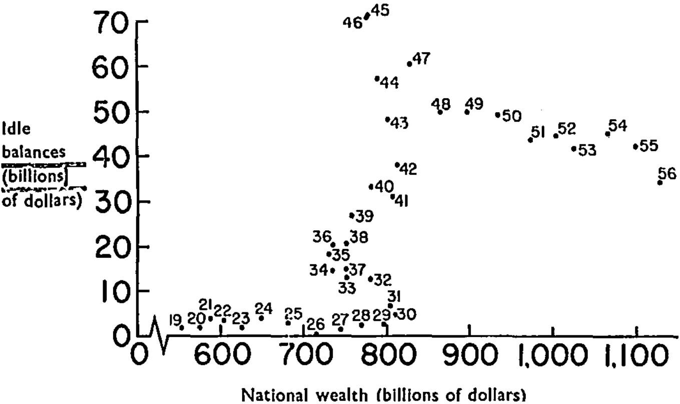

FIGURE 2. Idle balances and national wealth 1919-1956.

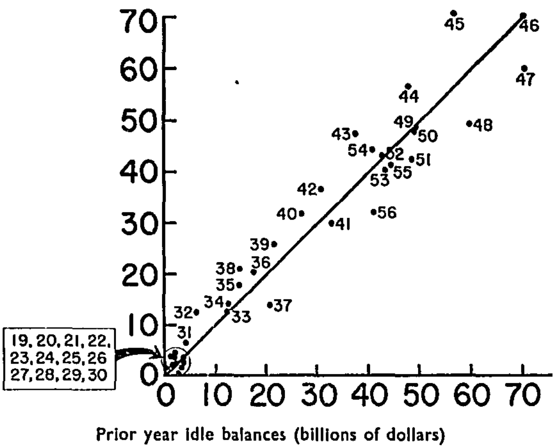

FIGURE 3. Idle balances ratchet effect 1919-1956.

sloping line, 1945–56. Figure 3 the scatter diagram of given year and prior year idle balances, shows a close fit through the thirty-seven year period, which suggests a high degree of inertia in money habits.

We made three separate statistical estimates of liquidity functions. The first two are estimates of the demand for idle balances and employ the modified Tobin technique: income is not one of the independent variables. The third is an estimate of the demand for all private cash balances, and income is one of the independent variables. The first two estimates differ in that the first includes the years 1926 and 1927, while the second excludes them. (In 1926, the Tobin technique fixes the volume of idle balances as zero, whose logarithm we have treated as though the volume were fixed at $0.1 billion. In 1927, the same value enters as a lagged variable.)

The results are as follows, the figures in parentheses being standard errors:[24]

Estimate 1 (Idle Balances, all years):

$$X_1 = -\underset{(0.0482)}{4.2066} - \underset{(0.2030)}{0.5304}\, X_2 + \underset{(0.8906)}{1.6849}\, X_3 + \underset{(0.1323)}{0.5416}\, X_4 ,$$

$$r_{1.234} = 0.901 , \qquad \frac{\delta^2}{s^2} = 2.23 .$$

Estimate 2 (Idle balances, 1926-27 omitted):

$$X_1 = -\underset{(0.0198)}{1.9552} - \underset{(0.0952)}{0.2772}\, X_2 + \underset{(0.4313)}{0.8269}\, X_3 + \underset{(0.0793)}{0.7158}\, X_4$$

$$r_{1.234} = 0.978 , \qquad \frac{\delta^2}{s^2} = 2.40$$

Estimate 3 (Total balances, all years):

$$X_1 = \underset{(0.0032)}{0.1065} - \underset{(0.0139)}{0.0928}\, X_2 - \underset{(0.0883)}{0.1158}\, X_3 + \underset{(0.0576)}{0.7217}\, X_4 + \underset{(0.0862)}{0.3440}\, X_5$$

$$r_{1.2345} = 0.997 , \qquad \frac{\delta^2}{s^2} = 1.91 .$$

The statistical fits are obviously close. All variables except X_3 (wealth) are statistically significant by the t-test at the 1 per cent level;[25] the von Neumann test shows no significant auto-correlation between residuals. Our slope coefficients are all elasticities, since all variables are measured

[24] The variables are, to repeat: X_1, log of deflated cash balances; X_2, log of the commercial paper rate; X_3, log of deflated national wealth; X_4, X_1 of the prior year; and (in the third estimate) X_5, log of deflated private GNP.

[25] In Lydall's cross-section study for different income and asset classes in a single year in Great Britain, the wealth variable was clearly significant (*op. cit.*, p. 6). The interest rate, furthermore, could not enter directly, being a constant for all observations. It is possible, as implied in Lydall's appendix (*ibid.*, p. 14) that in time series fluctuations in wealth would reflect inversely fluctuations in interest rates, since wealth is largely evaluated by capitalizing expected income at expected interest

logarithmically. All coefficients except that of wealth in Estimate 3 have the signs suggested by received economic theory; negative for interest rates, positive for income, wealth, and prior money holdings. The negative elasticity for wealth, while statistically not significant, suggests that money may be an "inferior asset," of which people hold less as their wealth (and credit-worthiness) increases. The interest elasticity in particular, the nub of liquidity theory, is estimated at between 0.3 and 0.5 for idle balances, slightly less than 0.1 for total balances.[26] The lower elasticity for total balances again conforms to economic theory. There is no evidence for the proposition that any of these elasticities goes to zero for high rates of interest, or for the proposition that some "floor" or "bottom stop" exists for interest rates at which the elasticity goes to infinity.

Our results arouse some suspicion of multicollinearity, a type of spurious accuracy obtainable by fitting a function in n variables to a relationship or model in only $(n - k)$ variables.[27] Here the simple correlations r_{14} are respectively 0.875, 0.972, and 0.993. What we may have, expressed verbally, is an inertia relation between demand for money this year and last, with the other independent variables largely superfluous window-dressing. This suspicion is to some extent dispelled by the considerable uniformity among the three sets of numerical results.

Figure 4 compares actual and computed values of X_1 (idle balances) for the first two estimates. The fits to the arithmetic data are generally close (especially in the case of the second estimate), although naturally not so close as would be similar fits to the logarithmic data. There is a clear tendency for the fluctuations of computed values to display smaller amplitudes than the fluctuations of the actual data, and also to lag for a year at peaks and troughs. These are normal attributes of estimates relying heavily on ratchet terms; the first deficiency is also usual for moving averages. The fits are not good during the years of World War II (reflecting accumulation of cash for patriotic reasons and postwar purchases), but they are

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rates. Our own correlations between observed wealth and observed interest rates, while negative, are so low (—0.303, —0.289, —0.303, respectively) as to cast doubt on the efficacy of Lydall's indirect method of taking into account interest rate changes via the wealth variable.

[26] Lydall's indirectly-computed estimate of the interest elasticity of demand for bank deposits in Great Britain is 2.72 (*ibid.*, p. 11), which we do not attempt to reconcile with our own results. See also A. J. Brown, *The Great Inflation, 1939-1951* (London: Oxford University Press, 1955), pp. 204-07, for higher estimates.

[27] For two elementary introductions to the collinearity problem, see Mordecai Ezekiel, *Methods of Correlation Analysis* (Second Edition: New York: Wiley, 1941), p. 448, and E. F. Beach, *Economic Models: An Exposition* (New York: Wiley, 1957), pp. 171-175, 182-184. The standard treatment remains Ragnar Frisch, *Statistical Confluence Analysis* (Oslo: Universitetets Konomiske Institutt, 1934), *passim*.

not so poor as to justify omission of these years from our study. The period 1941-45 is accordingly included on the same basis as other years.

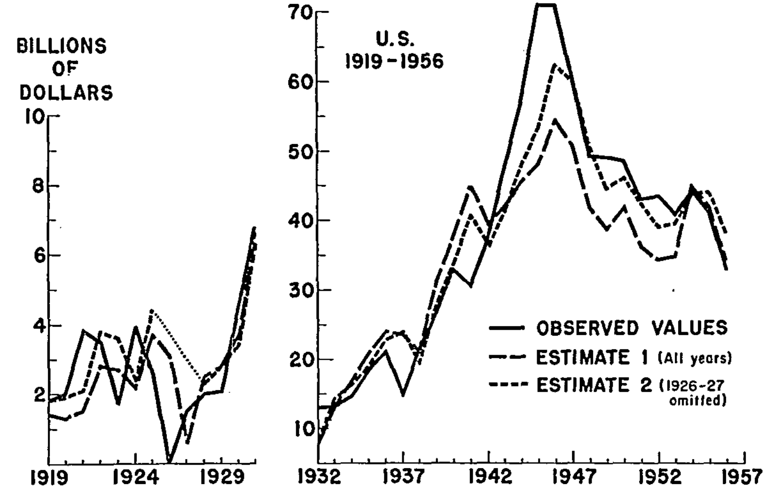

FIGURE 4. Idle balances, observed and estimated values.

IV. IDENTIFICATION PROBLEM

Before accepting this function in any of its variants as representing a liquidity function (a structural equation of the demand for money in a more general economic model) we face an *identification problem*.[28] Supposing the function to be useful for prediction purposes, how do we know that it is not rather a supply curve, or perhaps a hybrid between the two? Our procedure cannot be said to meet this challenge. Rather it avoids the challenge by assumption. It is tantamount to specifying the form of the supply function for money as influenced by none of the independent variables of our demand or liquidity function for money. Only under this assumption can we avoid some modification of our least squares fitting procedure by some of the additional complexities of the simultaneous equations approach.

Implicitly at least, we have supposed the supply function of money to the private sector of the American economy to be a quantity whose movements through time are unaffected by any of our independent variables

[28] The most readily available treatment of the identification problem is probably by Lawrence R. Klein, *A Textbook of Econometrics* (Evanston, Ill., and White Plains, N.Y.: Row Peterson, 1953), ch. 3, sec. 3, pp. 92-100.

(the interest rate, the level of real wealth, the prior year money supply, or the level of real income). This assumption is open to question as regards all these variables. Insofar as it is rejected, the demand or liquidity function we have fitted may include some elements from the supply side, and be in fact a hybrid monstrosity. Our best hope is that our hybrids are approximately 99-44/100 per cent pure demand or liquidity function. Their coefficients seem to point in this direction.

We may, however, interpret the lagged variables X_4 as reflecting supply relationships rather than demand inertia. The "supply relationship" is in this view the unwillingness of the monetary authority to permit sharp year-to-year changes in the money supply. If we interpret the ratchet variable in this way, X_4 must be omitted from our liquidity functions or demand curves for money. When this is done we have, corresponding to the three estimates above (page 817):

Estimate 1a (Idle Balances, all years):

$$X_1 = -\underset{(0.0580)}{9.9740} - \underset{(0.1731)}{1.1172}\, X_2 + \underset{(0.8442)}{3.9330}\, X_3$$

$$r_{1.23} = 0.848\,, \qquad \frac{\delta^2}{s^2} = 0.93\,.$$

Estimate 2a (Idle Balances, 1926-27 omitted):

$$X_1 = -\underset{(0.0372)}{9.5246} - \underset{(0.1093)}{0.9518}\, X_2 + \underset{(0.5205)}{3.7830}\, X_3$$

$$r_{1.23} = 0.919\,, \qquad \frac{\delta^2}{s^2} = 0.45\,.$$

Estimate 3a (Total Balances, all years):

$$X_1 = -\underset{(0.0076)}{0.4958} - \underset{(0.0234)}{0.2160}\, X_2 - \underset{(0.2114)}{0.1859}\, X_3 + \underset{(0.0963)}{1.2992}\, X_5$$

$$r_{1.235} = 0.984\,, \qquad \frac{\delta^2}{s^2} = 0.68\,.$$

These interest elasticities are more than double their counterparts in Estimates 1–3, and remain higher for idle than for total balances. The "inferior asset" position of total balances is repeated in Estimate 3 but its statistical significance is not improved. The multiple correlation coefficients are all lower, but that for total balances holds up surprisingly well. A statistical warning is given by the von Neumann coefficients, which are all less than unity. This implies significant autocorrelation of the residuals —a not unexpected result, in view of the strong ratchet effects observed earlier.

The liquidity function was disaggregated in two ways. The first was by disaggregation over time and examination of year to year changes. This was done because for policy purposes the short-run liquidity function may at times be more important than the long-run one. Moreover, by analyzing year to year changes, one can observe some interesting shifts in the liquidity function and its elasticity.

Second, separate liquidity functions were computed for several major economic sectors.[29] They were first computed for corporations and then for individuals plus unincorporated businesses combined[30] to see if only corporations have liquidity functions. Then individuals and unincorporated businesses were analyzed separately. Finally, since time deposits are sometimes included in the money supply, an analysis for all holders based on this alternative definition of money was included to see if our results would also apply to this broader definition of money. We therefore computed separate liquidity functions for the following:

1. All private holders combined.[31]
2. Corporations.
3. Individuals plus unincorporated businesses.
4. Individuals.
5. Unincorporated businesses.
6. All holders—alternative definition of money.

No data on money holdings as usually defined are available for individuals and unincorporated business separately; for these two sectors time deposits are included in money. Moreover, the separate data for these individuals and unincorporated businesses are subject to a large margin of error.

The independent variables used are again idle balances, computed as described above, and total money holdings relative to income, as expressed by the Cambridge *k*.[32] Only one independent variable is used explicitly in

[29] All money figures are deflated by the consumers' price index, which unlike the GNP deflator, is available in monthly form.

[30] Throughout this analysis, the money holdings of non-profit institutions are included with those of individuals, because separate data for individuals are not available.

[31] Private holders are defined as all holders except the Federal Government.

[32] In both cases income figures are needed for the computations. Unfortunately, no accurate income concept is available for any of the sectors other than "all holders" and "individuals." For individuals and unincorporated business combined total *money* income was used. This is not a good measure, since a shift from unincorporated business to the corporate form affects the numerator but not the denominator of the fraction M/Y. For corporations, gross income was used, because a corporation's need for transactions balances is more closely related to its gross than to its net income. (For example, a corporation's demand for transaction balances does not become

this section. This is the short-term interest rate, measured by the 4-6 months commercial paper rate before World War II, and by the Treasury bill rate after the War. Since there is a significant return on time deposits a rate adjusted for this return, as well as the unadjusted rate, was used for the analysis of the alternative definition of money.[33] One of the other independent variables of the aggregated analysis, last year's idle balances, was introduced implicitly by using year-to-year changes. In the computations based on the Cambridge *k* income was also introduced implicitly. The only variable completely omitted in this section is the stock of wealth.

To take account of possible lags different models were computed using zero, six months and one year lags for income, and using the current month's interest rate and the average interest rate for the last twelve months. Distributed lags were not used. To reduce the computational burden these lag models were not computed for all sectors; for individuals and unincorporated businesses separately, the data are too poor to justify a multiplicity of lag models, and only a one year lag was used. Similarly, preliminary analysis for corporations suggested that the current month's interest rate gives a better fit than the yearly rate, and only this rate was used.

The period covered by the analysis of all holders is 1913-1957 with the period of World War II excluded as abnormal.[34] For the other sectors only the interwar period was analyzed.

Before turning to the results, the reader must be warned again about the identification problem. To what extent do the observed points of intersection between supply and demand curves for money represent a single demand curve traced out by shifting supply curves? This problem is important for the derivation of a forecasting equation, but it is even more serious for the interpretation of the function, and the measurement of its elasticity. Fortunately, there is some evidence suggesting, though not proving conclusively, that the scatter of the points results *primarily* from shifts in the supply curve, and hence gives a fairly reasonable picture of

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zero if it has no net income, and does not become negative if the corporation has a net loss.) The *k* used for corporations is therefore the reciprocal of the corporation's transactions velocity, not of its income velocity. No income figures for unincorporated businesses were available and hence a wealth variable, total assets, was used instead.

[33] The adjustment consists of taking total interest paid on all deposits and dividing this by the money supply. This average rate of return on money is then subtracted from the short-term interest rate. For more detailed discussion see the mimeographed appendix described in footnote 21.

[34] The World War I period was not excluded because conditions were substantially different from those of World War II. In the first war there was an open inflation, but in the second war suppressed inflation. Hence money holdings were abnormally high in World War II, but not in World War I.

the demand curve for funds with a possible bias in its estimate of elasticity.

First, assume that the shifts in the supply curve and demand curve are not correlated.[35] Then, if we have a stable upward sloping supply curve and a fluctuating downward sloping demand curve, the points would lie on the supply curve. On the other hand, if the demand curve is stable and the supply curve shifting, the demand curve would emerge and, finally, if shifts in both curves are equally important, the points would tend to have a random distribution. As will be shown subsequently, negative slopes predominate, hence shifts in supply appear to predominate over shifts in demand.

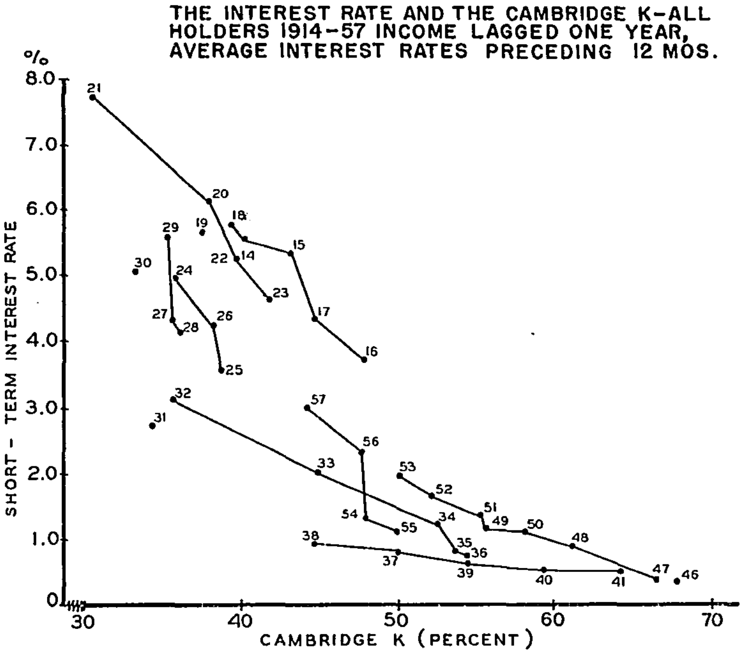

FIGURE 5.

Second, the relation found could not be merely the result of time trends in both money holdings and the interest rates, since our relation holds in a

[35] It is not possible to determine the validity of the assumption of uncorrelated supply and demand curve shifts. James W. Angell has suggested (*op. cit.*, ch. 2) that both supply and demand curves are substantially affected by expectations, favorable anticipations shifting both the supply curve and the demand curve to the right. In this case, the result depends upon the relative size of these shifts.

number of cases where the shifts could not be a simple function of time.[36] For example, in Figure 5, the observation for 1917 lies *between* those for 1915 and 1916; this type of relationship occurs quite frequently. This could not have happened if the increase in k and the decrease in interest rates had merely resulted from a monotonic time trend in both variables.

Third, there appears to be some consistency in the shift of the curves; the liquidity curve seems to shift in the same direction several times. Thus, in Figure 5 during the interwar period there were six separate liquidity

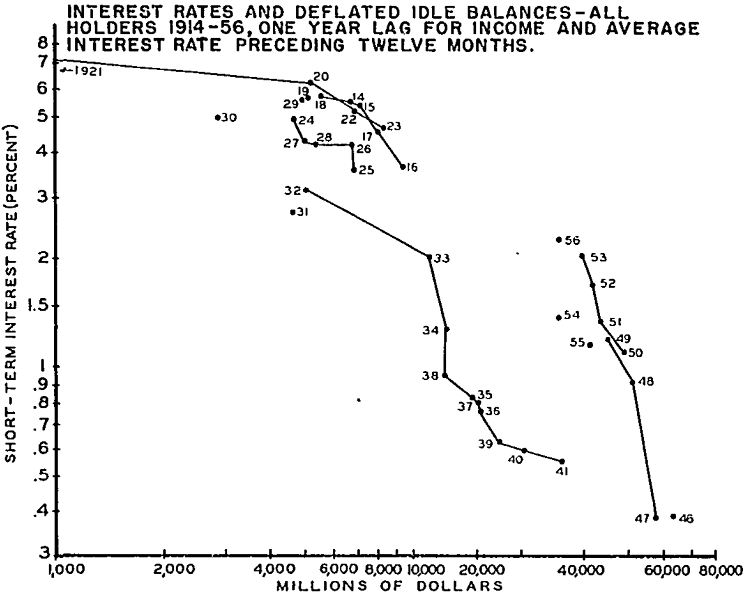

FIGURE 6.

curves, and each one of these curves is to the left of the previous one. Finally, there is *some* similarity among the slopes of the curves; it would take a very special shift of supply and demand curves to produce this if both had shifted substantially. In view of these factors the scatter diagrams of interest

[36] For a discussion of this point see A. J. Brown, "The Liquidity-Preference Schedules of the London Clearing Banks," *Oxford Economic Papers*, Number 1, (1938) pp. 54-55.

rates and money holding will be treated as reasonable approximations to demand curves for money.

Now for the results. Figures 5 and 6 are scatter diagrams relating the interest rate to the Cambridge k and to idle money holdings. To isolate short-run functions, all points for three or more *consecutive* years which could be connected by a negatively sloping line were so connected.[37] These lines are taken to represent short-run liquidity functions. In Figure 5, a single liquidity function fits the five year period 1914–1918 inclusive. In the following year the curve shifted to the left, and then the next year, slightly to the right again where it remained for the next four years. In the following six years, there were two more shifts to the left. Thus, for the whole period 1914-1929, all observations except one (1919) fell on fairly stable liquidity curves. The first two full years of the great depression are not on a stable curve, and then from 1932 there is again a single curve until 1936. The remaining interwar years are all on a single curve which is much flatter than the previous curves.

In the early post-war years, there was a shift of the function—the interest rate was the same in 1946 and 1947, but k differed slightly. All the remaining eleven years, however, fall on two liquidity functions. Nonetheless, the good fits for the post-war years may represent the spurious correlation of independent time trends. After 1947 there were only three years of falling interest rates. One of them, 1954, did not fall on the previous curve; the two other years of declining interest rates, 1949 and 1955, fell on their respective functions, but the slopes show discontinuity.

A similar pattern for idle balances is shown logarithmically in Figure 6. The only major differences in the pre-war period are that a single liquidity curve (of changing slope) accounts for all the years from 1924-28, and that the whole period 1932-41 also falls on a single liquidity curve. In the post-war period, however, four years are off the curves.

In addition to illustrating the existence of a liquidity function graphically, the data can be used to see how well one can forecast with the liquidity function. Such forecasts are tested in two ways here. First, there is a test for the *direction* of movement. If the interest rate really is an important determinant of money holdings then, if interest rates decline from one year to the next, money holdings should be higher in the second year than the first,

[37] The use of three years as a minimum period of time is of course arbitrary but preferable to a two year period. If there is *no* real correlation between two variables there is a 50 per cent chance that two observations can be connected by a line of negative slope. With three observations, however, the probability of a negative slope resulting from chance elements is only 25 per cent. This chance of error is still high but to use four years as a minimum period would probably have been too restrictive for *short-run* functions. As it happens, however, there are only two functions each of less than four years in Figure 5 and 6.

and conversely if interest rates rise money holdings should be less the second year. Second, the short-run liquidity function can be used to forecast the size of money holdings in any one year, and accuracy of this forecast can be compared to the accuracy of a naive model forecast.[38]

TABLE I
Accuracy of Forecast of Direction

Lag Model	Time Deposits Not Included in Money					All Holders—Time Deposits Included in Money	
	All Holders	Corporations	Individuals and Miscellaneous	Individuals	Unincorporated Businesses	Unadjusted Interest Rate	Adjusted Interest Rate*
	RIGHT FORECAST AS PER CENT OF ALL FORECASTS Money Holdings as per cent of Income						
Average Interest Rate for Previous 12 Months:							
1 Year Lag for Income	86%†		78%†	74%†	63%	78%†	66%
½ Year Lag for Income	81†		89†				
No Lag for Income	61		69				
Interest Rate of Current Month:							
1 Year Lag for Income	65	65	67				
½ Year Lag for Income	76†	67	80†				
No Lag for Income	82†	57	72†				
	Idle Balances						
Average Interest Rate for Previous 12 Months;							
1 Year Lag for Income	86†		74†	81†	58	89†	71†
½ Year Lag for Income	81†		89†				
No Lag for Income	62		78†				
Interest Rate of Current Month:							
1 Year Lag for Income	64	65	62				
½ Year Lag for Income	76†	67	80†				
No Lag for Income	79†	62	79†				

Note: Cases in which one variable changed and the other remained constant are not included. Blank spaces denote coefficient not computed.

* Interest rate adjusted for interest paid on deposits.
† Significant at the 5 per cent level. Includes several cases in which the probability is exactly 5 per cent.

Table I shows that Keynesian liquidity theory gives a good prediction of the direction of movement in money holdings. These predictions can be

[38] To reduce the computational burden only the lag models performing best on the first test were used in this and the subsequent analyses.

compared to those of a naive model. Our naive model assumes a random relation between money holdings and the interest rate, so that in half the cases money holdings and the interest rate move in the opposite direction, and in half of the cases in the same direction. If there is really no relation between the two variables, such a naive model would give a correct forecast 50 per cent of the time.

The results shown in Table I are better than this, and hence the Keynesian liquidity hypothesis appears to be useful in forecasting the direction of movements in real money holdings. More than this, Table I provides support for the Keynesian attack on Say's law. If, as is shown in Table I, money holdings increase when interest rates fall, then increases in *ex ante* savings do not lead automatically to an equivalent increase in investment, and hence it follows that "demand for commodities *is* demand for labor."[39]

Table I also shows that the responsiveness of money holdings to interest rate changes is not merely an attribute of financial corporations, but is widespread in the economy. Every one of the sectors shows a negative, though by no means always a significant, relation of interest rates and money holdings. However, the disaggregation by sectors does little or nothing to improve the accuracy of the forecasts. The forecasts for individuals and unincorporated businesses are no better than those for all holders, and the forecasts for the other sectors are worse.[40]

The second test of the short-run liquidity function is to forecast the size of money holdings. The short-run function can be used to forecast this by measuring the elasticity or slope between any two years and then multiplying this elasticity or slope of the function by the change in interest rates between the second and the third year. If the elasticity or slope is constant, the resulting forecast would be without error; and the actual error thus reflects the short-run instability of the function. This error can again be

[39] This does not completely settle the issue, however, for if prices would be sufficiently flexible, a decrease in the propensity to spend would lead to an increase in the real quantity of money sufficient to satisfy the increased demand for hoards. As will be shown below, the liquidity preference function is not very elastic, hence for relatively small declines in the propensity to spend, relatively small price declines might suffice.

[40] For the corporate sector it might reflect an instability of the function. Since corporations on the whole have *relatively* easy access to money market information it would not be surprising if their liquidity function would shift frequently. The poor results for individuals and unincorporated businesses could easily result from the weakness of the data—as stated above, the allocation of the money holdings of individuals plus incorporated businesses among its two components is based on worse data than the rest of the study.

compared to that of a naive model.[41] According to the naive model, money holdings are constant—hence year-to-year changes in money holdings measure the error of the naive model.

TABLE II
FORECAST ERRORS

	Per cent of Years with Better Forecasts for Liquidity Models than Naive Model*		Mean Error as per cent of Actual Value			Median Error as per cent of Actual Value		
				Liquidity Function			Liquidity Function	
	Elasticity	Slope	Naive Model	Elasticity	Slope	Naive Model	Elasticity	Slope
Cambridge k								
All Holders	60%	53%	7.3%	12.2%	9.7%	5.8%	6.6%	5.2%
All Holders—Time Deposits included in Money	50	50	6.7	17.4	12.7	5.6	5.6	4.3
Idle Balances								
All Holders	56	59	15.4	43.8	19.6	12.1	11.7	9.4
All Holders—Time Deposits included in Money	59	62	14.1	78.7	25.4	12.3	8.8	9.1

* Cases where both models gave equally accurate forecasts are excluded from both the numerator and denominator.

Table II compares the two forecasts for the all holder functions.[42] The first two columns compare the two models by showing the proportion of the years in which each function gives a better forecast. These results are mixed. The liquidity functions for all holders are better than the naive model but the differences are not significant at the 5 per cent level. Many of the sector forecasts are worse than the naive model.

[41] Elasticities were again computed by logarithms; those years in which the natural number was zero were omitted from the analysis. Since the slopes and elasticities are taken as constant in the forecasting model, this model is in a way close to a naive model. Basically, there are four possible models. First, there is the naive model described above; second, there is a model based on the assumption that some *average* relation between money holdings and interest rates will continue to hold in the future—this is the model of the aggregate function. Third, there is the model used here which projects, not the average relationship, but the relation in the last year. The fourth model, which is not used here, would take into account such factors as expectations and the structure of assets and claims.

[42] A similar analysis was tried for the other sectors but the results were quite disappointing.

TABLE III

Elasticities and Slopes of the Liquidity Functions

(All elasticities and slopes are negative)

	Elasticity					Slope*					Number of Cases
	Mean	1st Quartile	Median	3rd Quartile	Range	Mean	1st Quartile	Median	3rd Quartile	Range	
Cambridge k§											
All Holders	.64	.19	.34	.67	0— 3.58	17.78%	2.91%	8.21%	22.60%	.44—115.00	30
Corporations	.59	—†	.20	—†	.03— 4.93	1.67	—†	.39	—†	.06— 5.83	14
Individuals plus Unincorporated Business	.74	.18	.49	1.29	.06— 2.15	9.39	.94	2.76	9.64	.24— 73.00	24
Individuals	.42	.08	.34	.52	.03— 1.33	5.43	2.18	3.34	6.61	.74— 20.95	20
Unincorporated Business	1.13	—†	.51	—†	.08— 5.68	20.17	—†	3.41	—†	.27—144.00	16
All Holders—Time Deposits included in Money	.71	.28	.41	.69	.07— 3.15	28.93	6.82	17.41	36.27	1.15—143.00	26
Idle balances						Millions of Dollars					
All Holders	2.11	.63	1.07	1.23	.14—16.87	28,555	2,191	5,716	24,297	247—266,647	27—29•
Corporations	4.50	—†	.81	—†	.13—41.21	4,067	—†	790	—†	120— 16,314	12—14•
Individuals plus Unincorporated Business	3.63	.65	1.58	5.58	.25—14.83	14,472	730	3,158	8,112	82—186,500	22—24•
Individuals	3.21	.58	1.93	5.65	.15—12.39	899	1,528	2,785	6,875	184— 90,100	20—21•
Unincorporated Business	3.32	—†	1.25	—†	.14—22.59	8,255	—†	907	—†	18— 67,300	15
All Holders—Time Deposits included in Money	1.64	.42	.79	1.87	.09— 9.64	25,334	4,031	8,279	31,466	607 —170,533	27—29•

* Slopes unlike elasticities are expressed in the units of measurement, i.e., absolute values for the interest rate and the per cent change in money holdings as a per cent change of income for the Cambridge *k* or in millions of dollars for the idle balances.

§ For unincorporated business, assets rather than income are used: details of the income concept are available from the author.

† Omitted due to small number of observations.

• First number refers to elasticities, the second to slopes.

Turning to the mean size of the errors, the situation is worse. In all but one case the liquidity functions have higher mean errors than the naive model. But the mean error is not a good measure. In many cases it is high because of a few extreme observations. To avoid the effects of such few extreme cases the median errors were also computed.

Here the situation looks better. For the slopes, the liquidity functions do better than the naive model in all four "all holders" cases. This difference is significant at the 10 per cent level for the Cambridge *k* and at the 20 per cent level for idle balances. For the alternative definition of money the differences are significant at the 10 per cent level in both cases.[43] The disaggregated functions again perform badly.

In addition to testing the forecasts obtainable from the liquidity function, the data also make it possible to analyze the elasticity and slope of the function. As is shown in Table III, these short run slopes and elasticities are surprisingly low. For the Cambridge *k* of all holders the greatest single elasticity is 3.6 and even the third quartile elasticity is less than unity.[44] As in the aggregate function idle balances show a substantially greater elasticity than the Cambridge *k*, but even here the median and third quartile for all holders exceed unity by only a small amount.

[43] The significance test used is the median test described in Sidney Siegel, *Nonparametric Statistics for the Behavioral Sciences* (New York: McGraw-Hill Book Company, Inc., 1956) pp. 111-115. Comparing the various methods, the forecasting error is much greater for idle balances than for the Cambridge *k*, but this is merely a reflection of the fact the fluctuation of idle balances is greater, at least when computed by the above method. The naive model error for idle balances is more than twice as great as the naive model error for the Cambridge *k*; the forecast model errors, however, are not quite twice those of the Cambridge *k*, and hence show a greater improvement over the naive model. The inclusion of time deposits reduces the median error of the forecast relative to the naive model error. Finally, there is not much to choose between the elasticity and the slope models, though it should be noted that of the six cases where the forecast is better than the naive model, the slope model gives the best forecast in four.

[44] It is most unlikely that the smallness of these elasticities can be explained by the identification error. Even if half the figures are not genuine elasticities and if all of the erroneously included figures are clustered in the lower half of the distribution, the median of the true elasticities would be the figure now shown as the third quartile, and for all holders this figure is less than unity for the Cambridge *k* and not much more than unity for idle balances. Moreover, as can be seen from the range, not a single one of the figures for the Cambridge *k*, is very large. The only way these data could be made consistent with the view that the elasticities are quite large, is to argue that due to shifts of the function not a single one of the large true elasticities was included in the table. But if shifts of the function are so frequent, the two-variable liquidity function is of only limited use.

An important characteristic frequently attributed to the liquidity function is that at low rates of interest the demand for money becomes infinitely elastic.[45] The data of Table III make it possible to test whether there was such a *tendency* during the period studied. Specifically, the hypothesis to be tested is that the elasticity of the all holders function was greater at low interest rates than at high ones. Table IV shows that this was not the case. The correlation coefficient between the elasticities and the rates is neither significant nor of the "correct" (negative) sign.[46] This does not mean, of course, that the liquidity schedule could never become completely elastic even at a zero interest rate. However, the absence of a negative correlation in a period when interest rates were at times quite low casts doubt on, if not the truth, then at least the relevance of the liquidity trap proposition, and hence makes it worth while to reexamine its theoretical underpinnings.

TABLE IV

COEFFICIENTS OF RANK CORRELATION BETWEEN THE INTEREST RATE AND THE ELASTICITIES AND SLOPES OF THE LIQUIDITY FUNCTION

	Elasticity	Slope
Cambridge k	+ .16	−.52*
Idle Balances	+ .37	−.73*

* Significant at the 1 per cent level. The other coefficients are not significant even at the 5 per cent level.

There are essentially three reasons why the interest elasticity might be greater at low interest rates than at high ones. First, if people hold some idea of a "normal" interest rate, then the lower the interest rate is at any given time, the greater is the chance that it will rise again, and the greater

[45] Although the liquidity trap and absolute liquidity preference were emphasized by Keynes, their history, (though without relation to interest rates) really goes back *somewhat* further. "No one, when he has got sufficient furniture for his house, dreams of making further purchases on this head, but of silver no one ever yet possessed so much that he was forced to cry 'enough'. On the contrary, if ever anybody does become possessed of an immoderate amount he finds as much pleasure in digging a hole in the ground and hoarding it as in the actual employment of it." Thus wrote Xenophon (or pseudo-Xenophon—the attribution is uncertain). Quoted in G. W. Botsford and E. G. Sihler, *Hellenic Civilization* (New York: Columbia University Press, 1915), p. 437. Perhaps Xenophon should be called the first Keynesian.

[46] This conclusion differs from that reached by Henry A. Latané who found k to be less inelastic at low interest rates though he does not indicate whether the difference in the elasticities is significant. ("Cash Balances and the Interest Rate," *Review of Economics and Statistics*, November 1954, p. 460.) We know of no reason for this difference, Latané's data and methods differ in several respects from ours.

is the amount by which it can be expected to rise. Second, if the interest rate is already low it cannot fall much further, and hence the potential capital gain from holding securities is less at a low interest rate than at high ones. This results in less willingness to hold securities as interest rates fall. Finally, there is the argument that as interest rates approach the cost of dealing in securities the demand for money must become infinite. All of these arguments are open to criticism.

The argument from expectations is open to the objection that a decline in interest rates may lead to expectations of subsequent further declines. What is relevant here is not the long term rate (about which there may well be stabilizing expectations) but rather the short-term rate; for if someone expects long term rates to rise he need not hold cash, but can hold bills instead. And for the short-term rate an expected "normal" level is less likely to be significant than for the long rate. If there is such an expected normal level for the long rate it is determined by long run considerations of normal business conditions. For the short rate, however, it is current conditions rather than normal conditions which are relevant. And at a time when interest rates are abnormally low, conditions too are likely to be abnormal. The lower the rate of interest falls, the more abnormal conditions are likely to be, and hence the less reason there is to expect interest rates to rise again during the life of a Treasury bill.

The argument about the potential capital gain at different interest rates is also not convincing. It seems to relate to the level of demand for money, rather than to the elasticity of this demand. The absence of any possibility of a significant capital gain at low interest rates may make people less willing to hold securities, but this does not tell us anything about the *elasticity* of the schedule. Moreover, if we take capital losses into account too, the argument does not necessarily hold even for the *level* of demand. It is true that potential capital gain is less if the interest rate is low than if it is high. But the same applies to capital losses. This can be illustrated better in terms of opportunity costs than of capital values. For example, assume that the interest rate is initially 10 per cent. Then if the interest rate rises by half of itself, i.e., to 15 per cent, the opportunity loss on a one year $1000 certificate is $50, but if the interest rate falls by half the opportunity gain is also $50. Similarly, if the interest rate had been 1 per cent originally, the $5 loss resulting from fifty per cent interest rate increase would be just equal to the gain resulting from a 50 per cent decrease in interest rates. The critical assumption here is that the interest rate changes by a given per cent of itself rather than by an absolute amount. Given this condition high and low interest rates are on a par as far as capital gains and losses are concerned, whereas if interest rates decline by a *given amount* then the lower the interest rate, the less the possible amount of decline can be. On an *a* *priori* basis, it is of course not possible to say which of these two assumptions is better.

Finally, there is the argument that at some low rate of interest the demand for money may become infinitely elastic. While this argument sounds plausible on the surface, it does involve an aggregation problem. For any one person there is a certain cost (both psychic and financial) of buying securities, and at an interest rate just equal to that cost his demand for securities is zero (i.e., his demand for money is infinitely elastic). For a group of people together, however, there is no single cost of investment (per dollar of investment), and hence different persons will drop out of the security market at different interest rates. There is no reason to assume that the demand for money will necessarily become elastic at any point until the last man has dropped out of the security market.[47] Thus, while for each person separately the demand for money may become infinitely elastic at a certain interest rate, this conclusion does not necessarily follow for a group of people except in special cases.

It follows that on theoretical grounds there is little reason to expect the liquidity preference schedule to become elastic at low interest rates. And the above data suggest that during the period covered (and over the rates of interest covered) the schedule did in fact not become more elastic as interest rates fell. The *slope* of the schedule did increase, and while this might give the *appearance* of an increasing elasticity it is, of course, quite consistent with a constant, or even a decreasing, elasticity. Fortunately, for Keynesian theory, some of the propositions based on an increasing elasticity can be reformulated in terms of an increasing slope. The low mean level of the elasticity, and its failure to grow at low interest rates, suggests, however, that Patinkin's real balance effect (here the Keynes effect) may be quite significant in the bond market.

VII. CONCLUSION

As long ago as 1917 Pigou stated that demand for money was a function of, among, other things, the interest rate. What Keynes did in 1936 was to attempt a grand simplification by focusing attention on only two determinants of the demand for money, income and interest rates. While this has turned out to be a very fruitful insight it was too great a simplification, and

[47] This statement is not strictly correct; actually at certain points the curve would become elastic before the market is down to one man. Consider, for example, a market with two potential security buyers. As the interest rate falls by an amount just enough to induce one of the two people to leave the market, the curve is likely to be elastic. But clearly, as soon as there is a significant number of people in the market this possibility disappears.

much subsequent work on the liquidity function consisted of putting additional variables back into the function. This study shows that most of the fluctuation in idle balance holdings can be accounted for by changes in the stock of wealth and last year's idle balances, with all variables measured logarithmically.

When the function is disaggregated, a liquidity function can be found for some of the major sectors of the economy. While this relation is stable enough to allow one to forecast the direction of changes in money holdings from a knowledge of changes in the interest rate, it is not stable enough to allow one to forecast the change in the *size* of money holdings or idle balances.

For the period covered, the liquidity function was generally interest inelastic. Moreover, the elasticity does not appear to grow as interest rates fall—nor do there seem to be any strong *a priori* reasons for it to do so.

University of Minnesota and Michigan State University