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DEMAND AND SUPPLY FUNCTIONS FOR MONEY IN THE UNITED STATES: SOME STRUCTURAL ESTIMATES

by

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August 20, 1962

Professor Robert L. Bishop
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Dear Professor Bishop:

In partial fulfillment of the requirements for the degree of Doctor of Philosophy in Industrial Economics I hereby submit the following thesis entitled

"Demand and Supply Functions for Money in the United States: Some Structural Estimates."

Ronald L. Teigen

ABSTRACT OF THESIS

DEMAND AND SUPPLY FUNCTIONS FOR MONEY IN THE UNITED STATES: SOME STRUCTURAL ESTIMATES

Ronald L. Teigen

Submitted to the Department of Economics and Social Science on August 20, 1962, in partial fulfillment of the requirement for the degree of Doctor of Philosophy

This thesis investigates the hypothesis that single-equation models of the monetary sector are inadequate because they fail to recognize the interactions between the money stock, the rate of interest, and income. An attempt is made to specify and estimate a simple structural model of the monetary sector, using quarterly data for the postwar period and annual data for the prewar years.

The first chapter contains a discussion of study objectives in the light of the development of new analytical and statistical tools during the past few years. Following a critique of the literature on the empirical investigation of the demand for and supply of money balances in Chapter II, the investigation begins in Chapter III with some preliminary single-equation tests on a money supply hypothesis, on the assumption that such tests, while conceptually inadmissible if a structure exists, may indicate whether the hypothesis has any empirical foundation and whether it is worthwhile to make structural estimates.

The single-equation results are favorable, and in Chapter IV a supply-demand model of the monetary sector is postulated and tested, with the money stock, the short-term interest rate, and income as endogenous variables. Several variants of the basic structural model are tested; in particular, the lag structure of the supply of and demand for money balances is investigated. Based upon the evidence from these estimates, models which are judged to be the "best" representations of the postwar and prewar monetary sectors are selected.

These estimates provide several byproducts of interest. First, estimates of demand and supply elasticities of money which are assumed to be free of simultaneous equations bias are derived in Chapter V; these are compared with elasticities found by other investigators using the single-equation approach, and it is found that the structural elasticities tend to be somewhat greater than their single-equation counterparts. In Chapter VI, the structural coefficients are used to obtain total derivatives of each of the endogenous variables with respect to each policy variable at equilibrium; in this way some information on the effects of policy action by the monetary authorities through open market operations, discount rate changes, and changes in reserve requirements is obtained. Finally, the structure is used to generate estimates of income velocity of money over the periods studied; a comparison of the result with observed velocity is used as evidence in evaluating the contention that Keynesian demand-for-money functions cannot adequately explain both secular and cyclical movements in velocity.

It is recognized that the model is somewhat oversimplified, so the study closes with some suggestions for a larger and more representative model in Chapter VII.

Thesis Supervisor: Albert K. Ando

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CHAPTER I

INTRODUCTION AND OBJECTIVES

A. Introduction

Statistical verification of the important functional relationships which underlie Keynesian income theory has been a popular subject of inquiry since the publication of the General Theory.[1] In particular, much attention has been paid to the consumption function and the liquidity preference schedule.[2] However, it may be safely asserted that past empirical studies of the liquidity preference function have largely been confined to regressions of the quantity of money, income velocity, or transactions velocity on such variables as income and the rate of interest, using various functional forms. This leaves open the well-known question of simultaneous equations bias in the estimates so obtained, since it is generally accepted that such variables as income and the rate of interest which are used as independent variables in the

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[1] J. M. Keynes, The General Theory of Employment, Interest, and Money (New York: Harcourt, Brace, and Company, 1936).

[2] Reference to empirical studies of the liquidity preference schedule will be found in Chapter II below. A vast literature concerning consumption and savings studies has grown up. An idea of its scope can be had from the extensive references in Gardner Ackley, Macroeconomic Theory (New York: The Macmillan Company, 1961), Chapters X-XII. There are also a number of references in Milton Friedman, A Theory of the Consumption Function (Princeton, New Jersey: Princeton University Press, 1957).

regression analysis are likely to be influenced by the quantity of money. During the past twenty years, a body of statistical techniques designed to deal with the question of simultaneous equations bias was developed, and was applied to a number of economic relations. It is curious that there has never been any serious attempt to apply these new techniques to the relationships describing the monetary sector. The major purpose of this paper is to remedy partially this omission in our empirical knowledge.[1]

The simultaneous estimation of systems of equations, as exemplified by the two-stage least squares and limited information maximum likelihood methods, depends crucially on the specification of each equation involved in the system: proper specification of the form, the variables that should enter any specific equation, and, in particular, the designation of variables as either exogenous or endogenous are important considerations. Traditionally, the quantity of money supplied in the economy has been considered to be exogenous, determined by the policies of the government (in the case of the United States in recent years, by the Federal Reserve System). Since we are interested specifically in eliminating simultaneous equations bias, we have developed a

---

[1]All of the studies discussed below are based upon time-series data, and are therefore especially susceptible to the simultaneity problems mentioned above. One approach which has been used in studies of other functional relationships (such as consumption-savings studies) to avoid this difficulty is the use of cross-section data. As far as is known, no such studies of the demand for money have been made.

rather careful analysis of the supply of money, treating it as an endogenous variable, and taking as exogenous the factors that can be controlled by the Federal Reserve System in a more exact manner.

If our analysis were pushed to its logical conclusion, it would involve the integration of our description of the monetary market with other macroeconomic relationships describing the "real" markets, and the simultaneous estimation of them all. This would be a very large endeavor which is beyond the time and resources at our disposal. Instead, we have confined ourselves to integrating our description of the money market with the simplest possible Keynesian model of income determination, consisting of the consumption function and the savings-investment identity, taking investment as exogenous. This is, of course, not completely satisfactory, but we believe that even this partial measure is a distinct improvement over the past demand analysis of money using the single-equation approach.[1]

One of the major reasons why unbiased structural estimates of these relationships are important is that they are crucial in predicting the effects of exogenous changes in policies upon endogenous variables. In our context, we are interested in predicting the effects of such Federal Reserve

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[1]Some suggestions for the integration of our results into a larger and more satisfactory model (with a component of investment being treated endogenously, for example) are given in the final chapter of this study.

policy instruments as open market operations and changes in reserve requirements or discount rates on the quantity of money supplied and short term interest rates. We believe that our analysis and empirical findings throw some light on these important questions, although it must be admitted that the answers are only partial because of the partial nature of our analysis as suggested in the preceding paragraph.

B. Study Objectives

The primary objective of this study is to formulate a structural model which adequately describes the monetary sector of the United States economy, with particular emphasis upon the post-World War II period but also for the period between the two World Wars. Subsumed under this over-all goal are the following specific objectives:

1. Investigation of the validity of the usual exogeneity assumption with respect to the supply of money.
2. Estimation of unbiased partial elasticities of demand for and supply of cash balances with respect to various independent variables.
3. Analysis of the implications for monetary policy which result from the structure of the model used and from empirical estimates made using the model.

The nature of our investigation is such that some interesting results emerge as by-products. Information on the lag structures characteristic of the monetary supply and demand functions is derived from our inquiry into the general nature of these functions. Our findings also cast some light on

Friedman's contention that "standard" monetary demand functions are inadequate to explain simultaneously both cyclical and secular movements of income velocity of circulation.

C. General Procedure

The study begins with a discussion of the existing literature on the demand for money balances, tracing the development of thought from the classical economists into the post-Keynesian period as well as discussing a number of empirical studies of the demand for money. This is followed by an investigation of the exogeneity of money supply. Evidence which is favorable to the construction of an endogenous money-supply function is presented, and this leads to the formulation of a simple supply-demand model of the monetary sector. Two-stage least squares techniques are used to estimate the coefficients of the structural equations of this model and its variants. The properties of the estimates are discussed, and the various structural elasticities are calculated and compared with existing estimates using single-equation methods. Some implications for monetary policy are then drawn, and finally, suggestions for the incorporation of the results from this simple supply-demand study into a larger and more realistic model are presented and discussed.

CHAPTER II

THE DEMAND FOR MONEY: DEVELOPMENT OF THOUGHT AND EMPIRICAL INVESTIGATION

A. The Classical Conception of the Demand for Money

In the thought of the neoclassical economists, the significant relationship between money stocks and the "real" part of the economic system was based upon convenience in facilitating transactions. While it was recognized that money could have other functions, its role as a medium of exchange was emphasized almost to the complete exclusion of other functions by writers such as Walrus, Wicksell, and Pigou.[1] As Patinkin states;

> "In its cash balance version...neoclassical theory assumed that, for their convenience, individuals wish to hold a certain proportion, K, of the real volume of their planned transactions, T, in the form of real money balances. The demand for these balances thus equals KT. Correspondingly, the demand for nominal money balances is KPT, where P is the price level of the commodities transacted. The equating of this demand to the supply of money, M, then produced the famous Cambridge equation,

---

[1] A long list of works by these and other writers in the classical tradition could be cited here. However, a rather exhaustive summary of the classical position, and reference to the important works, is given in Don Patinkin, Money, Interest, and Prices (Evanston, Illinois: Row, Peterson, and Company, 1956), Chapter VII and Notes A-H. Reference is made here to Léon Walrus, Eléments d'économie politique pure, trans. W. Jaffé (Homewood, Illinois: Richard D Irwin, Inc.,1954); Knut Wicksell, Money (Vol. II of Lectures on Political Economy, ed. Lionel Robbins. 2 vols.; London: Routledge and Kegan Paul, Ltd., 1935); and A. C. Pigou, "The Value of Money," Quarterly Journal of Economics (XXXII), November, 1917, pp. 38-65, reprinted in Readings in Monetary Theory, Friedrich A. Lutz and Lloyd W. Mints, editors (American Economic Association Series of Republished Articles on Economics, Vol. V. New York: The Blakiston Co., 1951), pp. 162-183.

> M = KPT. In the transactions version--associated primarily with the names of Newcomb and Fisher--the velocity of circulation, V, replaced its reciprocal, K, to produce the equally famous equation of exchange, MV = PT. These equations were the paradegrounds on which neoclassical economists then put the classical quantity theory of money through its paces."[1]

Thus the classics thought of the demand for money in terms of transactions needs. That individuals held balances was due to the fact that income payments and requirements for outlays did not occur simultaneously, and that not all outlays were perfectly foreseen.[2] Possessing no inherent utility of its own, money could not be demanded for its own sake, as were commodities.[3]

To be sure, some hints at a more extensive view of money demand can be found. While denying that such concepts as "demand" and "supply" have any relevance at all when speaking of money, Wicksell acknowledges that money may act as a store

---

[1] Patinkin, op. cit., p. 97.

[2] For a discussion of this point, see Alfred Marshall, Money, Credit, and Commerce (London: Macmillan and Company, Ltd., 1923), pp. 46-47; Wicksell, op. cit., p. 15; Pigou, op. cit., pp. 164-174.

[3] Wicksell, op. cit., p. 20. Wicksell specifically denied that utility analysis was applicable to the study of money; he says "But money itself has no marginal utility, since it is not intended for consumption, either directly or at any ascertainable future time.", p. 20. On this point, see Patinkin, op. cit., pp. 240 ff.

of value over time.[1] But this is not to be construed as a foreshadowing of Keynesian "liquidity preference;" Wicksell is careful to say that "...the object in view is nearly always that of procuring something else for it at a future time. In other words, it is the exchange value which it is desired to preserve; it is money as a future medium of exchange which is hoarded."[2] In discussing the quantity theory (i.e., the relationship expressed by the Cambridge equation in the quotation from Patinkin above), Wicksell further states that

> "Naturally we must not suppose that a sudden increase or decrease in the quantity of money immediately produces an equally large rise or fall in commodity prices. In the first place the latter would presumably remain as high or low as before, and the whole change would be noticeable as a retardation or acceleration in the circulation of money, or, the same thing, an increase or decrease of average individual cash holdings. Only gradually would the excess or deficiency in the holdings lead to increased demand (and diminished supply) for goods, or vice versa."[3]

These comments of Wicksell's point up the long-run static-equilibrium nature of the classical model, and indicate how

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[1] Wicksell, op. cit. He says "...'supply' and 'demand', expressions so conveniently applied to almost everything under the sun, become obscure and, in reality, meaningless when applied to money...in a word, there is nothing in the act of exchange as such which can determine the value of money or concrete commodity prices. This is the more obvious since, at bottom, it is only goods which are exchanged against each other.", pp. 20-22.

[2] Ibid., p. 8. Walras also speaks of the role of money as a store of value over time. See the discussion in Patinkin, op.cit., pp. 389-390.

[3] Ibid., pp. 142-143.

observed aberrations from the theory in the short run could be rationalized while maintaining the classical emphasis on transaction demand.

Pigou expands this classical concept of the demand for money somewhat by introducing the effects of fractional reserve banking. He makes the additional important step of discussing expectations (although they play a subsidiary role in his analysis), pointing out that the anticipation of a price increase in the future will cause people to hold less money and more goods now, and vice versa.[1] However, his alignment with the classical school of thought on money demand may be demonstrated by the following quotation:

> "...everybody is anxious to hold enough of his resources in the form of titles to legal tender i.e., currency and demand deposits both to enable him to effect the ordinary transactions of life without trouble, and to secure him against unexpected demands, due to a sudden need, or to a rise in the price of something that he cannot easily dispense with."[2]

Why did the classics fail to discern the relationship between money stocks and the interest rate which is so important in the Keynesian analysis? This is a question for the history of economic thought; however, it is possible that this occurred because of the preoccupation of classical economists with the "real" part of the economic system and the tendency to regard money as a veil. Money was thought to be something which simply facilitated the workings of the real system rather than entering directly into the determination of equilibrium real income, output, and interest rate (the latter being

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[1] Pigou, op. cit., pp. 169-170.

[2] Ibid., p. 164.

considered a "real" variable by the classics).[1] It can also be argued that treatment of the interest rate exclusively as a real variable followed from the development of thought; the quantity theory in crude form is said to be found in writings as early as the sixteenth century.[2] This suggests that the emphasis on real elements in the classical model is a result of the quantity theory, and not a cause. Finally, it may be that the long-run equilibrium character of classical analysis diverted attention from the effects of short-term expectations. Keynesian liquidity preference, to which we now turn, arises from the existence of such expectations.[3]

B. Keynesian Liquidity Preference

Because it overlooked the relationship between the market rate of interest and the stock of money, Keynes found the

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[1] This is perfectly illustrated by Marshall as follows: "Money may indeed be compared to oil used to enable a machine to run smoothly. A machine will not run well unless oiled; and a novice may infer that the more oil he supplies, the better the machine will run; but in fact oil in excess will clog the machine. In like manner an excessive increase of currency causes it to lose credit, and perhaps even to cease to be 'current.'" Marshall, op. cit., p. 38.

[2] A.C.L. Day and S.T. Beza, Money and Income (New York: Oxford University Press, 1960), p. 277.

[3] As far as is known, no systematic empirical investigation of the demand for money was carried out by any of the classical writers. This is not surprising, since they labored under the double handicap of theoretical inadequacies and shortcomings in statistical technique. An outgrowth of their view of the demand for money which had empirical implications was the common belief that this demand had the form of a rectangular hyperbola. On this point, see Wicksell, op. cit., pp. 141-142; Pigou, op. cit., p. 165; Patinkin, op. cit., pp. 421-425. However, no studies of importance were made to test this hypothesis.

classical transactions approach to the demand for money to be inadequate. He proposed an alternative demand-for-money formulation which provided the basis for early empirical investigation. In his scheme, cash balances were wanted by individuals to bridge the time interval between the receipt and disbursement of income (the income-motive); by businesses to bridge the interval between the time when costs were incurred and the receipt of sales revenue (the business-motive), and by both firms and individuals to provide a reserve for unforeseen contingencies requiring outlays or for unexpected opportunities to make advantageous purchases.[1] All of these motives for the holding of balances are consonant with the classical analysis. However, Keynes added a fourth category--the speculative-motive--which linked the money stock, or part of it, and the interest rate; this was an innovation that became one of the building-blocks of the "new" economics. Very briefly, the relationship is based upon expectations concerning the future course of the rate; asset holders prefer to hold money (as opposed to bonds) when the rate of interest is low relative to the expected or "normal" rate and vice versa. Keynes stated that, as a first approximation, the demand for money of an individual could be split into a transactions demand, which is a function of the level of that

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[1] J. M. Keynes, The General Theory of Employment, Interest, and Money (New York: Harcourt, Brace, and Company, 1936) pp. 195-196.

individual's money income, (encompassing the first three "motives" described above) and a liquidity demand, which varies only with the rate of interest. Symbolically, this is expressed as follows:[1]

$$M_T = M_1(Y) + M_2(r)$$

Although this proposition was intended to describe the behavior of an economic micro-unit, several macroeconomic studies have been made to determine whether, by approximating the transactions demand for the whole system on the basis of certain assumptions and deducting transactions balances from total money stocks, the liquidity preference function $M_2(r)$ could be shown to exist. A number of writers have demonstrated by graphical or statistical methods that there appears to exist a schedule relating liquid balances, estimated in this manner, and the rate of interest over some period of time. This functional relationship usually turns out to be inverse J-shaped and this result is taken to be evidence that the Keynesian liquidity preference function, which is supposed to be asymptotic to the "institutionally minimum" interest rate, really exists. Studies of this type have been made by Tobin, Khusro (for Great Britain), Kisselgoff

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[1] Ibid., p. 199. See also J. M. Keynes, A Treatise on Money (New York: Harcourt, Brace and Company, 1930), esp. Vol. I, Chapter 10, pp. 146-150 and Chapter 13, pp. 216-220, for a discussion in which the strands of thought later unified in the General Theory can be discerned.

(for large manufacturing corporations in the United States), and, more recently, Bronfenbrenner and Mayer.[1]

These studies typically find the relationship between income and the transactions demand for money by assuming that $M_2(r)$ was zero for some year (ordinarily 1929). The income velocity of money for that year is then used to find transactions requirements for other years; the assumption is that the ratio is constant for the whole period studied. For example, suppose that idle balances are assumed to be zero for 1929, and that the income velocity of the money stock for that year is 3.00. Then liquid balances for other years are found by subtracting one-third of that year's income from the total money stock for that year.[2] This allows the calculation of transactions demand for all periods studied, and, therefore, of asset demand. The relationship between this macroeconomic residual and the interest rate is examined over a period of years and is assumed to represent, at least approximately, the liquidity preference function.

---

[1]James Tobin, "Liquidity Preference and Monetary Policy," Review of Economic Statistics (XXIX), February, 1947, pp. 124-131; A. M. Khusro, "Investigation of Liquidity Preference," Yorkshire Bulletin of Economic and Social Research (IV), January, 1952, pp. 1-20; Martin Bronfenbrenner and Thomas Mayer, "Liquidity Functions in the American Economy," Econometrica (XXVIII), October, 1960, pp. 810-834; Avram Kisselgoff, "Liquidity Preference of Large Manufacturing Corporations," Econometrica (XXIII), October, 1945, pp. 334-344.

[2]Khusro is slightly more sophisticated and is able to find the appropriate multiplier using least-squares estimation procedures.

The approach outlined in the preceding paragraphs has a certain plausibility about it, especially since the inverse J-shaped function which results agrees with a priori reasoning. It is argued below, however, that there are difficulties involved which may not be obvious but which may operate to make meaningless the conclusions thus obtained about the shape and elasticity of the liquidity preference function.

A liquidity preference schedule is a demand function for cash balances, in which the price paid for the privilege of holding such balances is the market rate of interest. Obviously, therefore, any graphical or statistical estimate of this function is an estimate of a demand function, and is susceptible to the usual problems of demand analysis. It is well known that observed quantities and prices of any commodity represent equilibrium points (i.e., intersections of supply and demand functions, both of which are shifting in response to the movement of latent variables). By extension, the same is true of observed money balances.[1] Such equilibrium points will trace out the true demand schedule only if the function is perfectly stable while supply is shifting. If, however, both the supply and demand functions are shifting, the observed points trace out neither curve. Furthermore, if supply and demand are functions of the same variables, single-equation estimates of the coefficients of either function are

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[1]It is not to be inferred from this comparison that money is equivalent to commodities which yield utility in consumption or use. The demand for money does not arise from utility considerations.

biased (and may not be amenable to estimation, unless proper restrictions are placed on the parameters of the system).[1]

The studies to which reference is made above have almost completely overlooked the possibility that their results may be meaningless because (1) both the demand for and supply of money balances may be shifting systematically over time, and (2) the demand and supply functions may contain the same

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[1]Single-equation estimates of the demand-for-money function may be biased even though supply is exogenous, if the demand for money is assumed to be a function of the rate of interest (considered to be endogenous) and perhaps other exogenous variables. This can be demonstrated by an easy example. For simplicity, suppose that the demand for money is a function of the rate of interest only, and that the money supply is an exogenously determined non-stochastic variable and can therefore be exactly determined. We then can write down a supply-demand system as follows:

$$M^D = a + \beta r + \epsilon$$

$$M^S = \bar{M}$$

$$M^D = M^S$$

where ϵ represents errors of observation. Note that if ϵ rises, either r or M must rise. But $M^D = \bar{M}$; therefore r must rise. This means that r and ϵ are correlated, the Markov conditions are not satisfied, and an estimate of β obtained by regressing M on r will be biased. In the simple case presented here, the problem can be avoided by a reduced-form regression of r on M; the reciprocal of the coefficient of M will be a best linear unbiased estimate of the true coefficient of r. The fact that the demand equation is just identified offers an easy way out of this particular problem, but the specification of more complicated functional forms for demand and supply, as in the discussion below, usually leads to overidentification and the need to use simultaneous estimation methods. It is of interest to note that the Bronfenbrenner-Mayer study referred to above uses the type of model set out in this illustration and regresses M on r and other variables; therefore their estimates are biased even if the model is adequate, which is not the case in any event.

arguments, so that if anything, hybrid supply-demand functions are being estimated. I shall argue that both of these conditions are likely to exist.[1]

It seems likely that systematic shifts in the aggregate liquidity preference function may well have occurred over the periods studied by Tobin, Khusro, and others. This is simply another way of saying that other variables besides the interest rate affect the demand for idle balances as a macroeconomic concept. Wealth might be mentioned as a candidate, and Stedry has presented evidence favorable to a reformulation of Tobin's approach along these lines.[2] An even more obvious example, which follows precisely from the flaw in reasoning involved, is population change. Even if the formulation $M_T = M_1(Y) + M_2(r)$ adequately approximates the demand for money by the representative individual, so that for him

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[1]A brief example will illustrate the well-known difficulties which result from systematic shifts in both supply and demand functions. Suppose that the true (but unknown) functions are both being systematically shifted to the right due to the influence of some variable such as population change, and that we have data on the average amount of liquid balances held and the average rate of interest each year for several years. If both schedules are shifted outward at precisely the same rate, the observed points will fall in a straight horizontal (perfectly elastic) line, and this line will be our estimate of the liquidity preference function using the Tobin approach. Note that this line has no relationship to the slopes of the true demand and supply functions.

[2]Andrew C. Stedry, "A Note on Interest Rates and the Demand for Money," Review of Economics and Statistics (XLI), August, 1959, pp. 303-307.

the demand for liquidity is a function of the level of interest rates alone, the aggregate demand for liquidity must increase as the population increases over time. Thus an error is committed in the unwarranted use of a microeconomic formulation for purposes of macroanalysis. It can also be argued (and has been by Modigliani, Stedry, Scitovsky, and others) that the individual's demand for liquid balances should be a function of wealth in addition to the interest rate, and that in practice it is not possible to separate the demand for money into neat subcategories, even though it may be convenient to do so for expository purposes.[1]

The studies on liquidity demand cited above indicate a surprising lack of awareness that the problem described may exist. In his 1947 article, Tobin wrote "Average 'idle deposits' are plotted against the average rate on prime commercial paper....the relationships are of the general form postulated by liquidity preference theory."[2] Khusro made

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[1]Cf. Franco Modigliani, "Preliminary Notes on the Theory of Money and Interest in the Framework of General Equilibrium Analysis" (unpublished manuscript); Stedry, op. cit., Tibor Scitovsky, "A Study in Interest and Capital," Economica (N.S. VII), August, 1940, pp. 293-317. The concept that cash balances should be a function of wealth in addition to other variables was first suggested by Marshall. He wrote "...let us suppose that the inhabitants of a country, taken one with another (and including therefore all varieties of character and of occupation) find it just worth their while to keep by them on the average ready purchasing power to the extent of a tenth part of their annual income, together with a fiftieth part of their party; then the aggregate value of the currency of the country will tend to be equal to the sum of these amounts." Money, Credit, and Commerce (London: Macmillan and Company Ltd., 1923), p. 44.

[2]Tobin, op. cit., p. 131.

similar calculations for Great Britain over the period 1920-1945, and his comments illustrate very well the erroneous interpretation which a writer who is preconditioned to believe in the existence of a liquidity function of a certain shape (and who is perhaps unaware of some of the problems encountered in statistical estimation of economic functions) may attribute to a scatter of supply-demand intersection points. He writes (italics inserted):

> "...the quantity of idle money is very useful as an indicator of liquidity. Its relationship with the rate of interest in the schedule of liquidity preference is also of great importance, for upon the nature and elasticity of this schedule depends many a proposition in monetary theory and policy, not to speak of the whole difference between the Keynesian and the classical approach."[1]

Having plotted the British "idle balances" against the consol rate, Khusro makes the following comments with respect to the result:

> "The schedule exhibits many of the characteristics so often assigned in theory to the schedule of liquidity preference proper...(It) exhibits a low elasticity of M_2 a high interest rates and a high elasticity at low ones. This is, of course, as it should be. For according to the celebrated argument of the 'General Theory,' a very low rate is associated with an indefinite expansion of M_2..."[2]

It is true that the diagrams provided by both these authors show the inverse J-shaped relationships between their

---

[1] Khusro, op. cit., p. 1. The quantity of idle money to which Khusro here refers is the aggregate amount resulting from Tobin-type calculations, not the per capita amount.

[2] Ibid., p. 4.

"idle balances" and the interest rate which Keynesian theory leads us to expect. However, during the periods covered by the studies, idle balances have exhibited a secular increase, the only major exception being the British experience during the 1920's. In that case, the quantity of idle balances calculated by Khusro remained fairly constant or declined slightly, while the consol rate first dropped and then rose back to the level of 1921 (see Fig. I.1, where the diagrams used by Khusro and Tobin are reproduced). If a stable functional relationship of the type supposed by Khusro existed, a drop in idle balances should result in a movement back up the schedule. It is not clear that such behavior is taking place. We observe that as time progresses, the observed points fall farther and farther to the right (increase secularly), and if this is not true in particular cases, the points which regress toward the left on the chart do so in a rather unsystematic way. In short, it is not clear that a functional relationship between the interest rate and money balances is being observed; rather, it seems likely that a secular shift of unknown demand and supply functions is occurring.

The intersection loci shown by Tobin and Khusro can be explained by the kinds of systematic shifts described above. In both cases, we observe a general downward movement during the 1920's and a flattening out at a low interest rate level during the 1930's. During the 1920's, the speculative pressure which existed during most of the period probably caused demand

Fig. II.1: Liquidity Functions Found by Khusro and Tobin

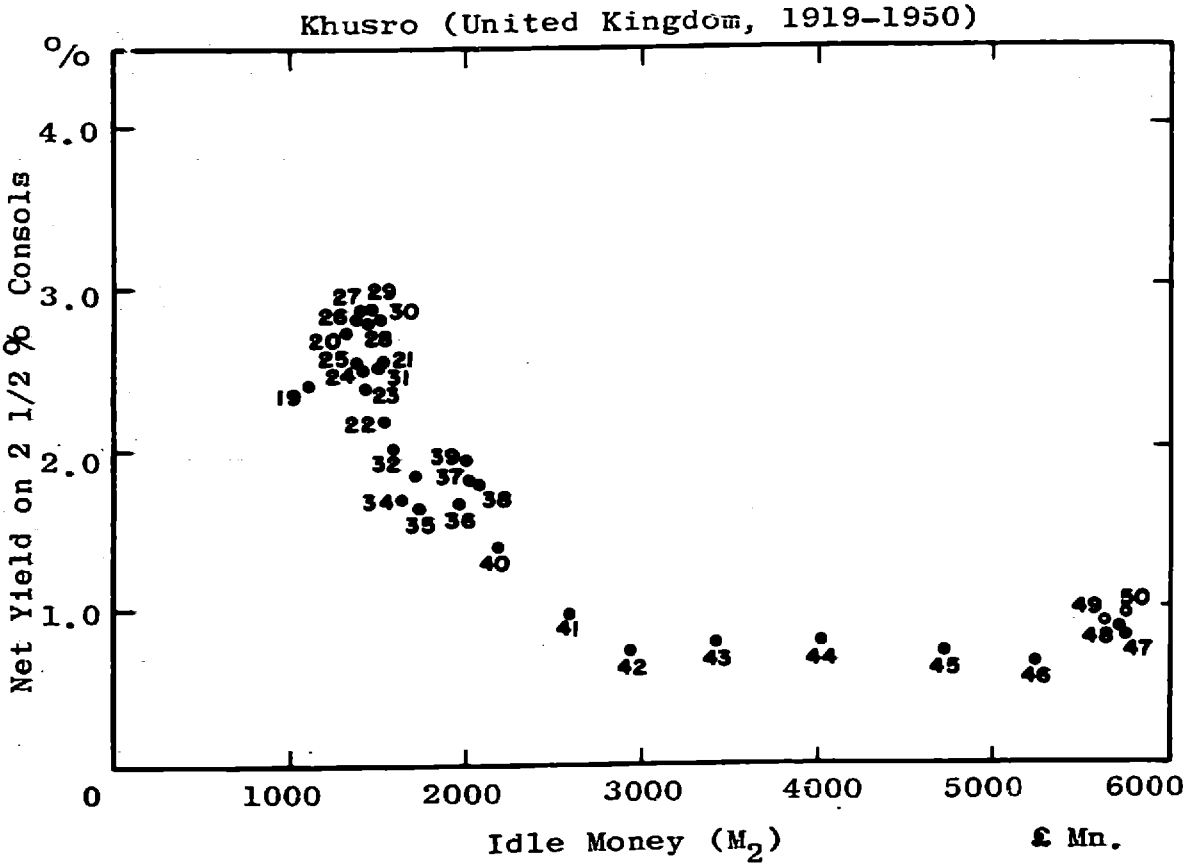
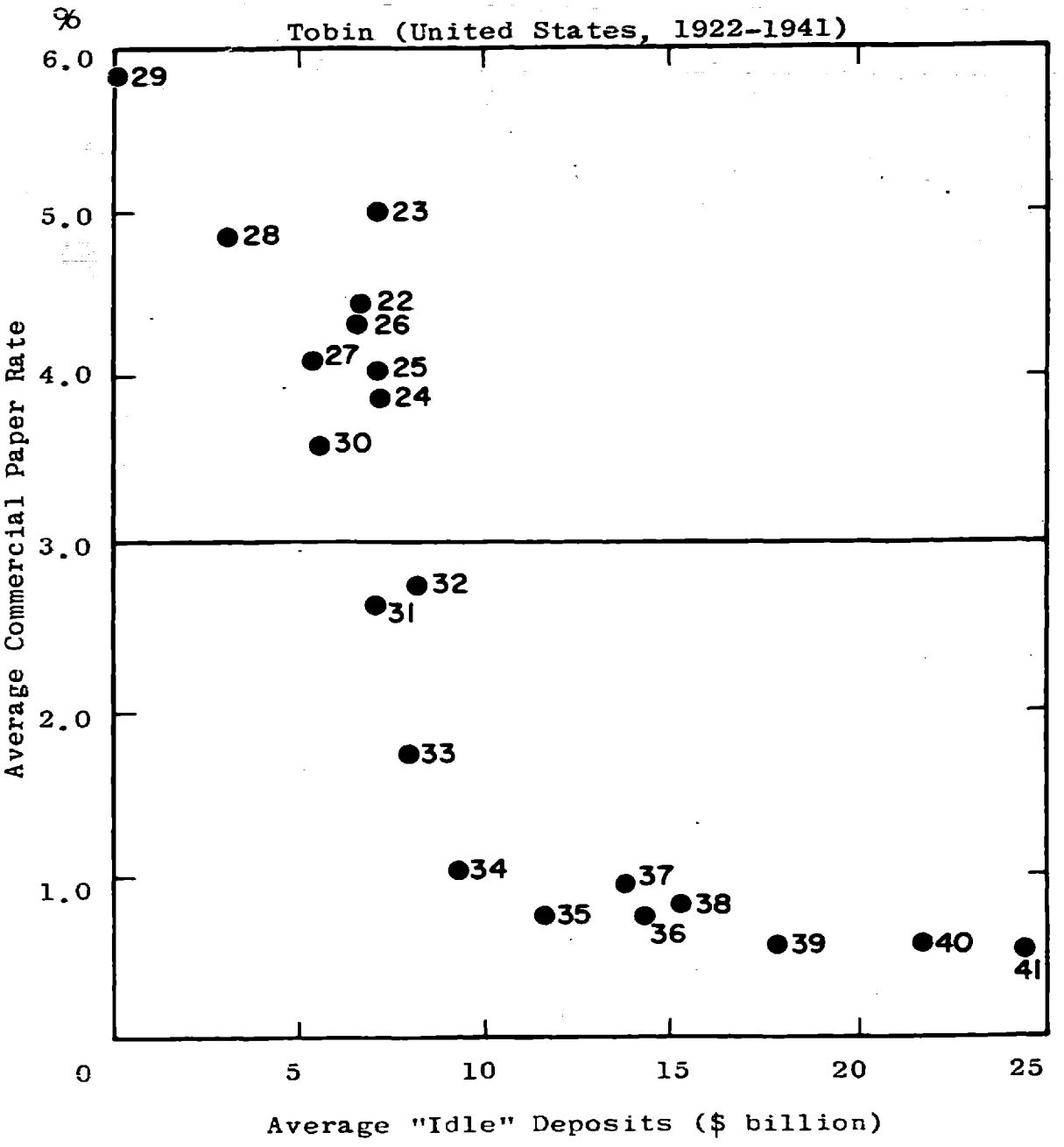


Fig. II.1 (cont.)


%
Tobin (United States, 1922-1941)
6.0
5.0
4.0
3.0
2.0
1.0
0
5
10
15
20
25
Average Commercial Paper Rate
Average "Idle" Deposits ($ billion)
29
28
23
22
26
27
25
24
30
32
31
33
34
37
38
35
36
39
40
41

for liquid balances to decline cyclically (Tobin assumes it had reached zero by 1929), although this was perhaps offset slightly by population and wealth increases. At the same time, the commercial banks were borrowing extensively from the Federal Reserve System in order to make loans and thus increase the supply of money. This combination of a rightward shift in supply and a shift of demand to the left could result in the approximately vertical locus of intersection points which we observe for the 1920's. During the 1930's, with a high level of liquidity in the banking system in the form of excess reserves, the commercial banks probably stood ready to lend to creditworthy, qualified applicants, so that no worth-while loan applications could have been rejected on the basis of a general shortage of credit; in that sense, demand for and supply of money should have increased at about the same rate. This would result in the observed rather level path of intersection points. Thus the observed loci may have nothing to do with the functional form of the true supply and demand functions, but may be related only to their systematic movement over time.[1, 2]

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[1] In fairness to Mr. Khusro, it must be acknowledged that he was not completely unaware of this problem. Having made the calculations described above, he goes on to state that his analysis "...assumes constancy in the liquidity preference schedule and fails to take account of any possible shift in it under the influence of other variables...If, in the face of constancy in r, there comes about a rise in the volume (and value) of assets held by the community, as happened during the war, M_2 will increase. This will bring about a shift in the liquidity curve and the simple relation between r and M_2 will break down." (pp. 9-10). He then corrects for changes in assets by regressing the rate of interest on the ratio of liquid balances to total

In more recent work, Bronfenbrenner and Mayer recognize that the Tobin-Khruso approach may contain inherent problems. They write:

> "Before accepting this function in any of its variants as representing a liquidity function...we face an identification problem. 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... we have supposed the supply function of money...to be a quantity whose movements through time are unaffected by any of our independent variables (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 functions. Their coefficients seem to point in this direction.".[1]

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assets and other variables. If no other shift variables are at work, this procedure meets the above criticism but still results in biased estimates if a structure is the true model.

[2]The rigid relationship between income and transactions demand which these studies postulate may also contribute to the observed results. If transactions demand is assumed to be responsive to the interest rate, the quantity of money held for this purpose in relation to income would be much higher in the 1930's than say, in 1929. This would mean that the "liquidity demand" found by Tobin and others for the 1930's is too great and would negate to some extent the "properly shaped" functions found by these authors. See James Tobin, "The Interest Elasticity of Transactions Demand for Cash." Review of Economics and Statistics (XXXVIII), August, 1956, pp. 241-247; William J. Baumol, "The Transactions Demand for Cash: An Inventory Theoretic Approach," Quarterly Journal of Economics (LXVI), November, 1952, pp. 545-556.

[1]Bronfenbrenner and Mayer, op. cit., pp. 819-820. The function to which they refer in the first sentence is a Tobin-type construction.

Bronfenbrenner and Mayer seem to be confused as to the exact nature of the problem. Having calculated Tobin-type idle balances for the years covered, they fail to see that the function they are estimating by single-equation fits may simply be an approximation to an equilibrium locus so that the resulting slopes are unrelated to the true liquidity function. Even under the assumption that systematic shifts do not present a problem, however, the reference to the identification problem is puzzling. Strictly speaking, identification as an econometric problem arises only within the context of a structural model. Once such a model is specified, the identification question must be faced; it asks simply whether a given equation within the structure can be estimated. Identification results from restrictions on the parameters of the system.[1] But if a single-equation model is assumed to represent the real world adequately, the question of identification does not arise. Rather, the problem is one of bias arising from incorrect specification.

Aside from this terminological point, a literal reading of the Bronfenbrenner-Mayer discussion quoted above indicates that they seem to envision a supply function which does not respond to exogenous shocks, while the demand function is shifting. It is well known that if this is occurring, a supply

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[1] See Tjalling Koopmans, "Identification Problems in Economic Model Construction," in W. Hood and T. Koopmans editors, Studies in Econometric Method (New York: John Wiley and Sons, 1953), Chapter II, for a discussion of the identification question.

function rather than a demand function will be traced. In order to estimate a demand function, supply must be shifting in response to latent variables more extensively than demand. In any case, even though some of the regressions in this study include several variables, the possibility of simultaneous equations bias remains.[1]

In summary, the Tobin-Khusro approach is valid only if the aggregate demand for money is in fact the sum of two independent components [i.e., representable as $M_T = M_1(Y) + M_2(r)$] and if the aggregate demand for liquid balances over time is a function of the interest rate alone. I have argued above that there seems to be reason to believe that even if this equation adequately represents the demand of an individual for money balances, aggregation may introduce serious problems; and, in any case, the *a priori* omission of variables such as wealth from the demand function may mean that micro demand behavior is not adequately described. Of course, the empirical importance of these conceptual shortcomings depends on the extent to which secular change in variables such as population and wealth have actually occurred over the period studied. Table II.1 presents data for these variables for certain years during the prewar period.

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[1]Note also that their procedure of assuming the money stock to be exogenous and then regressing M on r and other variables introduces bias. See note 1, page 15.

Table II.1

Population and Total Net Worth Data for Selected Years In The United States

Year	Net Worth[a]	Index	Population of Age 14 Years and Older[b]	Index
1919	$ 311	100	73.1	100
1924	328	105	80.7	110
1929	456	147	87.9	120
1935	337	108	95.4	131
1941	403	130	102.9	141

[a]Billions of dollars

[b]Millions

Source: The population data are from Historical Statistics of the United States, (Washington, D.C., U.S. Government Printing Office, 1960) p. 8. The net worth data represent the net worth of consumers, and are taken from the Appendix.

Data on the population aged 14 years and older are used as a rough measure of the number of individuals accumulating cash balances. This series increases at the rate of almost two percentage points per year on the average, rising 41 per cent over the period 1919-1941.

Net worth as measured above moved cyclically over the period 1919-1941, although its level in 1941 was 30 per cent higher than in 1924. It increased through 1929 (except for a slight decline in 1921) then fell to a low of $306 billion in 1933, rose to $377 billion in 1937, declined in 1938, and then rose through 1941.

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It is impossible to say precisely what effect the changes in population and net worth had on the aggregate liquidity function over the period studied by Tobin and others. However, the steady increase in the adult population is evidence tending to support our criticism, as is the secular increase in net worth. During the early 1930's, of course, the cyclical downturn in net worth may have offset the population increases. Except for the years 1921 and 1938, however, the period 1930-1933 was the only part of the interwar period studied in which net worth declined. In general, it seems that our criticism is valid, with the reservation that it may not have been serious for a few years during the early 1930's Evidence of this kind, added to the strong possibility that major structural changes occurred during the extensive periods covered by the studies cited, lead to the conclusion that it is unrealistic to suppose that the liquidity preference function was stable over this period, and that it could be even approximated by the simple techniques used in these studies.

Another group of economists has attacked the problem of money demand functional estimation by using interest rates and other variables to explain changes in the stock of money. One of the first to use this approach was A.J. Brown, who discussed many of the problems of estimation noted here, and devised the technique used to separate transactions demand for money from the total money stock by Tobin, Khusro, and

Bronfenbrenner and Mayer, in a rather remarkable pair of articles appearing in 1938-1939.[1] The usual approach among investigators in this category is to include income as an explanatory variable, and to attempt to explain the entire money stock rather than only a part of it.[2] Other variables, such as wealth, are also introduced. In some cases, the income velocity of money, rather than the money stock itself, is taken as the variable to be explained. Kalecki used this approach in an early British study, and more recently Latané employed it on American data.[3]

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[1] A. J. Brown, "The Liquidity-Preference Schedules of the London Clearing Banks," Oxford Economic Papers, No. 1., October, 1938, pp. 49-82 (especially pp. 52-55); A. J. Brown, "Interest, Prices, and the Demand Schedule for Idle Money," Oxford Economic Papers, No. 2, May, 1939, pp. 46-69 (especially p. 51

[2] This point of view is well summarized by Ralph Turvey, who writes "...once choice and uncertainty are introduced... interest rates and income become determinants of transactions demand. Interest rates, and perhaps income too, also affect the non-transactions demand for money, however, which makes it impossible to split the determinants of the total demand for money into two completely different groups. Consequently this demand cannot be regarded as the sum of a transactions demand determined by one set of forces and a non-transactions demand determined by a different set...[There are interactions, and] Transactions balances can therefore only be measured in the case of money holders who are known to have no other motive for holding money...Except in this case the propositions concerning the transactions motive for holding money can only be tested as part of an analysis of the total demand for money,", Interest Rates and Asset Prices (London: George Allen and Unwin Ltd., 1960), pp. 38-39.

[3] M. Kalecki, "The Short-Term Rate of Interest and the Velocity of Cash Circulation," Review of Economic Statistics (XXIII), May, 1941, pp. 97-99; Henry A. Latané, "Cash Balances and the Interest Rate-A Pragmatic Approach," Review of Economics and Statistics (XXXVI), September, 1954, pp. 456-460.

The demand formulations used in studies of this type, which are of the form

$$M = M(r, Y, X)$$

where X stands for other variables not specified here, are somewhat more satisfactory than those used by Tobin and others, because by including income, wealth, and other variables, the problem of systematic shift discussed above may be minimized, and it is unnecessary to divide the money stock arbitrarily according to use. However, the problem of simultaneity and single-equation bias has not been avoided, and estimates of this type will result in biased elasticities if simultaneity exists. As has been shown above (see Note 1, p. 15), it will result from direct single-equation least squares estimation even though supply <u>is</u> exogenous, if the money stock is regressed on the rate of interest (considered to be endogenous) and perhaps other exogenous variables.

In later sections of the present study, evidence in support of a money supply function, one of whose arguments is a function of the rate of interest, will be presented and discussed. The existence of such a supply relationship means that the estimates of demand-for-money functions in this second category, while avoiding the gross errors made by studies of the first type, are nevertheless biased to some degree and therefore may be unsatisfactory for a true understanding of the functioning of the monetary sector, use in policy recommendations, etc. Given the fact of interdependence among the stock of money,

the rate of interest, and other variables, unbiased estimates are obtained only by properly specifying a structural model which satisfactorily explains all of these interdependent variables and then making estimates of their coefficients by simultaneous equation methods. A first attempt at doing so is reported below.

A third approach to the specification and estimation of money demand functions is represented by the work of Professor Milton Friedman and his associates at the University of Chicago. Their viewpoint is neoclassical rather than Keynesian, and they attempt to demonstrate the validity of the Cambridge equation, the basic form of which is $M = kY$. In recent work, Friedman attempts to show that a variant of this formulation, adapted to become an extension of his "permanent income hypothesis," can explain what he believes to be otherwise incompatible secular and cyclical changes in velocity.[1]

Friedman's views on the demand for money are based upon some rather strong assertions and assumptions. In his recent article, for example, he states that

> "...the changes in the real stock of money and in the income velocity of circulation reflect either (a) shifts along a relatively fixed demand schedule for money produced by changes in the variables entering into that schedule; (b) changes in the demand schedule itself; or (c) temporary departures from the schedule...[we could]

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[1]Milton Friedman, "The Demand for Money: Some Theoretical and Empirical Results," Journal of Political Economy (LXVII), August, 1959, pp. 327-351.

> regard the cyclical changes in velocity as reflecting the influence of variables other than income. In order for this explanation to be satisfactory, these other variables would have to exert an influence opposite to that of income and also be sufficiently potent to dominate the movement of velocity. Our secular results render this implausible, for we there found that income appeared to be the dominant variable affecting the demand for real cash balances. Moreover, the other variables that come first to mind are interest rates, and these display cyclical patterns that seem most unlikely to account for the sizable, highly consistent, and roughly synchronous cyclical pattern in velocity."[1]

Thus Friedman may be interpreted as asserting that no other variable except income has any potency in explaining the demand for real money stocks, so that the Cambridge formula is the only explanation of the demand for money which is worth considering, and that even this relationship in simple form cannot simultaneously account for what he maintains are conflicting secular and cyclical patterns of movement in the income velocity of money.

While Friedman's results are interesting, their implications are limited because the definitions and formulations used are somewhat idiosyncratic, thus insulating his work from the main stream of research effort in the monetary area. For example, the importance of his reconcilement of divergent secular and cyclical movements of velocity, which is the central objective of his study, depends on the continuing existence of this divergence. If the usual definition of the money supply (demand deposits adjusted in commercial banks plus currency

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[1]Friedman, op. cit., p. 332.

outside banks) is used, however, the only lengthy period of velocity decline which shows up in the American data is 1929-1946, a period marked by unusual conditions, to say the least. Only the use of an unconventional money supply definition (the above plus time deposits in commercial banks) results in a longer downward movement in velocity, and even by this measure, observed velocity begins to rise in 1946.[1] In any event, it would appear that the inclusion of time deposits in commercial banks would require the inclusion of time deposits in other institutions also, leading to a more expanded (but more consistent) definition than Friedman's. If velocity is computed using this definition, the pattern over time is somewhat more similar to that of velocity computed using the standard money supply definition (see Fig. II.2). In other words, consistency would seem to require the use of one or the other polar definition of the money stock. The definition used by Friedman is arbitrary.

As much as Friedman's results seem to be forced into a preconceived mold, we will not base our evaluation of his work entirely on these grounds. We will go further and attempt to show that our conventional Keynesian structural model of the monetary sector, using the commonly-accepted definition of the money supply, does as well as or better than Friedman's idiosyncratic model in explaining movements in velocity,

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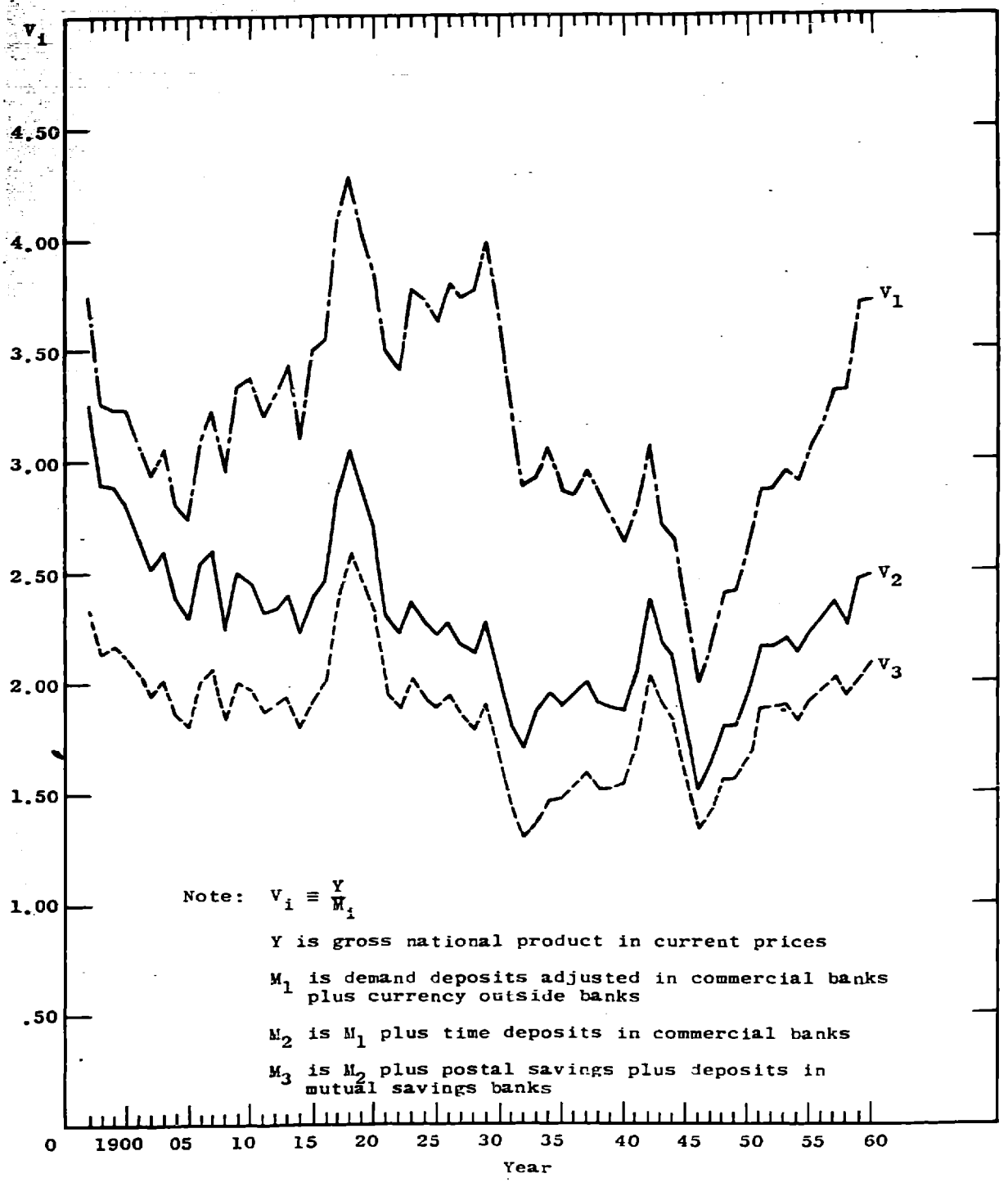
[1]This is shown by Friedman's Chart I, op. cit., p. 340.

Fig. II.2: Three Measures of Velocity Compared, for the United States, 1897-1960



which is the test by which he judges his model.

A brief digression on one of Friedman's arguments for using the Cambridge approach to the demand for money will illustrate how crucially his results depend upon his definitions. Friedman dismisses the rate of interest as a useful explanatory variable because "...[it] displays cyclical patterns that seem most unlikely to account for the sizable, highly consistent, and roughly synchronous cyclical pattern in velocity."[1] In Figure II.3, income velocity based upon the usual concept of the money supply is plotted against measures of the long-term and short-term interest rate. Two facts seem clear from this figure: velocity has been increasing quite steadily since 1946, with little evident trend over the whole period plotted, and there does exist a fairly strong positive relationship between movements of the rate of interest and velocity, especially in a cyclical sense.[2] Adding time deposits to the money supply, however, obscures the relationship and thus appears to be evidence in favor of the Cambridge approach. Evidence is presented below which indicates that the demand for money as commonly defined is responsive to changes in the rate of interest; in fact, it is slightly more responsive than most single-equation "Keynesian" estimates would lead us to believe. Friedman assigns a negligible role in explaining

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[1] Ibid., p. 332.

[2] Latané gives further evidence that this relationship exists.

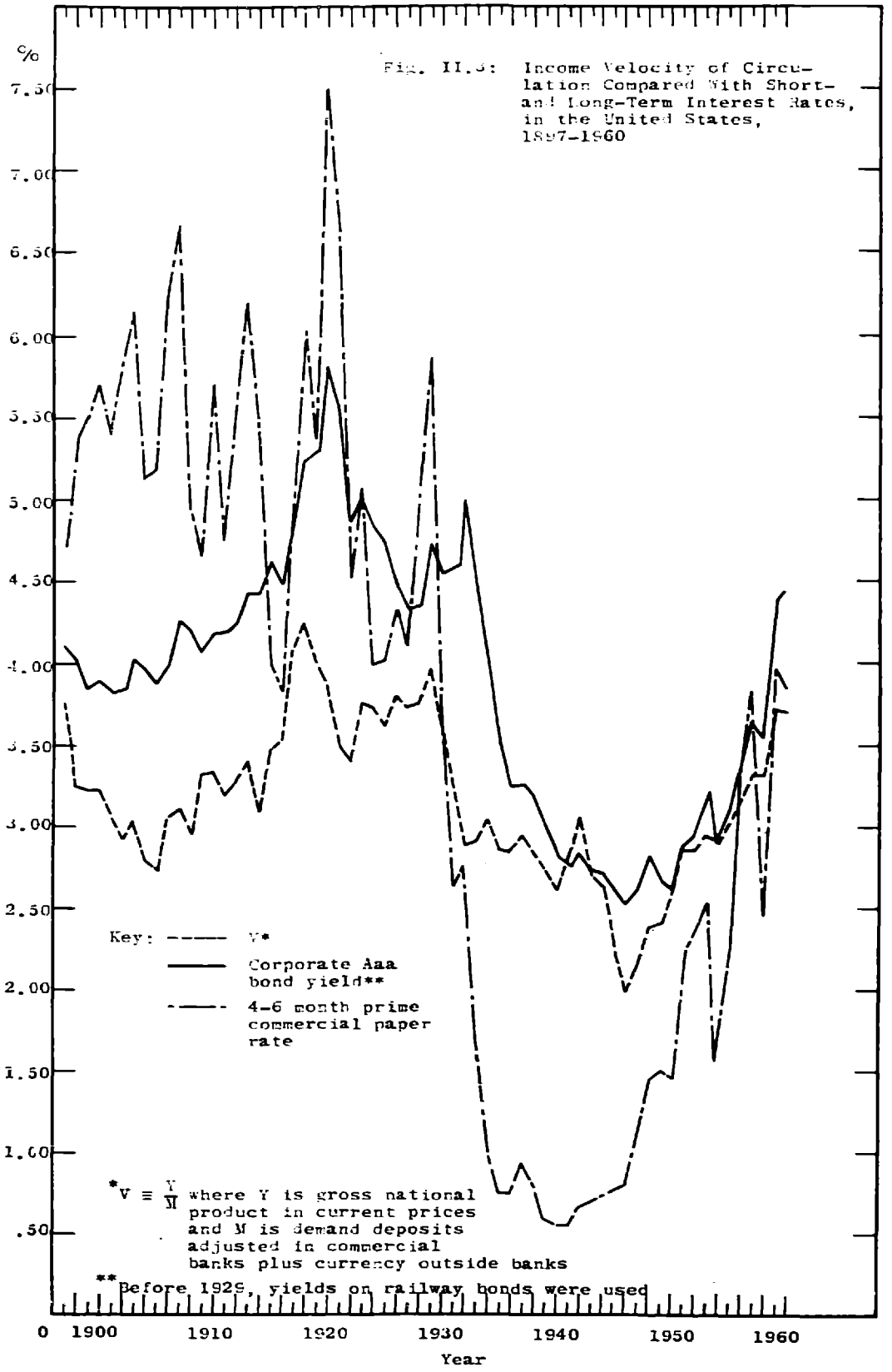

Fig. II.3: Income Velocity of Circulation Compared With Short- and Long-Term Interest Rates, in the United States, 1897-1960

the demand for money to the rate of interest, using it only to explain residuals resulting from use of the basic neo-classical model. He tests his model by comparing velocity computed using the model with observed velocity and citing the resulting fairly good fit as evidence that his approach faithfully reflects both secular and cyclical changes. Since our model seems to do an even more satisfactory job of estimating velocity, the contradiction in results appears to be due, at least in part, to the difference in definitions.

In matters of definition, there are few, if any, absolutes. The definition of money is no exception; for example, most introductory textbooks in money and banking include in an early chapter some such statement as "Money is anything that people accept as money." The arbitrary cast of this statement is deceiving. While it sounds permissive enough to accord equal validity to almost any definition, it really contains the kernel of the argument for excluding (in modern times and for this country, at any rate) any definition except the usual one of demand deposits adjusted plus currency outside banks. The key to this apparent paradox is contained in the words "...anything that people accept as money." This confusing phrase is designed to stimulate college sophomores to think about the problem; what is meant, of course, is that money is anything that people accept, or more generally, that custom recognizes, as payment in discharge of debt.

We know that money has other characteristics. It is a standard of value, a store of wealth, and so on. When the demand for money is viewed as a part of the larger problem of portfolio selection, as it should be, we note that some of the attributes of money are shared by other liquid assets. For example, wealth can be held from period to period in many forms, including money. However, we study the demand for money apart from the demand for liquid assets in general precisely because its unique property--that it is a means of payment in discharge of debt--differentiates it from all other liquid assets and thereby differentiates the demand for it from the demand for all other liquid assets. For example, the knowledge that a person faces certain payment obligations during a period, certain discrete flows of income, and certain fixed and variable charges for moving in and out of liquid income-earning assets will cause him to hold certain amounts of cash during the period in preference to, say, short-term government securities precisely because the latter cannot be used directly to meet his obligations; that is to say, precisely because money (i.e., demand deposits and currency) has the unique characteristic of being accepted as a means of payment.[1]

This leads to a conclusion similar in sound and real meaning to the typical textbook statement quoted above: if

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[1]Cf. James Tobin, "The Interest-Elasticity of Transactions Demand for Cash," Tobin, op. cit., for a discussion of money holdings and transactions requirements.

we are going to study the demand for money, let us study the demand for money. The demand for money plus time deposits in commercial banks is a different sort of demand, generated by different motives; it may, of course, be of interest in its own right, as may be the demand for money plus all time deposits, money plus all time deposits plus securities, etc. Friedman's defense is that he includes time deposits in commercial banks because the data do not distinguish between time and demand deposits in commercial banks before 1914, and he is thereby able to extend his study back to 1867.[1] While this may be a convenient operational technique, it is indefensible conceptually since, as argued above, it appears to change the whole nature of the problem. Its needlessness can perhaps best be demonstrated by showing that a more conventional formulation can be shown to explain whatever secular and cyclical movements exist as well as or better than Friedman's model.

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[1] Friedman, op. cit., p. 328, n. 3. The value of a study which covers the whole period 1867-1957 with a single formulation must be questioned, in view of the structural change which must have taken place.

CHAPTER III

FORMULATION AND PRELIMINARY TESTING OF A SUPPLY FUNCTION FOR MONEY

A. Introduction

In Chapter II, the existing literature on the demand for money was examined, and it was noted that the demand functions which have been formulated and tested were estimated by single-equation techniques.[1] Such an approach neglects the possibility of simultaneous-equations bias; that is, if variables such as the money stock, the interest rate, and income interact, single-equation estimates are biased, and an appropriate structural model must be specified and estimated to avoid this problem.[2] This chapter is devoted to the formulation and preliminary empirical testing of a supply-of-money hypothesis which will be incorporated into a structural supply-demand model in Chapter IV of the study if these preliminary results are favorable.

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[1] An important exception is the Klein-Goldberger model, which is presented in Lawrence R. Klein and Arthur S. Goldberger, An Econometric Model of the United States, 1929-1952 (Amsterdam: North-Holland Publishing Co., 1955), especially Chapters IV and VI. The monetary sector of this model is examined critically in a later section of this chapter of the present study.

[2] For a discussion of least-squares bias, see Jean Bronfenbrenner, "Sources and Size of Least-Squares Bias in a Two-Equation Model" in William C. Hood and Tjalling C. Koopmans, ed., Studies in Econometric Method (New York: John Wiley and Sons, Inc., 1953) pp. 221-235.

B. The Money Supply Literature

Although existing theory and empirical work indicate the arguments which are appropriate for the demand-for-money function, very little has been written on the functional specification of money supply; the almost universal practice has been to assume that, for all practical purposes, the size of the money stock is exogenously controlled by the monetary authorities.[1] However, some suggestions for endogenous treatment of the supply of money are contained in studies by Brunner and by Polak and White, and the Klein-Goldberger model appears to contain a set of equations describing the monetary sector in supply-demand terms.[2] Each of these contributions will be discussed briefly, using definitions and notations which conform to usage adopted for this study, In addition, Tobin has done a good deal of work on the nature of the monetary mechanism; on the supply side, he has dealt with both the decision-making process which a commercial bank goes through in determining its volume of desired lending and with broader questions of the supply of bank reserves, the effect of reserve requirements on the banking system, etc.[3] His contributions are too extensive to be summarized here, but his work contributed much to the approach adopted below. Before turning to

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[1] Cf. Bronfenbrenner and Mayer, op. cit., as an example.

[2] Karl Brunner, "A Schema for the Supply Theory of Money," International Economic Review (II), January, 1961, pp. 79-109; J.J. Polak and W.H. White, "The Effect of Income Expansion on the Quantity of Money," International Monetary Fund Staff Papers (IV), August, 1955, pp. 398-433; Klein and Goldberger, op. cit.

[3] James Tobin, "Unpublished Monetary Manuscript," (New Haven, 1959). (Mimeographed.)

a discussion of the literature itself, the following section of this study will be devoted to setting out the definitions needed.

1. Definitions and Notation

The definitions which will be useful for a discussion of the supply literature are as follows:

(1) M: The money stock, consisting of demand deposits adjusted in commercial banks plus currency outside banks. When reference is intended to the money stock as a supply concept, it will be designated as M^S; when the demand for money needs to be distinguished, the symbol M^D will be used.

In this, as other cases, the absence of a specific time subscript indicates the current value of the variable. Time subscripts will always be written in quarterly terms, so that M_{t-4} would refer to the money stock existing a year prior to the present date.

(2) D_p': Demand deposits adjusted in member banks.

(3) D_p'': Demand deposits adjusted in nonmember banks.

(4) C_p: Currency holdings of the public. Based upon these definitions, we have $M \equiv D_p' + D_p'' + C_p$.

(5) R^T: Total legal reserves of commercial banks which are members of the Federal Reserve System. These reserves consist of deposits at the Federal Reserve Banks for the period 1917-December 1, 1959; such

deposits plus currency and coin in excess of two per cent of member banks' net demand deposits (for central reserve and reserve city banks) or in excess of four per cent of member banks' net demand deposits (for country banks) from December 1, 1959, to November 24, 1960; and such deposits plus all currency and coin held by member banks from November 24, 1960 to the present.[1]

(6) R^r: Required reserves of member banks (reserves required by law to be held behind demand deposits except balances due from banks and cash items in process of collection).

(7) R^e: Excess reserves of member banks, defined as total reserves less required reserves; i.e., $R^e \equiv R^T - R^r$.

(8) B: Borrowing by member banks from the Federal Reserve System.

(9) R^s: Supplied reserves, defined as member-bank reserves which are supplied by the Federal Reserve System as opposed to those created by member-bank borrowing. We therefore have $R^s \equiv R^T - B$.

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[1] Federal Reserve Bulletin, April, 1959. Net demand deposits are defined as "demand deposits subject to reserve requirements, i.e., gross demand deposits minus cash items reported as in process of collection and demand balances due from domestic banks." (Federal Reserve Bulletin, February, 1962). In practice, the important distinction between demand deposits adjusted and net demand deposits is that United States Government deposits in member banks are included in the latter but not in the former, since they are not counted as part of the money stock but must be backed by legal reserves in the same manner as other demand deposits.

(10) R^n: Net free reserves, defined as excess reserves less borrowing. $R^n \equiv R^e - B \equiv R^T - R^r - B$.

(11) r: The rate of interest. Various measures of the interest rate will be distinguished by subscripts, so that r_s will be a general term for the short-term rate, r_L the long-term rate, r_d the discount rate, etc.

(12) Y: National income or output, measured by gross national product in the empirical section of this study. Y_p will represent personal income.

(13) P: A price index of gross national product.

(14) W: Total compensation of privately-employed individuals.

(15) v: The ratio of disposable income to household holdings of money. $v = \frac{Y_d}{M^h}$. We define as V_o the ratio of disposable income to household holdings of money for 1929.

(16) k: The reciprocal of the weighted average required reserve ratio in effect at any given time; k is defined as the ratio of demand deposits in member banks to required reserves.[1] Thus we have $k \equiv \frac{D^n}{R^r}$, where D^n is net demand deposits.

(17) L_1: Liquid assets held by households, including money

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[1]While reserves are also required behind time deposits, the measure of required reserves used in the empirical investigation reported in this study was adjusted by removing estimated time deposit required reserves. Here R^r refers only to reserves required for demand deposits.

balances, time deposits, savings and loan shares, and U.S. Government securities.

(18) L_2: Liquid assets held by business firms (including cash balances).

2. Discussion of the Literature

Brunner has used a microanalytic approach to the supply of money, beginning with functional formulations to describe the behavior of individual banks in some detail.[1] Aggregate functions are then obtained by summing over the individual units. While this is perhaps a useful approach, it can become quite complex. A simpler macroanalytic approach is used in the present study, and it explains the data quite well, as will be seen below. Brunner has not reported any extensive statistical tests of his hypothesis, and his approach is not considered to be of immediate interest for this study.

Polak and White use a simple aggregative formulation. In their theoretical model, set out in their Appendix, a linear supply relationship is postulated in which the money stock is a function of total reserves and the rate of interest[2]

$$M^S = \alpha R + \beta r$$

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[1] Brunner, op. cit.

[2] Polak and White, op. cit., pp. 429-433. In their theoretical model, the proper measure of the interest rate (short term or long term) is not specified, although R is defined to be "the level of reserves of the commercial banks," which is taken to mean total reserves.

and the money stock is expected to be a positive function of both variables. The argument is that "Like the public, [banks] will want to balance the convenience of a high reserve ratio against a low rate of interest, the inconvenience and risk of a lower ratio against a higher rate of interest."[1]

The empirical tests which they report are based upon a slightly different model. To illustrate that there is a money supply relationship involving the interest rate and reserves, Polak and White chart the ratio of member bank net free reserves to their "total deposit liabilities" against the Treasury bill rate, and it is shown that this ratio falls as the bill rate rises.[2] The ratio is used as the dependent supply variable because it is felt that there exists a normal relationship between net free reserves and deposits, and it is variations from this normal relationship which need to be explained. That is, excess reserves are viewed as a "cushion" to absorb fluctuations in total reserves relative to required reserves. As deposits grow, these fluctuations become wider in an absolute sense, and more excess reserves are needed to perform this function.[3]

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[1] Ibid., p. 422.

[2] The precise definition of "total deposit liabilities of member banks" is not given by Polak and White. It will be assumed that net demand deposits are meant so that the ratio used is $\frac{R^n}{D^n}$.

[3] Ibid., p. 423.

Several aspects of the Polak-White study deserve comment. First is their choice of variables; in particular, their use of net free reserves and the Treasury bill rate in thier empirical money supply relationship. While their discussion is not completely clear as to the precise nature of the supply relationship they are postulating, it appears that they attempt to relate the money stock (represented by member-bank demand deposits) through the interest rate to a measure of the capacity of the banking system to create money. This is the general approach followed by the present study (see Chapter III.C below). In both cases, an attempt is made to explain the ratio of the money stock, or (in the case of Polak and White) that part of it represented by member-bank demand deposits to a measure of total money-creating capacity, with the money variable assumed to be endogenous. In the formulation employed in the present study, the denominator of the ratio is constructed so as to be determined exogenously by the monetary authorities (being based upon R^S). For any level of this exogenous variable, the ratio of the money stock to it is a function of the interest rate and other variables. By using R^n, however, Polak and White construct a supply variable which appears to have endogenous components in both numerator and denominator. This point may be illustrated by using the definitions set out above. We have:

$$R^n \equiv R^e - B \equiv R^T - R^r - B$$

$$\therefore \quad R^n \equiv (R^T - B) - R^r = R^S - R^r$$

Therefore the Polak-White supply variable, which is the ratio of net free reserves to net demand deposits, may be written as $\frac{R^s - R^r}{D^n}$. An examination of these relationships discloses that, although net free reserves can be affected by Federal Reserve action on either supplied reserves (through open-market operations) or required reserves (by changes in reserve requirements), they may also be manipulated by commercial bank action with respect to required reserves (by calling or refusing to make loans, for example); in other words, it appears that the Polak-White ratio has endogenous elements in both the numerator and denominator, while our variable was put in ratio form precisely in order to separate these two aspects of the money stock. The point in question is what effect, if any, this feature of their study has on their supply hypothesis.

First, it may be true that, in fact, net free reserves are exogenously determined by the Federal Reserve System. As a guide to policy action, the Federal Reserve uses the reserve position of member banks, and it may be inferred that the System believes it can control this reserve position quite precisely.[1] For example, it may be possible to consider borrowing as of any point in time (the amount of which is known

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[1]See Ralph A. Young, "Tools and Processes of Monetary Policy," United States Monetary Policy, Neil H. Jacoby, editor (New York: The American Assembly, 1958), pp. 13-48, esp. pp. 35ff. for an authoritative discussion. The goals and tools of monetary policy will be examined more extensively in Chapter VI.

quite exactly by the System) as given, so that the System can influence net free reserves directly by working on excess reserves through monetary policy.[1] To the extent that the Federal Reserve is able to operate on net free reserves in this fashion, it may be considered as an exogenous supply variable similar in nature to our "supplied reserves" concept.

Secondly, even though the Polak-White supply variable may contain endogenous variables in both numerator and denominator, this does not change the direction of expected response to movements in the interest and discount rates. For example, a rise in interest rates, other things being equal, is expected to elicit a rise in demand deposits and an increase in required reserves (the latter as a direct result of the increase in deposits and perhaps also on account of policy action by the monetary authorities directed at restricting the money supply during an inflationary period). The result is an unequivocal decrease in their supply ratio, just as we would expect an increase in the supply ratio used for the present study.

Our objection to this feature of the Polak-White supply formulation is that it is impossible to state with certainty

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[1]Professor Robert M. Solow has suggested that the Federal Reserve System can control total reserves, including borrowing, and that excess reserves should be considered the endogenous variable, via bank lending policy. His conclusion is based upon work done for the Commission on Money and Credit.

that net free reserves are controlled precisely by the monetary authorities, as can be said of our exogenous supply variable; to the extent that endogeneity exists in both the numerator and denominator of their supply ratio, some irregularity may be introduced into their relationship which is not present in ours.

There are other shortcomings in the Polak-White empirical analysis which may be more serious than that mentioned above. Although they discuss both demand[1] and supply functions for money, a single-equation approach is used in both cases. Thus, in fitting the supply relationship, Polak and White must assume the interest rate to be exogenously determined. This is a questionable assumption, especially in relationship to short-term rates.[2]

In addition to these criticisms, the Polak-White study is somewhat inadequate on the supply side as it fails to take the entire money stock into consideration, including only deposits at member banks. Thus about one-third of the money

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[1]In the demand function, the money stock is apparently assumed to be a linear function of income and the short-term interest rate. Since it is of standard form and no regression results were reported, it was not included in the discussion in Chapter II.

[2]Polak and White use short-term interest rates in both the money-demand and money-supply functions. The latter function contains the Treasury bill rate, as previously noted. The demand function is fitted using the "interest rate on short-term government securities." This presumably is not the Treasury bill rate, but probably should be related to it functionally in a complete model since all short-term interest rates are highly intercorrelated.

stock is excluded from their study.[1] In the present study, the whole money stock is taken into account in both the demand and supply formulations.

Finally, Polak and White can be criticized for selecting the Treasury bill rate as a measure of the return from lending. When the bill rate rises, ceteris paribus, Treasury bills become more attractive as a component of the banks' investment portfolios relative to other assets, and some shifting into Treasury bills would be expected. Under these circumstances, the Polak-White supply ratio would be expected to exhibit a positive relationship with the bill rate, not an inverse one. For this reason, a direct measure of the return from lending, such as the 4-6 month prime commercial paper rate, would seem to be a more satisfactory explanatory variable in the supply function. However, all short-term interest rates are very highly intercorrelated and usually move closely together, which is to say that all other things do not remain the same; this close interrelationship among interest rates results in the bill rate exhibiting an inverse relationship with the dependent variable as expected of a measure of return. While their approach may be open to criticism, however, their work leads to the important conclusion that empirical evidence supporting an endogenous supply-of-money function can be shown to exist.

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[1]This fraction has varied between 30 and 40 per cent during the entire period since 1922.

The Klein-Goldberger model contains a set of equations which are meant to describe the relationships within the monetary sector, and those between that sector and the rest of the model.[1] Therefore it might be expected at the outset that some of the questions regarding the single-equation bias of existing empirical liquidity functions, the nature of monetary supply functions, etc., which were raised above had already been solved by the structural estimates made using this model. An examination of each of the functions describing the monetary sector will indicate that this is not the case, however. The four functions which are of particular interest are: (1) the household liquidity preference function; (2) the business liquidity preference function; (3) the relationship between short-and long-term interest rates; and (4) the money market adjustment equation. In our notation, these four functions may be written as follows:

(1) The household liquidity preference function:

$$\frac{L_1}{p} - \frac{1}{v_o}\frac{Y_d}{p} = \gamma_{11}\,(r_L - r_L^o)^{\gamma_{12}}\epsilon_1$$ where r_L^o is the "minimum possible interest rate" at which point the demand for idle balances is assumed to become infinite

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[1] Klein-Goldberger, op. cit. As this model appears to contain both supply and demand functions, a discussion of the demand equations logically should have appeared in Chapter II. Because of the structural nature of the model, however, both the supply and demand functions will be examined here for the sake of unity and convenience.

(in the Klein-Goldberger study, this level was assumed to be two per cent), and L_1 is household holdings of liquid assets (savings deposits, U.S. Government bonds, savings and loan shares, and idle money balances).

(2) The business liquidity preference function:

$$\frac{L_2}{P} - \gamma_{21}\frac{W}{P} = \xi_2 + \gamma_{22}(P - P_{t-4}) + \gamma_{23}r_s + \gamma_{24}\left(\frac{L_2}{P}\right)_{t-4} + \epsilon_2$$

where L_2 is business holdings of liquid assets (including idle cash balances).

(3) The relationship between short and long-term interest rates:

$$r_L = \xi_3 + \gamma_{31}(r_s)_{t-12} + \gamma_{32}(r_s)_{t-20} + \epsilon_3$$ (Note that all time subscripts are written in terms of quarters in the notation used in our study.)

(4) The money market adjustment equation:

$$\frac{r_s - (r_s)_{t-4}}{(r_s)_{t-4}} = \xi_4 + \gamma_{41}\left(\frac{R^e}{R^T}\right)100 + \epsilon_4$$

The household liquidity function is structurally the same as the function postulated by Tobin which was discussed in Chapter II above. The income velocity of money for 1929 is used to separate "transactions balances" from total household holdings of money in each year, and the residual is assumed to be a function of the rate of interest. Tobin used

the average rate on prime commercial paper to explain total idle balances (including both household and business balances) while the long-term interest rate is used by Klein and Goldberger in the household equation, presumably because they assume that consumers hold either long-term bonds or stocks, and not short-term securities in appreciable amounts.[1] This household liquidity function appears to be unsatisfactory for the same reasons that the Tobin formulation was criticized in Chapter II: systematic shifts which are not taken into account in the model may be occurring. In addition, no relationship between household demand for liquidity and total wealth was investigated or discussed.

The same type of formulation is used to explain business demand for liquid assets. The transactions demand of business for money is assumed to be proportional to costs, here represented by the wage bill, and the total business stock of liquid assets, less this transactions requirement, is explained by price change, the short-term interest rate, and a lagged value of the dependent variable. This approach grew out of the work of Kisselgoff, who in turn employed a variant of Tobin's approach.[2] In this case, the short-term rate is used as the measure of the cost of holding idle balances.

The short- and long-term interest rates are connected by a simple linear function, under the assumption that the long

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[1] Ibid., p. 24.

[2] Kisselgoff, op. cit.

rate is an average of lagged short rates only. The particular lags which are used are those which give the best empirical results.

The money market adjustment equation, containing interest-rate and member bank reserve terms, appears to be a money supply equation at first glance, corresponding more or less to the Polak-White supply function. However, a closer inspection reveals that this is not true. In this equation, the rate of change of the short-term interest rate is explained by excess reserves as a percentage of total reserves. This percentage is assumed to be exogenous. Therefore the current rate of increase of the short-term rate, and hence, in effect, its current value, is determined by the past period's value of this rate and the exogenous fraction $\frac{R^e}{R^T}$. This equation does not interact with the remainder of the monetary sector or with any other part of the system. The long-term rate is also assumed to be a function only of predetermined variables (lagged values of the short-term rate). Therefore neither interest rate in this system is determined jointly with other endogenous variables. Rather, the monetary subsector of the Klein-Goldberger model may be described as consisting of the two non-interacting interest rate equations, together with a pair of liquidity preference functions of the Tobin-Khusro-Kisselgoff type; there is no supply-of-money function as such. Furthermore, L_1, the liquid assets of households, is affected only by the long-term interest rate. The only equation which is connected with the

rest of the model is the business liquidity preference function, which is linked through the rate of change of prices and the private wage bill. The most important conclusion for our purposes which results from the above analysis is that the monetary subsector of the Klein-Goldberger model is not an interacting supply-demand model.

The above discussion may be summarized by saying that the literature on endogenous supply-of-money functions, especially the empirical investigation of such functions, is practically nonexistent. The standard procedure which is used in most investigations is to consider the money stock to be set exogenously and to use this assumption as a basis for single-equation tests of liquidity functions. In subsequent sections of this study, evidence is offered in support of endogenous treatment of the money stock. This leads to the derivation of an interacting supply-demand model of the monetary sector.

C. The Supply of Money as an Endogenous Function

The remainder of this chapter will be devoted to the formulation and empirical testing of a money supply hypothesis. The following approach will be taken. First, the hypothesis will be stated in its most general form, the nature of expected relationships will be suggested, and the underlying utility analysis will be discussed. Since the hypothesis involves an unfamiliar monetary variable (M*), in the next step a simple behavioral representation of the institutional relationships existing in the monetary sector is set out and manipulated in

order to demonstrate the derivation of this variable. Finally, the results of preliminary tests on the hypothesis are reported.

1. Statement and Discussion of the Hypothesis

In general form, the monetary supply hypothesis put forward in this study may be written as follows:[1]

$$\frac{M}{M^*} = f(r, r_c)$$

where r stands for the return to commercial banks from making loans (measured in this study by the 4-6 month rate on prime commercial paper), and r_c represents the cost of lending for commercial banks, possibly measured by the discount rate (the cost of borrowing to create new reserves) or some short-term security rate, standing for the opportunity cost of using reserves for lending to money demanders instead of holding securities or lending to other banks. M^* is defined to stand for the maximum possible stock of money supportable by supplied reserves, given the existing institutional structure. Since it depends only on R^s and institutional factors, M^* is an exogenous supply variable over which the monetary authorities are able to exercise precise control. In a sense, it may be thought of as the "money equivalent" of reserves

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[1]While the practice of omitting time subscripts when referring to current variables is followed in this report, the general form of the hypothesis as written here is not meant to exclude the possibility of lags in the arguments of the function.

supplied by the Federal Reserve System. The method by which M^* is derived will be made clear in section C.2 of this chapter.

The supply formulation proposed above is designed to take into account and segregate the endogenous and exogenous aspects of the money supply mechanism. The stock of money could be regarded as exogenously determined by the Federal Reserve System only if commercial banks had no endogenous supply potential; that is, only if they were completely "loaned up" (i.e., had no excess reserves) at all times, and could not borrow or convert other assets into new reserves.[1] But member banks usually hold some excess reserves, and also have the discounting privilege; in addition, they hold Government securities in their portfolios which they may be able to convert into new reserves (by sales to nonmember banks, for instance) when monetary pressure tightens and the return from lending increases. In addition, banks have access to the federal funds market, through which existing reserves can be utilized more efficiently. Thus the money supply can (and does) increase even when restrictive pressure is applied, while an increase of liquidity through policy action during

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[1] In a certain sense, of course, Federal Reserve action in the exercise of monetary policy might be considered to be endogenous, since such action is not taken in a vacuum but rather is triggered by economic events. But it can be argued that policy action, as contrasted to response in a "schedule" sense, is consciously designed to achieve certain economic ends and goals, rather than being determined precisely by the interaction of the system, and is exogenous. In the final analysis, the question of exogeneity versus endogeneity is not polar in nature, but is a matter of degree.

recessions may not result in any immediate increase in the money stock. In our supply hypothesis, then, account is taken of both the endogenous (through M) and exogenous (through M^*) aspects of the money supply mechanism.[1]

The expected relationship between the ratio $\frac{M}{M^*}$ and its proposed functional arguments is straightforward. When the return on loans rises, ceteris paribus, banks presumably will shift the composition of their portfolios in such a way that relatively fewer securities will be held, the margin of excess reserves which banks like to keep as a buffer aginst unforeseen contingencies will be cut down in size, and in general, an effort will be made to expand deposits, causing a rise in the money stock relative to M^*. The opposite effect will result from an increase in the cost of making loans. Thus the dependent variable is expected to be related positively to the measure of return on loans, and inversely to the measure of cost.[2] Variation in $\frac{M}{M^*}$ resulting from changes

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[1] In the sense that M^* represents the potential amount of money which the Federal Reserve System can control directly at any given time, it is an exogenous supply variable which can be manipulated by the monetary authorities to achieve monetary policy goals. Thus it is an "instrumental variable," to use Tinbergen's terminology. See J. Tinbergen, Economic Policy: Principles and Design (Amsterdam: North-Holland Publishing Company, 1956), p. 5.

[2] A thorough and systematic treatment of the considerations underlying banks' asset decisions in response to changes in cost, changes in behavioral parameters, under various institutional arrangements with respect to reserve requirements, etc., is James Tobin, Unpublished Monetary Manuscript, op. cit., Chapter 8. Further considerations are discussed in Chapter 9.

in the amount of money supplied may be reinforced by cyclical changes in M^*. Rising interest rates, inducing M to increase, tend to be associated with restrictive open-market operations which reduce M^* and vice versa.

We have explained above that, when the return from lending rises, banks are expected to adjust their portfolios so that less excess reserves will be held in order that the amount of loans outstanding can be increased, etc. A further explanation is needed, however: since excess reserves are a sterile form of asset, why are they held at all, as long as the rate of return on alternative means of holding assets is greater than zero?[1]

For an adequate explanation, the concept of a bank's "defensive position" must be considered. This is defined as the sum of net free reserves (excess reserves less borrowing) and secondary reserves (income-earning assets of very high liquidity and small risk of capital loss for which a broad market exists, such as short-term government securities). Assets of this type, including positive net free reserves, are held as a class because of uncertainty about future events; a bank is always faced with the real possibility that unexpected large withdrawals of deposits (and therefore reserves) may

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[1] As long as a bank is in debt to the Federal Reserve System, excess reserves may be considered to have a negative yield, since they could be substituted for borrowed reserves on which the bank is paying the discount rate. When borrowing is zero, net free reserves and excess reserves are equal and have zero return.

occur, and that it may not be able to meet the regular "reserve test" as a result, with consequent penalty charges and other inconvenience. Therefore the bank's decision to hold liquid, low-yield assets is part of the over-all decision with respect to portfolio choice under risk. For utility-maximizing individuals, Tobin has shown that a preference for risk-avoidance leads to selection of a portfolio which contains some zero- and low-yield assets under normal circumstances.[1] An indifference map between expected return and risk similar to that for a utility-maximizing individual with a risk-avoiding utility function can be imputed to a commercial bank, either directly or by assuming that the bank officer in charge of portfolio management acts in this way. If we assume that the bank has such a risk-avoiding preference function, its choice to diversify its portfolio among investments of various risks and yields can be explained in utility-maximizing terms.

Given this basic decision to hold a positive defensive position, the portion of such assets held as net free reserves is a function of several factors: the rate on government securities (an alternative means of maintaining a defensive position); institutional arrangements, etc. Because inflows and outflows of reserves and deposits are not synchronized,

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[1]James Tobin, "Liquidity Preference as Behavior Towards Risk," Review of Economic Studies (XXV), February, 1958, pp. 65-86; see also James Tobin, Unpublished Monetary Manuscript, Chapter 3.

a more or less careful management of the liquid segment of the bank's portfolio is required to achieve the desired relationship between this category and other assets. The degree of management exercised by a bank concerned with the goal of profit maximization in all aspects of its operation may be expected to be a positive function of the Treasury bill rate. When the bill rate is high, management of the defensive position will be active, and it will consist largely of income-earning assets. When the bill rate is low, the amount of management exercised tends to decline, and net free reserves (a sterile asset) increase as a fraction of the defensive position.[1]

Institutional arrangements must also be taken into account in explaining why banks continue to hold excess reserves; indeed, such reserves continue to arise partly because of the institutional fact that deposit inflows and outflows are not synchronized. There are both fixed and variable costs associated with movements into and out of short-term securities which may cause even larger and more sophisticated banks to hold excess reserves if the bill rate is low enough. Country banks with smaller average amount of excess reserves to manage may be deterred by such costs from shifting into income-yielding assets at any level of the bill rate within the

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[1]This discussion draws heavily upon the thorough analysis of the subject by James Tobin in Chapter 9 of his Unpublished Monetary Manuscript.

relevant range. Finally, there probably exist many small local banks which simply are not profit-maximizers in this sense; i.e., they just lack the knowledge, interest, or facilities to actively manage their defensive position, and elect to hold enough reserves to meet the reserve test under the most severe conditions likely to occur. In fact, a very large fraction of total excess reserves probably exists for these institutional reasons. As evidence, we may examine the distribution of excess and total reserves among the classes of member banks:

Table III.1: Distribution of Total and Excess Reserves Among Federal Reserve System Member Banks, by Class, February, 1962 (average of daily figures, in millions of dollars)

Class of Member Bank	Total Reserves Held	Per Cent	Excess Reserves Held	Per Cent
Central Reserve City Banks	$ 4,635	23.7	$ 18	3.6
Reserve City Banks	8,094	41.3	47	9.4
Country Banks	6,842	35.0	437	87.0
	$19,571	100.0	$502	100.0

Source: Federal Reserve Bulletin, April, 1962, pp. 418-419.

The fact that country banks hold almost 90 per cent of excess reserves indicates that the prime reason for their existence in any significant amount may be the costs associated with movements into and out of securities and the other institutional factors mentioned above.

2. A Behavioral Representation of the Monetary Sector

The concept upon which the variable M^* is based has been discussed above. However, its value for any point in time depends not only upon the level of supplied reserves but also upon the structure of the monetary sector at that time. To take account of the interrelationships which are involved, a model of the monetary sector has been constructed and solved in such a way that a measure of the maximum possible money supply based upon the existing structure is obtained. This model is based upon and is basically similar to those of Meade[1] and Modigliani,[2] and consists of four definitions and three behavioral relationships. It is actually a part of the structural supply-demand model to be constructed and tested in Chapter III. However, it will be used here to define the precise meaning of M^*, and may be considered to be subsumed under this variable in the structural model of Chapter III. The model is constructed as follows:

(1) $C \equiv C_b^f + C_p^f + C_b^g + C_p^g$. Here C stands for total currency in circulation. The superscripts denote the issuing agency and stand for the government (i.e., the Treasury) and the Federal Reserve System respectively, The subscripts refer to currency holders and stand

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[1] J.E. Meade, "The Amount of Money and the Banking System," Economic Journal (XXXXIV), March, 1934, pp. 77-83, reprinted in Readings in Monetary Theory, Friedrich A. Lutz and Lloyd Mints, editors (American Economic Association Series of Republished Articles on Economics, Vol. V. New York: The Blakiston Co., 1951), pp. 54-62.

[2] Franco Modigliani, "Unpublished Monetary Theory Notes" (Pittsburgh, 1956), (Mimeographed.)

for the public and the banking system respectively. The equation states that the total amount of outstanding currency is held by the public and the banking system.

(2) $M \equiv C_p^f + C_p^g + D_p' + D_p''$. M denotes the total money stock of the public: Federal Reserve and Treasury currency held by the public plus demand deposits adjusted in both member banks (D_p') and nonmember banks (D_p'').

(3) $L_f \equiv C_b^f + C_p^f + D_b$. This equation defines the liabilities of the Federal Reserve Banks (L_f). D_b represents deposits of member banks at the Federal Reserve Banks.

(4a) $R^e \equiv D_b - \frac{1}{k} D_p'$. Excess reserves of member banks are defined by this equation, which is valid only for the period 1922-1935 during which time reserves were not required for United States Government deposits (D_g'). It became necessary to hold reserves against these deposits under the Banking Act of 1935, and so beginning with the third quarter of that year, the equation is superseded by (4b) below. In all of these equations, the term $\frac{1}{k}$ represents the weighted average reserve ratio in effect at the point in time at which the variables are measured (i.e., all variables in this model, including $\frac{1}{k}$, should display the time subscript, but it has been omitted for

convenience, since there are no lags involved). It is important to note that $\frac{1}{k}$ may change each period, if only because deposits shift between member banks of different classes.

(4b) $R^e \equiv D_b - \frac{1}{k}(D'_p + D'_g)$. This equation defines excess reserves for the period 1935-1959. On December 1, 1959, however, currency and coin in excess of 2 per cent of a member bank's net demand deposits (demand deposits subject to reserve requirements) in the case of central reserve and reserve city banks, or in excess of 4 per cent of net demand deposits in the case of country banks, was declared elegible to be counted as reserves, and after November 24, 1960, all currency and coin held by member banks was elegible for use as reserves. For purposes of this study, it is assumed that equation (4b) approximates excess reserves until November 24, 1960, but as of that date, it is replaced by equation (4c) below:

(4c) $R^e \equiv D_b + C'_b - \frac{1}{k}(D'_p + D'_g)$ where C'_b is currency held by member banks and is equal, of course, to the sum of Treasury and Federal Reserve currency held by these banks.

(5) $C_p^f + C_p^g = cM$ where c is a parameter and $0 < c < 1$. This is a behavioral relationship which states that currency holdings of the public are a constant fraction of the total money stock.

(6) $C_b^f + C_b^g = d(D_p' + D_p'')$ where d is a parameter and $0 < d < 1$. Vault cash is taken to be a constant fraction of total deposits of the public in commercial banks. For purposes of this study, it is assumed that average vault cash holdings are thesame proportion of deposits for member banks as for nonmember banks. This is a fairly realistic assumption: as of June 30, 1961, vault cash was 2.3 per cent of member bank deposits and 3.3 per cent of nonmember bank deposits, while at the end of 1941 and the pereentages were 3.2 per cent for member banks and 4 per cent for nonmember banks.[1]

(7) $D_p'' = hM$ where h is a parameter and $0 < h < 1$. This relationship states that nonmember bank deposits of the public are a constant fraction of the money supply.

The purpose of this model, which contains four definitions and three behavioral relationships, is to show how certain regular relationships--that is, certain aspects of the structure--influence the maximum possible stock of money supportable by the structure (which we shall label M^{**}) given the existing reserves, and furthermore, to discover how M^{**} can be broken down to yield a measure of that part of the maximum possible money stock which is based upon supplied reserves. That is,

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[1]Source: Federal Reserve Bulletin.

it is not adequate for our purposes to find the "money equivalent" of Federal Reserve-initiated reserve changes simply to multiply R^S by k, the reciprocal of the average reserve requirement, because certain structural aspects of the system also affect the size of this "money equivalent."

The behavioral relationships, of course, are only approximations if examined against the history of the entire period covered by the study. However, the absolute stability of these parameters (c, d, and h) over the whole period is not required. It must be remembered that the model is designed simply to show what data are required to measure M^*, period by period. In supposing that M^* is a policy variable of the Federal Reserve System, and that the Federal Reserve therefore knows the size of M^* at all times, it is only required that the size of the behavioral parameters at some time in the recent past be known, plus perhaps some information on the direction of trends in these behavioral relationships, since the Federal Reserve conducts day-by-day operations on reserves (and thus on M^*). Such knowledge is sufficient to give the monetary authorities effective (although only approximate) control of M^*. It is true, for example, that there have been fairly large variations in the amount of the total money stock that the public chooses to hold as currency and coin; this was demonstrated and discussed by Cagan recently.[1]

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[1]Phillip Cagan, "The Demand for Currency Relative to the Total Money Supply," Journal of Political Economy (LXVI), August, 1958, pp. 303-328. Cagan uses the Friedmanesque

However, these movements occur as trends or long cycles rather than sharp, quarter-to-quarter changes.[1] In order to account for these longer-term movements while reflecting short-term stability, the parameters were estimated for use in the statistical investigation discussed below by taking moving averages. The data used may be found in the Appendix.

The system which is defined above can be solved so that M is expressed as a function of the behavioral parameters, the exogenous variable D_g', excess reserves, supplied reserves, borrowing, and the weighted average effective reserve ratio for member banks. This is easily done by substituting into equation (3). The maximum potential money supply which the system can support occurs when excess reserves are zero; therefore it is found simply by setting $R^e = 0$. The result is three equations expressing M^{**} as a function of the variables mentioned above (except R^e); each equation corresponds to one of the equations (4a), (4b), and (4c) [equation a is based on (4a),etc.]:

$$\text{(a)} \quad M^{**} = \frac{k}{(1-c-h)} R^s + \frac{k}{(1-c-h)} B \qquad \text{(1922-1935 II)}$$

$$\text{(b)} \quad M^{**} = \frac{k}{(1-c-h)} R^s + \frac{k}{(1-c-h)} \left(B - \frac{1}{k} D_g'\right) \qquad \text{(1935 III-1960 III)}$$

$$\text{(c)} \quad M^{**} = \frac{k}{(1-c-h-kdh)} R^s + \frac{k}{(1-c-h-kdh)} \left(B - \frac{1}{k} D_g'\right) \qquad \text{(1960 IV-)}$$

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definition of money supply; however, the variation in the ratio of currency to total money which he observes over time is also found when the standard money supply definition is used.

[1]There is one notable exception: the period from June 30, 1931, to December 31, 1932, when the ratio of currency and coin held by the public to total money stock increased from .145 to .221.

In each of the above expressions, the maximum potential money stock supportable by the system at any given time is shown to be a sum of which one component in supplied reserves multiplied by the ratio of k, the reciprocal of the weighted average reserve ratio, to a number which involves the parameters of the system. Having solved this system of equations, it is easy to see that M^* can be calculated at every point of time for which data are available on the weighted average reserve ratio, total reserves of member banks, borrowing, and the parameters c, d, and h.[1] The reciprocal of the weighted average reserve ratio (k) is calculated <u>for each period</u> simply by dividing net demand deposits in member banks by required reserves at the same point in time.

For convenience, we will rewrite the relationship between M^{**} and its components as follows:

$$(a') \quad M^{**} \equiv k^*R^S + k^*B = M^* + k^*B \qquad (1922\text{-}1935\ II)$$

$$(b'), (c') \quad M^{**} \equiv k^*R^S + k^*(B - \tfrac{1}{k}D'_g) = M^* + k^*(B - \tfrac{1}{k}D'_g) \quad (1935\ III\text{-}\ )$$

where k^* is defined by

$$k^* \equiv \frac{k}{1 - c - h} \qquad (1922\text{-}1960\ III)$$

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[1] In order to allow for trend movements in these parameters they are calculated using moving averages so that the value assigned to the current period is actually an average of recent past periods' values.

$$k^* \equiv \frac{k}{1 - c - h - kdh} \qquad (1960\ IV- \quad)$$

The definition of M^* is obvious from these manipulations; $M^* \equiv k^* R^s$. An examination of these equations will demonstrate that the object of this exercise was not simply to divide the maximum potential money stock into exogenous and endogenous components, but rather to segregate that portion over which the monetary authorities exercise effective control. For example, the expression for the period after 1935 III contains a term which is the difference between borrowing (endogenous) and a multiple of United States Government deposits in member banks (considered to be exogenous but <u>not</u> subject to control by the Federal Reserve System).

In summary, through manipulation of the model set forth above, we have arrived at an expression for the maximum potential money supply possible, given the total reserves and the structure (M^{**}), and have shown how that total can be divided into two segments, over one of which (M^*) the monetary authorities exercise regulatory control, and over one of which they do not.

Having discussed our expectations as to the response of $\frac{M}{M^*}$ to its functional arguments, we are now in a position to test the money supply hypothesis

$$\frac{M}{M^*} = f(r,\ r_c)$$

to determine whether or not it explains the existing data

adequately, and in what form (with respect to the best measures of return and cost, lag structure, etc.) that it does the best explanatory job. Following a discussion of these results, we will employ them in the formulation and testing of a structural model of the monetary sector.

3. Empirical Evidence on the Supply Hypothesis: Single-Equation Results

The supply hypothesis was tested by first putting it into operational form and then performing a number of regressions covering the periods 1923-1941 and 1946-1960 separately, based upon the assumption (verified by analysis of variance tests on some regressions) that structural change had taken place between the prewar and postwar periods to the extent of making them nonhomogeneous. It could be argued, of course, that this is also true of the 1920's as compared with the 1930's; however, this possibility has not been investigated.

The tests whose results will be discussed in this section consist of single-equation linear regressions. This may seem inconsistent, since a central premise of this study is that the monetary sector can be properly represented only by a simultaneous supply-demand model. Let it be clearly understood, therefore, that these single-equation regressions are only being done as a preliminary and economical means of investigating whether or not certain variables (especially various types of lag structures) have any explanatory content for the hypothesis. No supply elasticities will be estimated

from these single-equation results, since simultaneous-equations bias may have a serious effect upon the size of the estimated coefficients. Estimation of elasticities is left until simultaneous estimates of the structure are made. For the purposes of this chapter, only such aspects of the estimates reported here as the relationship of each coefficient to its standard error and the value of the Durbin-Watson statistic will be considered. Making single-equation tests of this kind is simply a slightly more sophisticated way of examining and comparing possible relationships than is the plotting of scatter diagrams. The latter approach has been used in several structural studies for the same purpose that single-equation estimates are used here.[1]

a. Measurement of Variables Used

The data upon which both these single-equation regressions and the structural estimates discussed in Chapter IV are based can be found in the Appendix, together with comments on sources and methods of derivation. However, a brief discussion of definitions and methods of manipulation for certain variables will be useful at this point in order to clarify the general approach which has been followed.

Time intervals. This study has been carried out using quarterly data, although several quarterly points are missing

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[1] Cf. Klein and Goldberger, op. cit. In their study, scatter diagrams are used extensively to demonstrate the relationships set out in individual structural equations, even though the entire structure is estimated simultaneously.

over the periods covered. All time subscripts are written in quarterly terms for consistency, even when only annual observations are used (as in the structural estimates for the prewar period). Quarterly observations are useful not only because they provide more observations, and hence a greater degree of statistical reliability, than annual data, but also because they provide an opportunity to study lag structure in the monetary sector. This sector is assumed to be quite flexible and rapid in reaction to changes in economic variables, and response lags are therefore probably relatively short. For this reason, annual data are assumed to be inadequate for the study of lag structure in this sector.

The calculation of parameters. The parameters c and h (the fraction of the money stock held by the public as currency, and the fraction of the money stock held as demand deposits in nonmember banks, respectively) are easily found for each call data by dividing currency outside banks, and demand deposits in nonmember banks, by the money stock as of the call date.[1] These series are then smoothed by taking the average of the current and the previous values for the prewar period (in this case, the previous period is that for six months previously, as money stock data are not available for all quarterly points in the prewar era), while for the

[1] All stock variables used in the study are measured as of quarterly call dates, which fall on or near the last day of each quarter (although the call dates for the first and third quarters sometimes vary in either direction by as much as two weeks). While the parameter d (proportion of vault cash to total deposits in commercial banks) appears in our theoretical formulation, it is not used in the empirical part of the study because it does not enter the equations until the fourth quarter of 1960.

postwar points the value used was the average of the two previous (quarterly) observations. Such a procedure is supposed to approximate the information the monetary authorities would have at their disposal regarding these parameters. The multiplier k^* is then found by dividing k by the quantity (1-c-h) where c and h refer to these averaged values. Multiplying supplied reserves (found simply by subtracting borrowing from total reserves behind demand deposits as of each call date) by k^* results in the value for M^*.

The rate of return on loans. While all of the short-term interest rates are very highly correlated with each other, and therefore any of them might perform in approximately the same manner as a measure of the return on loans, there is a strong case for using the rate on 4-6 month prime commercial paper for this purpose, since these short-term business loans account for the bulk of endogenous changes in the money stock.[1] This rate has therefore been used for the present study. Since one of the objectives of the study is to investigate the lag structures involved in the demand for and supply of money, the period over which this rate is measured seems quite important. It is usual in studies of this kind to use averages over a long period of time--a month, quarter, or year--but

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[1]Of all loans made by commercial banks, the category "commercial, including open-market paper" is consistently the largest in dollar amount by a wide margin. See the Federal Reserve Bulletin data on "Loans and Investments of Member Banks, by Class."

since call date (point) data are being used in this study, it seems necessary to use a value which reflects current, rather than average, conditions. For this reason, it was decided, more or less arbitrarily, to take as a measure of the 4-6 month rate the average of daily values for the last full week preceding the call date. Thus some averaging occurs, and at the same time a value is being used which is contemporaneous with the other data.

The cost of loans. The choice of a proper measure of the cost of loans is somewhat more difficult than the measure of return. There are several candidates; for example, the discount rate (r_d), the federal funds rate (f), or the Treasury bill rate (r_T) might all be considered as costs in this respect. Various tests have been made to attempt to discriminate among these measures, and these will be discussed below. It seems almost impossible to hope to make a clear choice empirically between the Treasury bill rate and the federal funds rate, because of the extremely high degree of intercorrelation existing between these rates, so it will be assumed that the federal funds rate will reflect the influence of the Treasury bill rate in addition to its own effect in these regressions. The tests which are reported therefore compare only the discount rate and the federal funds rate as alternative measures of cost.

The reasoning underlying use of the discount rate and the federal funds rate as alternative cost measures is somewhat

different for each variable. The discount rate is a cost in that it is the charge levied by the Federal Reserve System for borrowing by member banks; thus if there are no excess reserves and banks wish to expand loans and therefore borrow, the discount rate is literally the cost which is paid for the loan expansion. The federal funds rate, however, is a measure of opportunity cost. If a bank has excess reserves and there is active demand for loans, it has the alternatives of making loans to credit-demanders, lending these reserves to other banks in the federal funds market, or purchasing securities. When it lends, it foregoes the other alternatives, and the opportunity cost it pays is the foregone return on them. The federal funds rate, being highly correlated with the Treasury bill rate, is a good measure of the cost of foregoing the purchase of securities as well as measuring the cost of deciding not to lend reserves in the federal funds market.[1]

The discount rate for each Federal Reserve district is set by each district Federal Reserve Bank, although there is a strong tendency toward uniformity. The rates do differ occasionally, however, and the measure of the discount rate which is used here is a weighted average of all twelve rates as of each call date. The weights used are member-bank deposits

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[1]The analysis suggests that perhaps a cost index made up using both series could be used. It would follow the discount rate during periods of "tight money" when excess reserves are very low, and it would follow the federal funds rate during periods when excess reserves were more abundant and demand for credit was lower. This approach was not tested, however.

with the Federal Reserve Bank in each district. For the federal funds rate, the value used is the "effective rate" for each call date.[1] Some judgment has been used in constructing this series in cases where it appears that unusually high or low values bias the result obtained in this way. It should be noted that both the federal funds rate and the bill rate are inferior to the discount rate in that the prewar data are very inadequate, extending only back to 1934 for Treasury bills and to 1928 (as of June 30 only) for the federal funds rate.

b. Empirical Results.

The general supply hypothesis outlined above can be made operational in a number of forms. For example, the ratio $\frac{M}{M^*}$ might be assumed to be a function of the difference between the return on loans and their cost, or of the ratio of return to cost. For each case, one of several functional forms might be appropriate: linear in the untransformed variables, linear in the logarithms, etc. The possibility that nonlinear forms might be appropriate must be mentioned, although none were tested. Furthermore, each combination above might be tried out using first the discount rate and then the federal funds rate as a measure of cost. Finally, various lag structures must be tested. It is clear that this

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[1]The "effective rate" is a weighted average representing the rate at which the bulk of transactions during the day occur.

investigation involves a huge number of possible regressions, and the problem has been kept within manageable proportions by omitting some of the possibilities mentioned. In particular, most of the tests have been made on linear functions of the untransformed variables, in the light of some preliminary tests which indicated that the results obtained using logarithmic transformations were uniformly slightly inferior to those on untransformed variables.

As a result, single-equation tests for the postwar period involve comparisons of the federal funds rate and the discount rate as cost measures, and include regressions using both ratios of and differences between return and cost. For the prewar period, the shortage of data on the federal funds rate restricts the tests to formulations involving the discount rate.

Criteria used. This study contends that the monetary sector must be represented by a structural model. Only the asymptotic properties which estimates of these models possess are known. Strictly speaking, the statistical tests which can be used on regression where single-equation models are appropriate do not apply either to a structural estimate itself or to single-equation regressions on structural relationships, such as those reported in the following section.

However, it is necessary to establish some systematic means of evaluating these single-equation tests. With serious reservations because of their theoretical limitations, we

will tentatively employ the usual regression criteria for this purpose, as well as for the structural results reported in Chapter IV. These criteria are: goodness of fit, measured by R^2, the coefficient of determination; the t-test for significance of regression coefficients; the Durbin-Watson statistic, measuring the degree to which serial correlation is present in the residuals; the extent to which the signs of the regression coefficients agree with prior expectation; and lack of multicollinearity among the explanatory variables. In general, the formulation will be preferred which displays the highest coefficient of determination, whose coefficients have signs which agree with prior expectation and are largest in absolute value relative to their standard errors, whose Durbin-Watson statistic is closest to 2.00 in value, and which displays the least evidence of multicollinearity.

1946-1960. For the postwar period, tests were made on the supply hypothesis using the discount rate and the federal funds rate as alternative measures of cost; these results are summarized in Table III.2. For each cost measure, regressions were done on linear functions in which it entered as the denominator of a return/cost ratio and, alternatively, as the cost element in a term involving the difference between return and cost. We would expect the formulation using the difference between return and cost to give better results than that using a return/cost ratio, since the possibility of making a one percentage point profit over cost should induce

a banker to act in the same manner whether the commercial rate is two per cent and the cost of loans is one per cent, or whether the return is six per cent and the cost is five per cent. However, other factors, such as expectations concerning future interest rates and general business conditions, may be operating in such a way that the ratio will perform more satisfactorily than the difference.

In the first set of tests, the discount rate is used as the measure of cost. In this and following regressions, we establish the following definition for expository convenience:

$$X \equiv \frac{M}{M^*}$$

The first test involves the simple regression of X on net return, $(r-r_d)$; that is:

$$(III.2.1) \qquad X = \alpha + \gamma_1(r-r_d) + \epsilon$$

Reference to Table III.2 shows that γ_1 is highly significant by the t-test, being 3.9 times its standard error. Also, its sign is positive as expected. However, only 22 per cent of the variance of X is explained, and the low level of the Durbin-Watson statistic indicates that either the functional form is incorrect or there are important explanatory variables which are missing from this equation.

TABLE III.2 RESULTS OF SIMPLE-EQUATION TESTS OF THE SUPPLY HYPOTHESIS USING THE DISCOUNT RATE AS A MEASURE OF THE COST OF LENDING FOR THE POSTWAR PERIOD

Equation Number	Regression Coefficients (Standard Errors Shown in Parentheses)									
	γ_1 $(r-r_d)$	γ_2 (r)	γ_3 (r_d)	γ_4 (t)	γ_5* (S_1)	γ_6* (S_2)	γ_7 (X_{t-1})	γ_8 $(r-r_d)_{t-1}$	γ_9 $(\frac{\pi}{r_d})$	γ_{10} $(\frac{r}{r_d})_{t-1}$
III.2.1	.0899 (.0232)									
III.2.2		-.0036 (.0182)	.0678 (.0233)							
III.2.3	.0216 (.0206)			.0026 (.0004)						
III.2.4		-.004 (.0183)	.0609 (.0249)	.0005 (.0006)						
III.2.5	.0547 (.0164)				.0371 (.0117)	.1309 (.0159)				
III.2.6	.0442 (.0211)				.0347 (.0146)	.1123 (.0288)	.1423 (.1684)			
III.2.7	.0486 (.0209)				.0357 (.0122)	.1284 (.0169)		.0103 (.0215)		

*The variables S_1 and S_2 are shift variables which are assigned to the following values for the periods indicated:

$$S_1 = \begin{matrix} 0 & 46\ II\text{-}53\ II;\ 59\ I\text{-}60\ II \\ 1 & 53\ III\text{-}58\ IV \end{matrix}$$

$$S_2 = \begin{matrix} 0 & 46\ II\text{-}58\ IV \\ 1 & 59\ I\text{-}60\ II \end{matrix}$$

TABLE III.2 (Continued)

Equation Number	Regression Coefficients (Standard Errors Shown in Parentheses)									
	γ_1 $(r-r_d)$	γ_2 (r)	γ_3 (r_d)	γ_4 (t)	γ_5 (S_1)	γ_6 (S_2)	γ_7 (X_{t-1})	γ_8 $(r-r_d)_{t-1}$	γ_9 $(\frac{r}{r_d})$	γ_{10} $(\frac{r}{r_d})_{t-1}$
III.2.8									.1225 (.0533)	
III.2.9		.0550 (.0058)							-.0859 (.0392)	
III.2.10				.0028 (.0004)					.0193 (.0402)	
III.2.11		.0450 (.0103)		.0007 (.0006)					-.0733 (.0405)	
III.2.12		.0561 (.0061)							-.0699 (.0461)	-.0284 (.0425)
III.2.13				.0018 (.0006)			.3776 (.1491)		.0218 (.0418)	
III.2.14		.0478 (.0050)								

TABLE III.2 (Continued)

Equation Number	α (Constant)	Durbin-Watson Statistic	R^2	Period Covered and Degrees of Freedom
III.2.1	.8794 (.0103)	.932	.223	52 (1946 II-1960 IV)
III.2.2	.7709 (.0140)	1.565*	.691	51 (1946 II-1960 IV)
III.2.3	.8282 (.0112)	1.248	.564	51 (1946 II-1960 IV)
III.2.4	.7749 (.0149)	1.575*	.695	50 (1946 II-1960 IV)
III.2.5	.8558 (.0081)	1.700*	.670	50 (1946 II-1960 IV)
III.2.6	.7346 (.1435)	1.904*	.667	44 (1947 III-1960 IV)
III.2.7	.8557 (.0082)	1.696*	.671	49 (1946 II-1960 IV)
III.2.8	.7687 (.0601)	.637	.092	52 (1946 II-1960 IV)
III.2.9	.8694 (.0381)	1.641*	.671	51 (1946 II-1960 IV)
III.2.10	.8085 (.0428)	1.182	.557	51 (1946 II-1960 IV)
III.2.11	.8609 (.0386)	1.644*	.680	50 (1946 II-1960 IV)
III.2.12	.8801 (.0415)	1.635*	.674	50 (1946 II-1960 IV)
III.2.13	.4908 (.1260)	1.831*	.617	44 (1947 III-1960 IV)
III.2.14	.7906 (.0131)	1.566*	.640	52 (1946 II-1960 IV)

*No significant serial correlation at the 1 per cent level of significance. All other equations exhibit evidence of significant serial correlation by this test.

TABLE III.3 MATRIX OF SIMPLE CORRELATION COEFFICIENTS BETWEEN REGRESSION VARIABLES, 1946-1960

	X	r	r_d	$(r-r_d)$	$(r-r_d)_{t-1}$	$\frac{r}{r_d}$	$(\frac{r}{r_d})_{t-1}$	(r-f)	$\frac{r}{f}$	X_{t-1}	t	S_1	S_2
X	1.000	.800	.831	.472	.499	.304	.327	.167	.075	.735	.745	.687	.104
r		1.000	.965	*	*	.562	.552	*	*	.838	.837	.768	*
r_d			1.000	*	*	*	*	*	*	.864	.858	.782	*
$(r-r_d)$				1.000	.662	*	*	*	*	.495	.524	.167	.218
$(r-r_d)_{t-1}$					1.000	*	*	*	*	.495	.538	.295	.227
$\frac{r}{r_d}$						1.000	.668	*	*	.244	.194	.154	.200
$(\frac{r}{r_d})_{t-1}$							1.000	*	*	.259	*	*	*
(r-f)								1.000	*	*	*	.148	*
$\frac{r}{f}$									1.000	*	*	*	*
X_{t-1}										1.000	.785	.718	.062
t											1.000	*	*
S_1												1.000	-.333
S_2													1.000

*Not available

The hypothesis that one variable or the other may exert an independent effect may be tested by unrestricted regression on r and r_d as separate explanatory variables:

$$(III.2.2) \quad X = \alpha + \gamma_2 r + \gamma_3 r_d + \epsilon$$

As a result of removing the restriction, the degree of explanation achieved rises sharply, with 69 per cent of the variance of X being explained in Equation III.2.2. However, this result is not acceptable because of the perversity of sign exhibited by γ_2 and γ_3. The fact that these signs are the reverse of those expected a priori may well be due to the existence of a high degree of multicollinearity between the explanatory variables. The simple correlation coefficient between the dependent variable and the rate of interest is .799; between the dependent variable and the discount rate, it is .833; while the simple correlation coefficient between the interest rate and the discount rate is .965 (see Table III.3 for the simple correlation coefficients between all pairs of variables used in the postwar regressions). There is an econometric "rule of thumb" to the effect that multicollinearity presents a serious problem when the correlation coefficient between any two explanatory variables is greater in absolute value than between either variable and the dependent variable. Using this rule, it appears that serious multicollinearity exists and that it may be causing the estimates to be unreliable, yielding capricious results. This may be the case with Equation III.2.2.

Multicollinearity means that explanatory variables are correlated with one another, and it becomes a statistical problem when this intercorrelation becomes great enough so that the variables become difficult to distinguish from one another statistically. In effect, the variables in such a case are almost linear combinations of one another. This may lead to the following kinds of difficulty: first, computational problems are introduced. The matrix X'X may be almost singular, leading to the loss of significant digits in the inversion process with the result that rounding errors become very important in the calculation of $(X'X)^{-1}$. To the extent that the explanatory variables are intercorrelated, error from this source may bias the resulting estimates even though the variables themselves are observed exactly. In addition, errors of observation may, under these circumstances, add an additional degree of capriciousness to the results. For if the explanatory variables are very similar to each other in movement, a systematic observation error may cause the whole weight of the explanation to be thrown onto one variable or the other.[1]

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[1]This can be illustrated by a simple vector diagram. Suppose each of two explanatory variables to be represented by vectors A and B, while vector C is the dependent variable. In the first case shown, the vectors A and B are orthogonal, and a slight error of observation in one of them, say A, has very little effect on the explanation of C. But in the second case, vectors A and B are very similar to each other. Here the same error of observation, resulting in the observed values being represented by A' and B, causes A' and C to be

Since r and r_d are so closely related to each other, in comparison with their respective relationships with X, it is concluded that, for the postwar period at least, unrestricted estimates on r and r_d are not reliable. We shall perform at least one structural estimate over this period using a variant of this unrestricted supply function to see whether the interaction of the structure may produce the expected signs for r and r_d. Even if this were to result, however, the estimates would be suspected because of the close relationship of the interest and discount rates, which of course is not changed by the fact that the entire structure is being estimated instead of only one equation.

Thus far we have shown that a substantial portion of the variance of X can be explained by linear regression on other

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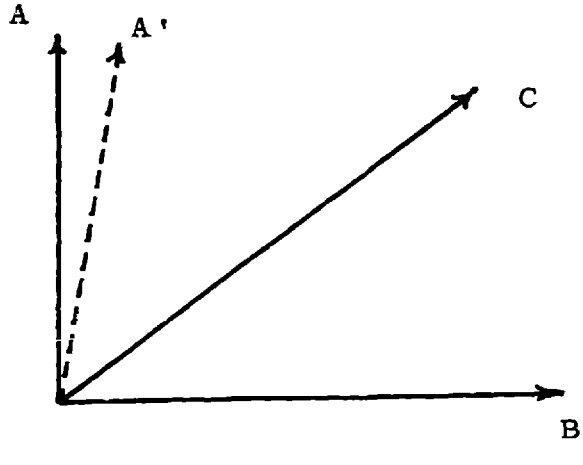
identical. In such a case, the coefficient of the variable represented by B would be estimated as zero, even though it actually affected the value of the dependent variable.

Case 1



Case 2

variables. While r and r_d gave good results as explanatory variables in terms of explanation, serious multicollinearity makes the discernment of the true relationships in this formulation practically impossible. This does not make further investigation futile, however. Our a priori hypothesis was that X should be a function of the ratio or difference of r and r_d, and not necessarily a function of each separately. Consequently, we look for other variables which will improve the basic relationship between X and $(r-r_d)$[1]. Such a variable with theoretical appeal is some measure of structural change. This could take the form of either a trend or shift variable. In Figure III.1, X is plotted against $(r-r_d)$, and it is obvious that there is a general movement upward over time. The reasoning behind use of a trend variable would be that the postwar era has, in general, been a period of continuing restrictive pressure by the monetary authorities; i.e., a period of continuing excess demand for funds. As a result, there has been a gradual process of structural change over the period, during which new institutions and practices have evolved so that the reserves existing at any time can be used more efficiently. This is another way of saying that such new institutions and techniques result in increases in M for a

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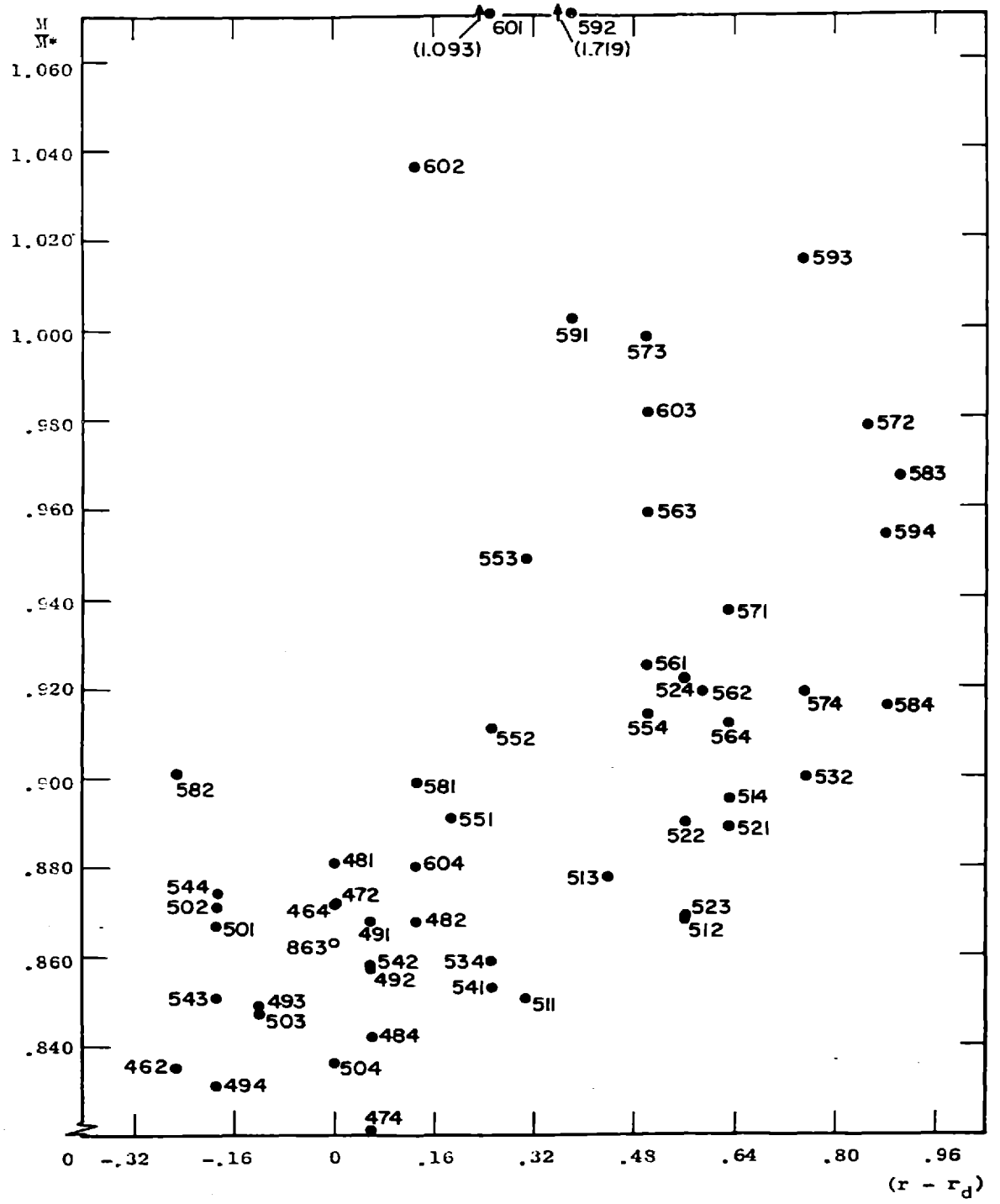
[1] In order to make comparisons more easily, all aspects of the relationship involving $(r-r_d)$ are investigated before turning to functions containing the ratio $\frac{r}{r_d}$.

Fig. III.1: Scatter Diagram: $\frac{M}{M^*}$ vs. $(r - r_d)$, 1946 II - 1960 IV



given level of M^* and $(r-r_d)$, or that an upward trend in X may be present.[1]

Alternatively, it may be hypothesized that structural change in the monetary sector has occurred in a number of steps, either self-contained in nature or as part of more far-reaching changes. In the present study, four such periods were originally examined: (1) the period from the end of World War II to the Treasury-Federal Reserve "accord" of March, 1951 (the structural change represented by the accord is an example of "self-contained" change mentioned above); (2) the period from the accord to the end of the Korean War in July, 1953; (3) the period from July, 1953 to the beginning of the balance-of-payments problem, dated at January 1, 1959;

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[1]There has grown up an extensive literature on the secular change in financial institutions and the development of new institutions during the postwar period. For example, see Commission on Money and Credit, Money and Credit: Their Influence on Jobs, Prices, and Growth (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961) Chapters 3 and 6; John G. Gurley and E. S. Shaw, "Financial Intermediaries in the Savings-Investment Process," Journal of Finance (XI), May, 1956, pp. 257-276; Joint Economic Committee, Staff Report on Employment, Growth, and Price Levels (Washington, D.C.: U.S. Government Printing Office, 1959), Chapter 9; J. M. Culbertson, "Intermediaries and Monetary Theory: A Criticism of the Gurley-Shaw Theory," American Economic Review (XLVIII), March, 1958, pp. 119-131; Hyman P. Minsky, "Central Banking and Money Market Changes," Quarterly Journal of Economics (LXXI), May, 1957, pp. 171-187.

(4) the period from January 1, 1959 to the present.[1] Preliminary tests indicated that, in terms of regression results, the first two periods were homogeneous in that the coefficients of their "shift" terms were almost identical. Therefore, these two periods have been combined into one in the test reported below.

In Equation III.2.3, the results of a regression on $(r-r_d)$ and a linear trend are reported. In this regression, γ_4 is more than six times as large as its standard error, but γ_1 is not significant by the t-test, being about equal in size to its standard error. Furthermore, the Durbin-Watson statistic indicates that serial correlation in the residuals is present to a significant degree. This formulation is unsatisfactory in that most of the weight of explanation is borne by the trend term, the measure of net return becomes insignificant, and the Durbin-Watson statistic indicates that other significant variables may be missing. However, the

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[1]The dating of the beginning of the balance-of-payments problem at January 1, 1959, is of course arbitrary; in fact, there was a significant balance-of-payments deficit in 1958. The above date was chosen for several reasons: it was assumed that decision-makers and institutions required some time to adjust to the new situation; the end of 1958 saw the establishment of external currency convertibility by several European countries, affecting United States participation in these markets; the balance of payments on current account was near its postwar low at that time; etc. Taking several such factors into account, the beginning of 1959 appeared to be a logical point for dating the structural change assumed to be taking place. For a discussion of some of the phenomena mentioned above, see United States Government Printing Office, Economic Report of the President (Washington, D.C., 1962), Chapter 3.

degree of explanation achieved is considerably better than in Equation III.2.1, indicating that the trend term may be a proxy for some other variable which will give better results in combination with a measure of net return on loans. A logical candidate for trial is the shift hypothesis mentioned above, and the results of regressions testing this hypothesis in various forms are found in Equations III.2.5, III.2.6, and III.2.7 in Table III.2. Division of the postwar period into the three subperiods discussed above necessitated the use of two dummy variables, S_1 and S_2. This procedure gives results which are more satisfactory than any previously achieved. (See Equation III.2.5) Sixty-seven per cent of the variance of X is explained, which is practically as high as the level attained by unrestricted regressions on r and r_d. The signs are all as expected, the coefficients are all significant at a high level (including γ_1), and finally, the Durbin-Watson statistic indicates that no significant serial correlation is present in the residuals. All in all, the results of this regression tend to confirm the original supply hypothesis and also indicate that discrete structural shifts of the type discussed have occurred during the postwar period.

Having determined that regression of X on the variable $(r-r_d)$ and these shift variables gives the best results among formulations using the difference between cost and return rather than their ratio, the next step is to investigate the possibility that a lagged response may exist. Two types of

lag were tested: a discrete lag, through the introduction of previous values of $(r-r_d)$, and a distributed lag. For convenience, a geometrically-decaying distributed lag will be used, based on the formulation devised by Koyck, which involves introduction of the lagged dependent variable as a proxy for this lag.[1]

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[1] L. M. Koyck, Distributed Lags and Investment Analysis (Amsterdam: North-Holland Publishing Company, 1954). The method is summarized in Marc Nerlove, Distributed Lags and Demand Analysis for Agricultural and other Commodities (Washington, D.C.: U.S. Government Printing Office, 1958), pp. 12-14. The principle involved can be demonstrated easily using as an example the case where the dependent variable y is a linear function of current and lagged values of one variable only. Thus we have

$$(1) \quad y_t = \alpha + \beta_o X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \cdots + \beta_k X_{t-k} + \cdots$$

Now suppose that $\beta_t = \delta\beta_{t-1}$ where $0 < \delta < 1$. Then

$$(2) \quad y_t = \alpha + \beta_o X_t + \beta_o \delta X_{t-1} + \beta_o \delta^2 X_{t-2} + \cdots + \beta_o \delta^k X_{t-k} + \cdots$$

Lagging this equation one period and multiplying by δ gives

$$(3) \quad \delta y_{t-1} = \alpha\delta + \beta_o \delta X_{t-1} + \beta_o \delta^2 X_{t-2} + \beta_o \delta^3 X_{t-3} + \cdots + \beta_o \delta^{k+1} X_{t-k-1} + \cdots$$

Subtracting (3) from (2) as usual in order to find the sum of a geometric series, we have

$$(4) \quad y_t = \alpha(1 - \delta) + \beta_o X_t + \delta y_{t-1}$$

It is possible to generalize this method to take account of more than one explanatory variable. In equation (4), the estimate of δ gives the distribution of the lag. Note that this coefficient must be less than unity in absolute value.

It should also be noted that the geometrically-decaying distributed lag response need not characterize all prior periods. Discrete lags may be specified for t-k past periods, with a geometrically-decaying lag being used to approximate the lagged response from period t-k-1 to negative infinity.

The results of the distributed-lag test are given in Equation III.2.6. Regressing X on $(r-r_d)$, the shift variables, and X_{t-1} results in no improvement in explanation and an insignificant coefficient for X_{t-1}. There is little change in the other coefficients; in fact, the only significant effect of adding X_{t-1} to the regression is to increase the value of the Durbin-Watson statistic, although it was already at a favorable level in Equation III.2.5. Thus we cannot conclude from this test that a distributed lag exists during the post-war period.

As an alternative, a one-period lag in $(r-r_d)$ was tested. The results are shown in Equation III.2.7. As above, the coefficient of this lag term is insignificant by the t-test, and no improvement is noted in the percentage of explained variance.

Based upon this evidence, Equation III.2.5 appears to give the best results among the formulations using the difference, rather than the ratio, between cost and return. Reference to Table III.3, the matrix of simple correlation coefficients for the period covered, indicates that no serious problem is presented by the existence of multicollinearity in this regression. This may not be true of the tests involving lag terms; in these cases, some of the explanatory variables used are much more closely related with each other than with the dependent variable. An example is the relationship between $(r-r_d)$ and $(r-r_d)_{t-1}$; the simple correlation coefficient

between these variables is .662, while that between X and $(r-r_d)$ is .472, and between $(r-r_d)_{t-1}$ is .499.

We now turn to the alternative return-cost formulation based upon the discount rate, using $\frac{r}{r_d}$ rather than $(r-r_d)$. The results of the regression of X on $\frac{r}{r_d}$ alone are shown in Equation III.2.8; it is clear that these results are unsatisfactory. Only nine per cent of the variance of X is explained in this way, and significant serial correlation exists in the residuals. However, γ_9 is just significant and is of the anticipated sign. In general, the low level of explanation in particular makes this formulation unsatisfactory, especially when compared to the regression of X on $(r-r_d)$ only.

Additional variables were tried to see whether the fit could be improved. Adding the interest rate alone improves the fit a great deal, but turns the sign of γ_9 from positive to negative (Equation III.2.9). This result is unsatisfactory because it implies a positive relationship between the discount rate and the money stock, contrary to prior expectation. It is possible that adding a measure of structural change may improve the fit as well as helping to avoid the sign problem encountered above. This is done in Equation III.2.10, and the result is that the trend takes all the burden of explanation upon itself while γ_9 becomes only half as large as its standard error. Adding a trend term to the regression on the return-cost ratio and the interest rate (Equation III.2.11) results in γ_9 becoming negative as before while the trend

coefficient loses significance. In Equation III.2.12, the variable $(\frac{r}{r_d})_{t-1}$ was added to the regression on r and $\frac{r}{r_d}$ in hope that such a procedure would remedy the sign problem. However, this regression is also unsatisfactory; both of the return-cost variables now acquire negative coefficients. Finally, Equation III.2.13 shows the results of a regression including $\frac{r}{r_d}$, X_{t-1}, and a linear trend. In this case γ_9 remains positive but is insignificant, while the trend term and the lagged dependent variable carry the weight of the explanation.

It is possible that serious multicollinearity may be responsible for the unsatisfactory results in the above tests; for example, in Equation III.2.12, the simple correlation coefficient between $\frac{r}{r_d}$ and $(\frac{r}{r_d})_{t-1}$ is .662, while between the former and X it is .472, and between the latter and X it is .499. In any event, none of the regressions using the ratio $\frac{r}{r_d}$ gave results which were as favorable by the criteria being used as the comparable regressions using $(r-r_d)$. This agrees with the a priori proposition that, other things being equal, it is more rational for commercial bankers to be guided in their decisions on credit extension by the difference between return and cost than by their ratio.

The other candidate as a measure of cost for the postwar period is the federal funds rate. Tests similar in nature to those above have been made using the federal funds rate rather than the discount rate, in spite of the fact that it must be considered as an endogenous variable in a structural monetary

model, being determined by the supply of and demand for deposits at Federal Reserve Banks.[1] The addition of the federal funds rate as a variable would therefore complicate the structural model; nevertheless, it must be included if tests indicate that it is superior to the discount rate as a measure of cost. The results of the regressions which were done are shown in Table III.4; again, formulations including both the difference (r-f) and the ratio $\frac{r}{f}$ have been employed.

In general, these regressions are completely unsatisfactory. Regressing X on (r-f) alone, less than three per cent of the variance is explained, and the coefficient γ_{11} is insignificant. (Equation III.4.1.) Adding a shift variable improves the explanation, but γ_{11} becomes practically zero and turns negative (Equation III.4.2).[2] Based upon this extremely poor performance, it was concluded that (r-f) was not suitable for use as an explanatory variable.

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[1]The market for federal funds is discussed in two publications of the Federal Reserve System. These are Parker B. Willis, The Federal Funds Market: Its Origin and Development (Boston: the Federal Reserve Bank of Boston, 1957); and Board of Governors of the Federal Reserve System, The Federal Funds Market (Washington, D.C., 1959).

[2]This regression was done as part of an early test in which the existence of a single structural shift was investigated; it was dated at the end of 1954. Since the above result was so unsatisfactory, it was not thought to be worthwhile to redo the regression using two shift variables, as was done above.

TABLE III.4 RESULTS OF SINGLE-EQUATION TESTS OF THE SUPPLY HYPOTHESIS USING THE FEDERAL FUNDS RATE AS A MEASURE OF THE COST OF LENDING; 1946-1960

Equation Number	Regression Coefficients (with Standard errors in parameters)			Constant	R^2	Durbin-Watson Statistics	Period Covered and Degrees of Freedom
	γ_{11} (r-f)	γ_{12} $(\frac{r}{T})$	γ_{13} (S_a)				
III.4.1	.0167 (.0146)			.8990 (.0144)	.028	.708	46 (1948 II-1960 IV)
III.4.2	-.0010 (.0117)		.0835 (.0122)	.8666 (.0110)	.535	1.120	45 (1948 II-1960 IV)
III.4.3		.0027 (.0052)		.9066 (.0136)	.006	.571	46 (1948 II-1960 IV)

Turning to the ratio $\frac{r}{f}$, the regression results are even less satisfactory, if that is possible. Here less than one per cent of the variance of X is explained (Equation III.4.3). This evidence plus that discussed above leads to the conclusion that the federal funds rate does not function effectively as a measure of the cost of loans for the postwar period. Thus we are left with a choice between $(r-r_d)$ and $\frac{r}{r_d}$ as this measure. Based both upon prior reasoning and empirical tests, the formulations using $(r-r_d)$ seem to be more satisfactory. In particular, the function

$$X = X[(r - r_d), S_1, S_2]$$

gave the best results by our criteria, and it will be included in a structural model in Chapter IV. The single-equation tests failed to disclose any significant lag in response; this will be investigated further within the context of the structure.

1923-1941. An investigation similar to that for the postwar period was carried out for the prewar era, in order to determine which explanatory variables best meet the criteria which were established above in explaining the movement of the supply variable over time. For this period, however, we are limited to use of the discount rate as a cost measure, because adequate data on the federal funds rate and the Treasury bill rate are not available. The results of the tests are given in Table III.5, while Table III.6 is the matrix of simple correlation coefficients between each pair of regression variables.

TABLE III.5 RESULTS OF SINGLE-EQUATION TESTS OF THE SUPPLY HYPOTHESES USING THE DISCOUNT RATE AS A MEASURE OF THE COST OF LENDING: 1923-1941

Equation Number	Regression Coefficients (with Standard Error in Parentheses)							
	δ_1 $(r-r_d)$	δ_2 (t)	δ_3 (S_4)	δ_4 $(r-r_d)_{t-1}$	δ_5 (X_{t-2})	δ_6 (r)	δ_7 (r_d)	δ_8 $(\frac{r}{r_d})$
III.5.1	.8145 (.0924)							
III.5.2	.6779 (.1318)	-.0109 (.0076)						
III.5.3	.5102 (.2019)		.4322 (.2566)					
III.5.4	.5936 (.2005)			.2424 (.1956)				
III.5.5	.5233 (.1028)				.4425 (.1047)			
III.5.6	.5184 (.1733)		.0087 (.2486)		.4405 (.1199)			
III.5.7			-.3174 (.2335)		.1793 (.1270)	.4657 (.1504)	-.1724 (.1786)	
III.5.8			-.2082 (.3661)		.4128 (.1227)			1.4097 (.6232)

TABLE III.5 (Continued)

Equation Number	Constant	R^2	Durbin-Watson Statistic	Degrees of Freedom
III.5.1	1.2656 (.0639)	.683	.705	36 (1923 II-1941 IV)
III.5.2	1.4414 (.1380)	.700	.738	35 (1923 II-1941 IV)
III.5.3	.9657 (.1886)	.707	.795	35 (1923 II-1941 IV)
III.5.4	1.2517 (.0645)	.697	.855	35 (1923 II-1941 IV)
III.5.5	.7170 (.1401)	.791	1.363*	35 (1923 II-1941 IV)
III.5.6	.7133 (.1759)	.791	1.363*	34 (1923 II-1941 IV)
III.5.7	.3279 (.1867)	.848	.973	33 (1923 II-1941 IV)
III.5.8	-.4104 (.3144)	.778	1.368*	34 (1923 II-1941 IV)

*Within the range of indeterminacy at the 1 per cent level of significance. The unstarred equations display evidence of significant serial correlation in the residual by this test.

TABLE III.6 MATRIX OF SIMPLE CORRELATION COEFFICIENTS BETWEEN REGRESSION VARIABLES, 1922-1941

	X	$(r-r_d)$	$(r-r_d)_{t-1}$	X_{t-2}	r	r_d	$\frac{r}{r_d}$	S	t
X	1.000	.827	.788	.797	.912	.889	.839	.809	-.689
$(r-r_d)$		1.000	.889	.670	n.a.	n.a.	n.a.	.895	-.723
$(r-r_d)_{t-1}$			1.000	.804	n.a.	n.a.	n.a.	.863	-.752
X_{t-2}				1.000	.824	.842	.757	.754	-.691
r					1.000	.976	.947	.917	-.884
r_d						1.000		.863	-.901
$\frac{r}{r_d}$							1.000	.961	-.860
S								1.000	n.a.
									1.000

We begin by examining the relationship between X and $(r-r_d)$. Equation III.5.1 summarizes the result of this regression. In terms of goodness of fit, it is much more satisfactory than the equivalent postwar regression. However, the low level of the Durbin-Watson statistic indicates that some significant explanatory variables may be missing. As above, the next combination tried involved, alternatively, a linear trend (Equation III.5.2) and a shift variable (Equation III.5.3), where S_4 is 1 through the second quarter of 1932 and zero thereafter. The difference in result between these two formulations is small, except that use of the shift seems to give results which are consistently slightly better than those using a trend, and the constant term in Equation III.5.3 is considerably smaller than that in Equation III.5.2. It is not surprising if a shift variable gives somewhat better results than a trend for this period, as some rather abrupt institutional changes in commercial banking occurred during the period 1931-1932, with many banks failing, a much higher proportion of the money stock being held by the public as currency than previously, changes in legislation affecting commercial banking, etc.[1]

Although these two equations do a fairly good job of explanation, their Durbin-Watson statistics indicate either that the functional form being used is incorrect or that

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[1]The shift was dated at the middle of 1932 because at that point in time, the proportion of the money stock held as currency was shifting sharply upward (from 14.5 per cent in the middle of 1931 to 23.2 per cent in the middle of 1933).

significant explanatory variables are missing. The next step, therefore, is to add other variables to see whether the Durbin-Watson statistic can be improved.

It seems logical to begin by testing for the presence of lags. Adding $(r-r_d)_{t-1}$ to the regression on $(r-r_d)$ does nothing to improve the previous results (Equation III.4.4). However, if the dependent variable lagged [1] is added to the regression on $(r-r_d)$, a significant increase in explanation is achieved and the Durbin-Watson statistic improves to a point where it is in the region of indeterminacy at the 1 per cent level of significance (Equation III.5.5).[2] The high level of significance of X_{t-2}, the proxy variable for a geometrically-decaying distributed lag, is evidence in favor of concluding that such a lag characterized the supply response in the prewar years. In Equation III.5.6, the shift term S_4 is added to this regression; however, it turns out to be insignificant.

As for the postwar period, unrestricted regressions on the interest rate, discount rate, and other variables were

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[1] For the prewar period, a two-quarter lag in the dependent variable must be used, because quarterly data on the money stock are not available for much of the period.

[2] This is an improvement over the previous situation, in which significant serial correlation in the residuals was indicated at the one per cent level of significance. In the present case, it cannot be concluded at this level of significance that serial correlation exists; neither can it be said conclusively not to exist.

tried. The best result obtained in this way is given in Equation III.5.7. While a higher degree of explanation results, as would be expected, the Durbin-Watson statistic gives evidence of serial correlation in the residuals, and the levels of significance which are achieved are less satisfactory than those in the restricted regressions. This may be due to the presence of serial correlation, which leads to inefficient estimates, or to serious multicollinearity. For example, the simple correlation coefficient between the interest rate and the discount rate over the period studied is .976. This is the closest of the relationships between the independent variables, and may well be the cause of the low level of significance of the coefficient of the discount rate (Table III.6 contains the matrix of simple correlation coefficients between each pair of variables for the period covered).

The supply hypothesis in this unrestricted form will be investigated further as part of a structure; however, its usefulness and reliability are limited because of the probable serious effects of multicollinearity.

The performance of the return-cost measure in its alternative form, $\frac{r}{r_d}$, is investigated in the regression represented by Equation III.5.8. The fit achieved here is slightly poorer than that obtained by the comparable regression using $(r-r_d)$ (Equation III.5.6). Since the negative constant term here suggests the possibility of a negative money stock or quantity of supplied reserves, the previous formulation seems preferable.

4. Conclusions from single-equation tests

In this chapter, an hypothesis concerning the endogeneity of the supply of money has been formulated, based upon a simple behavioral model of the monetary sector and has been subjected to extensive empirical testing by single-equation means. While our conclusions are necessarily tentative, due to the limitations of single-equation tests of structural equations, the evidence seems favorable enough to warrant further investigation of the hypothesis within the context of a structural model.

For the postwar period, based upon the criteria which were established, the best results were obtained using a supply function of the following general form:

$$X = X[(r-r_d),\ S_1,\ S_2]$$

A regression on these variables explained almost seventy per cent of the variance of X, all of the coefficients were significant by the t-test, and all displayed the expected signs. The other measure of the cost of loans during the postwar period, the federal funds rate (which was also assumed to be a proxy for the Treasury bill rate, measuring the opportunity cost of making loans instead of investing in securities) did not yield as high a degree of explanation or meet the other criteria as well as did the discount rate; for that reason, the discount rate is held to be preferable for purposes of the

structural models discussed in Chapter IV. The results obtained in these tests do not disclose a response lag in the supply function; this will be investigated further in the structural estimates.

For the prewar period, a high degree of explanation was achieved by using the formulation

$$X = X[(r-r_d),\ X_{t-2}]$$

Economic events of the early 1930's lead to the belief that structural change must have occurred at that time. A shift variable added to the above equation does not perform well in single-equation estimates, however; it will be tested further within a structure. A third alternative, which gives the highest degree of explanation, is

$$X = X(r,\ r_d,\ X_{t-2},\ S)$$

Just as in the postwar case, however, the extremely close relationship between the interest rate and the discount rate may be a source of error due to multicollinearity and therefore may compromise the usefulness of this formulation. Finally, the tests performed on the prewar data indicate that a lagged response of the geometrically-decaying type may be present.

In the next chapter, the results obtained here will be put to use in constructing and estimating variants of a structural demand-supply model of the monetary sector.

CHAPTER IV

STRUCTURAL ESTIMATES OF DEMAND AND SUPPLY FUNCTIO FOR THE MONETARY SECTOR

Throughout this study, emphasis has been placed importance of making structural, rather than single e estimates of functional relationships, if an interac tem of equations is believed to be the true represen that part of the real world being studied. Having c preliminary single-equation evidence in support of o hypothesis, we are now ready to try a structural app the monetary sector of the economy. We do so by set a simple supply-demand model of this sector and ther its coefficients by simultaneous methods. After pre and discussing these estimates for both the post- ar World War II periods, we conclude this chapter with of the effectiveness of the structural model in prec income velocity of money over the periods studied, plications of the model for Friedman's assertions c demand-for-money functions.[1]

The analysis and results discussed in this cha .then, form the central part of this study. We have

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[1]Friedman, "The Demand for Money: Some Theore Empirical Results," op. cit. See Chapter II for a c of Friedman's position.

at length the increasing emphasis on the concept of simultaneity, the development of new statistical tools, and the failure to apply these concepts and tools to the monetary sector. The contribution of this study is measured by the extent to which we are able to show that simultaneity does exist in the monetary sector, and by the degree of success achieved by our formulation in at least suggesting a more satisfactory approach than has been used until now. While it is felt that a positive contribution is made, it is also recognized that the model used below neglects to account for some significant relationships. A discussion of this problem, and suggestions for improvement, are contained below and in the final chapter of the study. Thus the present approach lacks generality, but is useful as an indication of the lines along which a more general model might be developed.

A. The Basic Structural System

We begin by postulating a structural model in which the number of endogenous variables is such that a reasonable degree of realism is achieved for the monetary sector without having to resort to a large macroeconomic model. The smallest conceivable structural model would be a self-contained supply-demand structure; the model used for this study is made somewhat more realistic by including income as an endogenous variable, together with the money stock and a short-term interest rate.

The model may be stated in its most general form as follows:

$$M^D = M(r,\ Y,\ NW,\ M_{lagged},\ S_1,\ S_2,\ S_3)$$

$$M^S = M^* \cdot X(Z,\ X_{lagged},\ S_4,\ S_5)$$

$$Y = Y(E,\ NW,\ Y_{lagged},\ S_1,\ S_2,\ S_3)$$

$$X \equiv \frac{M}{M^*}$$

$$Z \equiv (r - r_d)$$

where Y stands for total income or output, E represents exogenous expenditure, NW stands for net worth, and the S_i in the demand and income functions are seasonal shift variables. All variables are in current prices. In the supply function, S_4 and S_5 are the shift variables used to account for structural change in the single-equation regressions discussed in Chapter III. While they have been renumbered for notational convenience, they still refer to the same time periods as previously: S_4 is zero from 1946 IV through 1953 II and from 1959 I through 1959 IV and is unity from 1953 III through 1958 IV; S_5 is zero from 1946 IV through 1958 IV, and is unity from 1959 I through 1959 IV. We assume that there are no seasonal shifts in supply.[1] The seasonal shift

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[1]Any seasonal change in funds supplied by the commercial bank is assumed to be accounted for by the seasonal shift variables in the demand function. An argument can be made for including seasonal variables in the supply function on the grounds that the Federal Reserve System supplies reserves

variables in the demand and income equations are unity in the quarter corresponding to their subscript, and zero otherwise; thus we "normalize" on the fourth quarter. Precise definitions of the variables used are given in the Appendix.

While the existing literature, and our own single-equation experiments, have indicated that certain variables should be included in these functions (such as r and Y in the demand-for-money function and shift variables in the supply function), the decision as to whether or not others are empirically useful will be based upon structural tests. In this category fall net worth in the demand function, the lagged variables in the supply and demand functions, and the return-cost variable Z (as opposed to unrestricted estimates on r and r_d). Before presenting the results of these tests, we shall discuss the theoretical basis for the demand and income functions.

1. Specification of the Demand-for-Money Function

In specifying the demand-for-money function to be used in the structural model, we draw heavily upon the recent work

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(at Christmas, for example) in anticipation of a seasonal increase in demand. One preliminary structural test was made in order to determine whether or not seasonal shift variables in the supply function make a significant contribution to the explanation of the variance of X. While the results are not reported here, the coefficients of the shift terms were considerably smaller in absolute value than their standard error, and no contribution to the degree of explanation achieved was made. Based upon these empirical results, it was concluded that the supply mechanism does not exhibit significant seasonal changes.

of Tobin.[1] The demand for money is usually thought of as arising from two properties of money: its usefulness as a medium of exchange and as a store of value over time. It is important for out later discussion to note that the latter characteristic is shared by many other portfolio assets, while the former is unique. These two properties imply two possible motives for demanding money, which we may label transactions demand and asset (or investment) demand, following the practice of most writers on the subject. We shall discuss each of these possible aspects of the demand for money, and then derive a demand-for-money function based upon the results of our discussion. Our conclusion will be that demand for money as a means of holding wealth cannot rationally be shown to exist, given the array of portfolio assets available; however, demand for money for transactions purposes is rational, and this demand is a function of income, the interest rate, and transactions cost.

Transactions demand. The transactions demand for money arises because of two factors: money's unique characteristic as a means of payment, combined with the imperfect synchronization between the flow of income into the household or business enterprise and the requirements for payment of obligations.

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[1] James Tobin, "The Interest-Elasticity of Transactions Demand for Cash," Review of Economics and Statistics (XXXVIII), August, 1956, pp. 241-247; James Tobin, Unpublished Monetary Manuscript.

While money is useful in facilitating transactions, it is a sterile asset yielding no satisfaction directly. Thus if all receipts and expenditures were perfectly synchronized, money used for transactions would be held only for a moment.

It is illegitimate to infer directly from the above that money is therefore held by economic units because of the imperfect synchronization of receipts and expenditure requirements. It may be so held. However, it is usually possible for an economic unit to anticipate its future income flows and expenditure requirements with fair accuracy. During some periods, expected income will be greater than expected expenditure requirements so that a relatively large amount of cash on hand over some period will be expected, and conversely. It is possible to invest surplus cash in highly liquid, perfectly safe, income-earning assets; time deposits or short-term government securities are good examples. Therefore it appears to be irrational to hold transactions balances in cash, since such balances can be invested in this manner when received and converted back into cash immediately when needed.

Before discussing the nature of this investment decision more precisely, it should be pointed out that the transactions motive for holding highly liquid assets, perhaps including money, applies both to transactions on current account and on capital account. As Tobin demonstrates, costs and imperfections in the market may result in occasional accumulations of cash

in the permanent portfolio.[1] However, the same opportunities for investment of such balances in income-earning assets as above exist here.

Our discussion implies that all cash balances which arise from receipts exceeding expenditures and which do not become part of the permanent portfolio through investment in longer-term commitments should be immediately deposited in a savings account or invested in short-term securities until needed for transactions use. This would be true if such movements were costless. If, however, there are brokerage charges, bank service charges, etc., which apply, it may be economical to hold cash, expecially if interest rates are low relative to these costs.

The considerations which enter into such a decision have been discussed rather thoroughly by Tobin.[2] He has derived expressions for an individual's average holdings of "deposits" (a riskless, interest-bearing alternative to holding cash; Tobin calls these assets "bonds"), and the revenue and total profit resulting from such holdings, all based upon a given number of transactions (n) and upon the case in which one

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[1] Tobin, Unpublished Monetary Manuscript, Chapter IV, pp. 23-25.

[2] Tobin, "The Interest Elasticity of Transactions Demand for Cash," op. cit.; Tobin, Unpublished Monetary Manuscript, Chapter IV. See also William J. Baumol, "The Transactions Demand for Cash: and Inventory Theoretic Approach," Quarterly Journal of Economics (LXVI), November, 1952, pp. 545-554.

income payment is received at the beginning of the period and is disbursed at an even rate throughout the period. We will not reproduce his work here but will base our derivation of the demand-for-money function upon a generalization of his discussion.[1]

We suppose an individual economic unit to receive an income of Y_i during one year; this income is received in f equal installments, so that an amount of income expressed by $y \equiv \frac{Y_i}{f}$ is received at the beginning of each "income period," the period over which decisions concerning the relative holdings of cash and deposits areto be made. Since r will represent the level of the rate of interest, the effective rate for decisions over the income period will be $r^o \equiv \frac{r}{f}$. We begin by considering the case in which there is a fixed charge, a, and a variable charge per dollar transacted, b, for each transaction into and out of bonds. It is clear that there must be at least two transactions (into and out again) per income period if there are to be any at all. Also, no transactions will occur unless the effective rate of interest for the period is such that deposits can be held long enough to earn at least 2b, the round-turn transactions charge, per dollar. Thus, we may rewrite Tobin's formulations as follows:

$$D(n)_i = \left(\frac{n-1}{2n}\right) y_i \left(1 - \frac{2b}{r^o}\right)^2 \quad (n \geq 2), \ (r^o \geq 2b)$$

$$R(n)_i = \left(\frac{n-1}{2n}\right) y_i r^o \left(1 - \frac{2b}{r^o}\right)^2 \quad (n \geq 2), \ (r^o \geq 2b)$$

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[1] I am indebted to Professor Albert Ando for the derivation of the following relationships.

$$\pi(n)_i = \left(\frac{n-1}{2n}\right) y_i r^o \left(1 - \frac{2b}{r^o}\right)^2 - na$$

where $\bar{D}(n)_i$, $R(n)_i$, and $\pi(n)_i$ refer to average deposits, revenue, and profit for n transactions ($n \geq 2$).

A profit-maximizing individual will increase the number of transactions until a negative profit increment results. That is, he will increase n as long as

$$\pi(n)_i - \pi(n-1)_i > 0$$

Thus we find

$$\pi(n)_i - \pi(n-1)_i = \left\{\left[\left(\frac{n-1}{2n}\right) y_i r^o \left(1 - \frac{2b}{r^o}\right)^2 - \frac{1}{2}\left(\frac{n-2}{n-1}\right) y_i r^o \left(1 - \frac{2b}{r^o}\right)^2\right] - an + a(n-1)\right\} > 0$$

$$= y_i r^o \left(1 - \frac{2b}{r^o}\right)^2 \left(\frac{1}{2n(n-1)}\right) - a > 0$$

When the number of transactions is increased to the point where $\pi(n)_i - \pi(n-1)_i = 0$, the above inequality becomes an equality and we may write

$$\frac{y_i r^o}{2a}\left(1 - \frac{2b}{r^o}\right)^2 = n(n-1)$$

Substituting, we find that $\pi(n)_i - \pi(n-1)_i = 0$ when

$$\frac{Y_i r \left(1 - \frac{2bf}{r}\right)^2}{2af^2} = n(n-1)$$

As a first approximation, we substitute n^2 for $n(n-1)$; solving for estimated n gives

$$\bar{n} \simeq \frac{1}{f}\left(1 - \frac{2bf}{r}\right)\sqrt{\frac{Y_i r}{2a}}$$

Thus the number of transactions will be expected to be an increasing function of income and the rate of interest, and a decreasing function of the frequency of payments and transactions costs. There are two general possibilities for n^*, the optimal number of transactions in a payment period. Either we will have $n^* = 0$, in which case the average cash holding, $\bar{C}_i$, must be $\frac{y_i}{2}$ (or $\frac{Y_i}{2f}$) under the circumstances we have assumed, or we will have $n^* > 2$, in which case $\bar{C}_i = \frac{y_i}{2\bar{n}} = \frac{Y_i}{2f\bar{n}}$.

Given these relationships, we may now investigate the nature of the ith individual's money-demand function under the assumptions we have set up concerning the payment and disbursement of income. For simplicity, we will set b=0 and assume that only a fixed charge per transaction applies. We know that

(1) $\bar{C}_i = \frac{y_i}{2} = \frac{Y_i}{2f}$ if no movements into and out of bonds occur, or

$\bar{C}_i = \frac{y_i}{2\bar{n}}$ if bonds are held. We have shown above that

$\bar{n} = \frac{1}{f}\sqrt{\frac{Y_i r}{2a}}$; therefore,

(2) $\bar{C}_i = \frac{yf}{2}\sqrt{\frac{2a}{Y_i r}} = \frac{Y_i}{2}\sqrt{\frac{2a}{Y_i r}} = \sqrt{\frac{Y_i a}{2r}}$

For an individual profit-maximizing economic unit, then, one or the other of the above rules will be applicable with

respect to cash balances. If frequency of payment is high, annual income low, or if the rate of interest on deposits relative to transactions costs is very low, it may not pay to hold deposits at all. If it becomes profitable to hold deposits, however, Equation (2) should apply. Before investigating the means by which an aggregate demand-for-money function can be derived from these microeconomic formulations, we shall discuss liquidity preference and its relationship to the demand for money.

Asset demand. Keynesian "liquidity preference" states that an individual asset holder will tend to shift out of bonds when the capital value of bonds is expected to fall due to an expected rise in the interest rate, and conversely. Most investigators have made the inference that the choice facing such asset holders is between bonds and money. Money is assumed to be demanded as a means of holding assets, and the stock of money net of transactions requirements is assumed to vary inversely with the interest rate.[1]

As Tobin points out, this inference is valid only if there exists no alternate means of holding assets which is equivalent or superior to money in every respect for this purpose.[2] However, we have already mentioned time deposits as a perfectly

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[1]Cf. the discussion in Chapter II of the present study and the references to the empirical literature cited there. Among the theoretical discussions using this approach, Franco Modigliani, "Liquidity Preference and the Theory of Interest and Money," Econometrica (XII), 1944, reprinted in F. A. Lutz and L. W. Mints, ed., Readings in Monetary Theory (New York: The Blakiston Company, 1951), pp. 186-239, is an early example.

[2]Tobin, Ibid.

liquid means of holding assets, free from risk of capital loss due to interest rate change, and having the added advantage of earning a positive return. For the purpose of holding assets without risk of capital loss, therefore, time deposits appear to dominate money, to use Tobin's terminology.[1] This demonstrates the essentially different nature of the transactions and asset demands. Insofar as a transactions demand exists, it must be satisfied ultimately by money because of the unique character of money as a medium of exchange, although the gap between receipt and requirements for expenditure may be bridged by converting transactions balances into time deposits, bonds, etc. An asset demand for money, if it existed, would arise because of the store-of-value characteristic of money. This characteristic is shared by many other assets which therefore compete with money for this purpose. Given the existence of an asset or assets which dominate money as a means of holding wealth, we conclude that asset demand for money cannot rationally be shown to exist.

This conclusion is consonant with the theory of asset choice under risk developed by Tobin.[2] He concludes that a risk-avoider will choose to hold part of his portfolio in riskless assets. This may, but need not, include money. If assets which dominate money are available, they will rationally be held instead.

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[1]Tobin, Unpublished Monetary Manuscript, Chapter IV, pp. 25-26.

[2]Tobin, "Liquidity Preference as Behavior Toward Risk," Review of Economic Studies (XXV(2)), February, 1958, pp. 65-86.

Specifying the aggregate demand function. We have concluded that a transactions demand for cash balances exists as long as there are positive costs associated with the conversion of moneh income into other assets, and that the existence of an asset demand for money balances has no rational basis. The transactions demand for a rational, profit-maximizing individual was seen to be represented by alternative rules, the choice of the rule being governed by the profitability of investing a portion of income in deposits. The two rules were

$$(1) \quad \bar{C}_i = \frac{Y_i}{2f}$$

$$(2) \quad \bar{C}_i = \sqrt{\frac{Y_i a}{2r}}$$

Of course, these rules apply strictly only under the assumed conditions (complete rationality, even disbursement of income, etc.). In addition, they are microanalytic, whereas we require an aggregate model. The problem, then, is to go from this oversimplified microeconomic model to an adequate macroeconomic representation.

We shall make this step by using the above model as a basis and making approximations which will adapt it for use as a macroeconomic model of the real world and which are convenient for estimation. First, we find the aggregate demand simply by summing the demand of all individual units. However, we noted above that a rational individual's demand will be based upon different "rules" depending on such factors as income, payment frequency, relationship between transactions cost and interest rate, etc. In addition, we cannot expect the assumptions upon which these rules are

based to be fulfilled in the real world. Therefore we may approximate the demand for money over time of an individual by the following expression, in which the frequency of payment and the cost of transactions are considered to be institutionally-determined constants:

$$C_i = \xi_o \, r^{\xi_1} \, Y_i^{\xi_2}$$

We assume that the aggregation problem presented by the fact that response parameters differ among individuals can be ignored, and we represent the aggregate demand for money by the following approximation:

$$\sum_i C_i = M \cong \gamma_o r^{\gamma_1} Y^{\gamma_2}$$

In estimating this function as part of our structural model, we try alternative approaches. An obvious possibility, of course, is to perform a linear estimate on the logarithms of the variables; that is, the above expression is equivalent to

$$\ln M = \ln\gamma_o + \gamma_1 \ln r + \gamma_2 \ln Y$$

Most of the estimates which are reported below include this form of the demand function.

As the other alternative, we may approximate the relationship by considering the demand for money to be a product of a function of the interest rate and a function of income. Holding income constant, the relationship between M and r may be approximated by expanding r^{γ_1} using a Taylor series.

We have

$$f(r) = r^{\gamma_1}$$

If we expand about some rate $r = r_o$, we have

$$f(r) = f(r_o) + f'(r_o)\ (r-r_o) + \frac{f''(r_o)}{2!}\ (r-r_o)^2 + \ldots .$$

in the usual fashion. As a rough approximation, this series may be truncated after the first-order term, and we have

$$f(r) = r_o^{\gamma_1} + \gamma_1\ r_o^{\gamma_1 - 1}\ (r-r_o)$$

$$= \alpha + \beta_1 r$$

Examining the money-income relationship while holding r constant, we would expect the demand for money to be a positive function of income, although neither a proportional nor a square-root relationship would be anticipated as the "true" demand function of an individual, since, as noted above, different money-demand "rules" may apply depending upon the circumstances. However, it seems reasonable to expect an individual's transactions demand to be approximately zero if income is zero, and the alternative rules given above suggest that the demand for money ought to rise somewhat less than proportionately with income, resulting in a (hypothetical) demand function which passes through the origin and increases at a decreasing rate.

In the aggregate, however, there is some evidence that the relationship between the income velocity of money and the interest rate is approximately linear over a fairly wide range (although it seems to become asymptotic to both axes, as one would expect).[1] At a given interest rate, this would imply a constant velocity of money; or, in other words, a proportional relationship between M and Y. An observed proportional aggregate relationship is believed to be consistent with a curvilinear individual demand function of the type described because of aggregation effects, systematic shifts in the demand functions, etc. For example, the level of the individual's demand schedule is a positive function of brokerage costs per transaction. If rising income is accompanied by rising costs, as would usually be expected, then observations on the money stocks and income levels of an individual over time would tend to lie in a straight line. This is illustrated in Figure IV.1, where we observe points P_1, P_2, and P_3 in the three successive periods for which Y_1, Y_2, and Y_3 are the individual's incomes. Aggregation may also introduce effects of this kind if there is a positive correlation between the level of individual income and the level of the schedule (due, for example, to systematic changes in taste as income increases).

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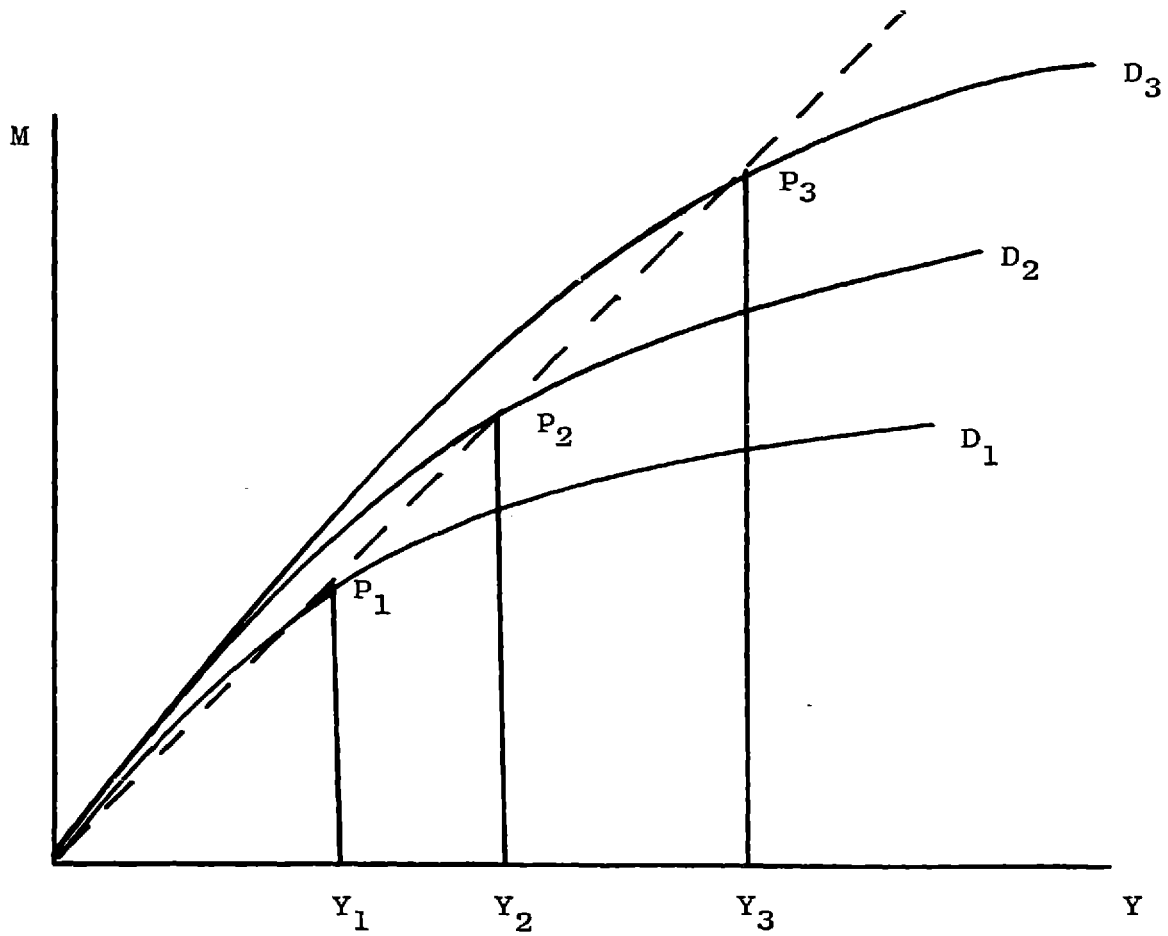
[1] On this point, see Henry A. Latane, "Cash Balances and the Interest Rate--a Pragmatic Approach," Review of Economics and Statistics (XXXVI), November, 1954, pp. 456-460; and Andrew C. Stedry, "A Note on Interest Rates and the Demand for Money," Review of Economics and Statistics (XLI), August, 1959, pp. 303-307.

Therefore it appears that the money-income relationship, holding interest rates constant, may be approximated by $M = \beta_2 Y$. Multiplying the two segments of the money demand function, we have

$$M = (\alpha + \beta_1 r)(\beta_2 Y)$$

$$\text{or} \quad M = \gamma_1 Y + \gamma_2 (rY)$$

Fig. IV.1: The Demand for Transactions Balances of an Economic Unit at a Given Rate of Interest, with Systematic Shifts in the Demand Function



In the structural system, this demand function is modified by adding dummy variables to account for seasonal changes in the relationship. This is necessary because the data used for estimation are not adjusted for seasonal variation. If there are seasonal shifts in money-holding habits (such as an increased willingness to hold cash at a given level of the interest rate and income during the Christmas season, for example), specification error is introduced by using such data, unless variables which account for the seasonal shifts are added. We shall also perform an estimate which includes a linear net worth term, to investigate the empirical significance of the transactions demand arising from adjustments in the permanent portfolio.

Single-equation experiments relative to the lag structure of money demand have not been made to the extent that they were done for money supply. Instead, two types of demand function have been estimated within the structure. The first is of the general form given above; no lags are included. In the second, the dependent variable lagged is included as an explanatory variable as a proxy for a geometrically-decaying distributed lag.

2. Specification of the income equation

The income equation, which specifies that income is a linear function of current exogenous expenditure and net worth as well as lagged income (added to increase the

efficiency of the estimates), is the resultant of a simple open Keynesian consumption-investment model.[1] The following variables are needed for this model:[2]

Y: Gross national produce

Y_d: Disposable income

C: Private consumption expenditure

I: Gross private domestic investment

Ex: Exports of goods and services

Im: Imports of goods and services

G: Government purchases of goods and services, at all levels (Federal, state, and local).

Tx: Total taxes (direct plus indirect corporate and personal taxes)

Tr: Transfer payments plus net interest paid by government

D: Depreciation allowances

CP: Undistributed corporate profits

SI: Total social insurance contributions

IV: Inventory valuation adjustment

NW: Net worth

In this simple model, private domestic investment, exports of goods and services, and government expenditures at all levels are taken to be exogenous. The consumption

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[1]Note that the current value of net worth is taken to be as of the beginning of the current quarter, for the postwar data, and as of the beginning of the current year, for the prewar period, while other stock variables refer to the end of the period.

[2]Precise definitions and sources for these series are given in the Appendix.

function is similar to the Modigliani-Brumberg-Ando formulation, being specified so that consumption is a function of net worth as well as disposable income.[1] Imports, all taxes, transfers, undistributed corporate profits, and social insurance contributions are assumed to be linear functions of gross national product, while depreciation is assumed to be a linear function of net worth, and the inventory valuation adjustment is made a linear function of the change of gross national product. Thus we have the following system (disregarding the constant terms in all but the final income equation for notational convenience):

a. $Y \equiv C + I + (Ex - Im) + G$

b. $C = \beta_1 \bar{Y}_d + \beta_2 \bar{NW}$

c. $Y_d \equiv Y - \bar{Tx} + Tr - D - CP - SI - IV$

d. $Tx = \beta_3 Y$

e. $Tr = \beta_4 Y$

f. $D = \beta_5 \bar{NW}$

g. $CP = \beta_6 Y$

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[1] Franco Modigliani and Richard Brumberg, "Utility Analysis and the Consumption Function; an Interpretation of Cross-Section Data," Post-Keynesian Economics, Kenneth K. Kurihara, editor (New Brunswick, N.J: Rutgers University Press, 1954), pp. 388-436; Franco Modigliani and Albert Ando, "The 'Permanent Income' and the 'Life Cycle' Hypothesis of Saving Behavior: Comparison and Tests," Study of Consumer Expenditures, Income, and Savings, Vol. II, Irwin Friend and Robert Jones, editors, (Philadelphia: University of Pennsylvania, 1960), pp. 49-174; Albert Ando and Franco Modigliani, "The 'Life Cycle' Hypothesis of Saving: Aggregate Implications and Tests," mimeographed paper, 1962.

h. $SI = \beta_7 Y$

i. $IV = \beta_8(Y - Y_{t-1})$

j. $Ex = \bar{E}x$

k. $Im = \beta_9 Y$

l. $I = \bar{I}$

m. $G = \bar{G}$

n. $C = \beta_1(Y-\beta_3 Y+\beta_4 Y-\beta_5 NW-\beta_6 Y-\beta_7 Y-\beta_8 Y+\beta_8 Y_{t-1}) + \beta_2 NW$

$= \beta_1 Y-\beta_1\beta_3 Y+\beta_1\beta_4 Y-\beta_1\beta_6 Y-\beta_1\beta_7 Y-\beta_1\beta_8 Y+\beta_1\beta_8 Y_{t-1}+(\beta_2-\beta_1\beta_5)NW$

o. $Y = Y\beta_1(1-\beta_3+\beta_4-\beta_6-\beta_7-\beta_8) + \beta_1\beta_8 Y_{t-1}+(\beta_2-\beta_1\beta_5)NW + \bar{I}$

$+\bar{E}x + \bar{G} - \beta_9 Y$

p. $Y[1-\beta_1(1+\beta_3-\beta_4+\beta_6+\beta_7+\beta_8)+\beta_9] = \bar{I} + \bar{E}x + \bar{G} + (\beta_2-\beta_1\beta_5)NW$

$+ \beta_1\beta_8 Y_{t-1}$

q. $E \equiv \bar{I} + \bar{E}x + \bar{G}$

r. $$Y = \alpha + \frac{E}{[1-\beta_1(1-\beta_3-\beta_4+\beta_6+\beta_7+\beta_8)+\beta_9]} + \frac{(\beta_2-\beta_1\beta_5)NW}{[1-\beta_1(1+\beta_3-\beta_4+\beta_6+\beta_7+\beta_8)+\beta_9]}$$

$$+ \frac{\beta_1\beta_8 Y_{t-1}}{[1-\beta_1(1+\beta_3-\beta_4+\beta_6+\beta_7+\beta_8)+\beta_9]}$$

Seasonal influences must again be taken into account, so seasonal dummy variables are introduced multiplicatively into the lag term for this purpose. A word of caution

concerning the coefficient of the lagged income term is in order. As the model stands, lagged income enters only through the expression for inventory valuation adjustment. However, the estimated coefficient of lagged income is quite large in value as well as being about four times as large as its standard error (see Equation IV.1c below). Therefore it is felt that a broader interrelation of the role of this variable is warranted. This is a short-term equilibrium model, and we view the variable Y_{t-1} as a variable through which a closer approximation to an equilibrium position can be achieved in the estimates.

Therefore the structural model which we have postulated consists of three structural equations--the demand, supply, and income functions--plus two identities needed to close the system.

3. Conceptual advantages

A construct of this type enables us to account for two basic sorts of interaction which all single-equation demand-for-money studies are forced to ignore. First, and perhaps most obvious, is the interaction between the stock of money and the rate of interest. There is little doubt (at least among non-Friedmanites) that the demand for money balances responds to the rate of interest, and this relationship is reflected in almost all studies of the demand for money, including the present one. But to say that the rate of interest is unaffected by the stock of money, as those who favor the

single-equation approach must do, is to neglect a basic relationship of the monetary sector.[1] For while the long-run level of the rate of interest is undoubtedly influenced by factors such as productivity, thrift, etc., its shorter-run movements are caused by, and react back upon, shifts in both demand and supply in the monetary sector. It has been demonstrated that simultaneous-equations bias due to this error of specification can be avoided by regressing the interest rate on the stock of money and other variables, but this procedure carries with it the assumption that the stock of money is set exogenously with respect to the rate of interest. Our single-equation supply tests, as well as the structural evidence to be discussed below, indicate that this is not the case, and therefore the stock of money and the rate of interest must be considered to be interacting (endogenous) variables, explained simultaneously by a set of interacting equations.

A second type of interaction which a structural model is capable of taking into account is that of the money stock and interest rate with income. In making income an endogenous variable, our model recognizes this interrelationship; however, the treatment of investment as an exogenous variable results in one-way causality from the income equation to the rest of the model, with no true interaction; income, in other words, is a function of exogenous variables only, and,

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[1]For example, see Bronfenbrenner and Mayer, op. cit.

according to our model, the first derivatives of income with respect to the money stock and the interest rate equal zero.[1] To the extent that two-way causal relationships between money, the rate of interest, and income exist, our failure to recognize them introduces bias into the estimates. Even in a preliminary investigation such as this, in which our immediate objective is to construct a model describing relationships in the monetary sector without constructing a general and inclusive model of the economy, we are justified in disregarding these interrelationships only if the amount of bias thereby introduced is relatively small.

It is believed that this is the case in our short-run, quarterly model. Changes in monetary conditions affect income chiefly through interest-rate effects on investment. Thus the changes in the short-term rate which our model accounts for must work themselves through the whole spectrum of interest rates before their total effect on investment decisions can begin to be felt. Even then, some time will elapse before investment decisions can be put into effect and be reflected in income. This is our justification for assuming in this study that changes in current levels of the money stock and interest rate have no effect on current income. On the other hand, it is assumed that changes in current income have a more

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[1]The current value of net worth includes the money stock. However, net worth for a given period is measured at the period's beginning, while the other variables are taken as of the end of the period. In effect, the stock of money included in the net worth term is M_{t-1}; therefore, net worth is considered to be exogenous.

or less immediate effect on the demand for money stocks and therefore, on the rate of interest. A more extended discussion of the implications of our model, and suggestions for improvement, will be found in Chapter VII. The point to be made here is that single-equation models fail even to recognize all of these interactions. We are able to take them into account in as small a model as this by making investment and net worth exogenous plus using the convenient simplifying assumption that a single rate of interest (in this case, the short-term rate) operates in all of the relationships. This should be true of the supply function, and as a first approximation, it should be representative of business demand for liquid balances; it may be least accurate in terms of household demand. While it would have been possible to use both short-term and long-term rates, doing so would have required additional structural equations to relate them to one another and might introduce problems of estimation due to the high intercorrelation among the various rates of interest. Since these rates are so closely related, using a single rate in all equations as a first approximation probably does not introduce an excessive amount of error. In order to keep the structure as simple as possible, therefore, the alternative of using only one rate of interest in the model was chosen.

4. Nonlinearity in the structural model

In discussing such features of this model as the identification of structural equations, we are treating it as though

it were completely linear. However, the model is not linear in that it contains the variable $\frac{M}{M^*}$, the multiplicative lag terms in the income function, the variable rY in one of the forms of the demand function as well as r and Y separately, etc. Strictly speaking, identification criteria, as well as the properties which two-stage least squares estimates are known to possess, apply only to linear models.

Fisher has recently derived the necessary and sufficient conditions for identification of certain types of nonlinear structural equations.[1] Our structural equations appear to satisfy these conditions, and so the identification of each is established simply by defining new variables for each of the nonlinear terms, substituting these new variables, and treating the system as though it were linear.

The use of a nonlinear model involves some compromises; the precise properties of these estimates are not known, and we simply infer that they may be similar to those possessed by two-stage least squares estimates of linear systems. The most difficult problem is presented by the variable $\frac{M}{M^*}$, which is the ratio of an endogenous variable to an exogenous variable. We have treated the ratio, designated X, as a new endogenous variable. It will be noted that M^* never occurs

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[1] Franklin M. Fisher, "Identifiability Criteria in Nonlinear Systems," Econometrica (XXXIX), October, 1961, pp. 574-590.

in the model except as the denominator of this ratio; this raised the question of whether M^* should be treated as a separate exogenous variable in the first stage of the two-stage least squares regression procedure. It was decided to include it. A few regressions in which it was omitted were done, and it was found that only small changes occurred in the estimates. In all of the structural estimates reported below, then, M^* is included as a separate exogenous variable in the first stage of the two-stage procedure.

B. The Results of Empirical Tests

Several simultaneous estimates of variants of the basic model given above have been made, and are discussed below. The method of estimation used was two-stage least squares. Because some of the data required were unavailable for some periods, these structural estimates cover a somewhat shorter time span, and include fewer observations, than did the supply estimates discussed in Chapter III. The postwar estimates are quarterly, and include 49 observations. Because quarterly observations on some variables were not available, the prewar estimates are based upon midyear observations for each year over the period 1924-1941 and thus include 18 annual observations.

Certain conventions will be followed in setting out the results of the structural estimates in this chapter. In general, the approach which has been followed in making these tests has been to start with an estimate of that variant of

the general model which conforms most closely to the results of our single-equation tests and *a priori* reasoning, and then to test modifications of this model. These modifications generally result from aspects of the structure for which it is felt that the single-equation tests did not provide conclusive answers (such as lag structure, for instance) or from unsatisfactory results in the initial structural estimates. Since each structural estimate of any of the structural equations depends upon the specification of the entire system, it will not be convenient to use the tabular form of presentation employed in Chapter III for the single-equation results. Rather, each particular model estimated will first be set out in general form, after which the results of the two-stage least squares estimates will be written down directly in the form of linear relationships between each dependent variable and its functional arguments. For the cases in which the demand function is estimated using alternatively a function which is linear in the untransformed variables and one which is linear in the logarithms, we shall present the results using the untransformed variables first, followed by the results based on logarithmic transformation; the latter results will be numbered by a prime to differentiate them from the former. Following the presentation of the data, there will be a brief discussion of the usefulness of the results in terms of the criteria which were established in Chapter III. Among the several estimates made, one will finally be selected as being

the most satisfactory, based upon these criteria, and will be used as a basis for a discussion of the efficiency of monetary policy in Chapter VI.

In the discussion of appropriate criteria for discriminating among regression tests in Chapter III, some reservation concerning the use of these tests on structural equations was expressed. We reiterate these reservations here. As was mentioned above, they are due to the fact that such tests are based upon finite sample sizes, while for simultaneous estimates of structural systems, only asymptotic properties (i.e., those involving infinite sample sizes) are known. Therefore such tests can only be considered to be suggestive and not conclusive in judging structural estimates, and a good deal of reliance must be placed upon the proper a priori specification of the structural model.[1]

In writing the general form of the models to be tested, only the structural equations will be included. The two endogenous variables X and Z, when they appear, will always have the same meaning:

$$X = \frac{M}{M^*}$$

$$Z = (r - r_d)$$

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[1]Discussions of these tests and their applications are available in many textbooks on statistics and econometrics. For example, see Lawrence Klein, A Textbook of Econometrics (Evanston, Illinois: Row, Peterson and Company, 1953), Chapter 3; Lawrence Klein, An Introduction to Econometrics (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962), esp. Chapters 2 and 6; Henri Theil, Economic Forecasts and Policy (Amsterdam: North-Holland Publishing Company, 1961); J. Durbin and D.S. Watson, "Testing for Serial Correlation in Least Squares Regression, II," Biometrika, June, 1951, pp. 159-178.

Thus most models will have five endogenous variables: the two above plus the money stock, the interest rate, and income (or functions of these variables). The only exception will be the structure containing a money-supply function in which the interest rate and the discount rate enter as separate variables; in that case, the endogenous variables will be M, r, Y, and $\bar{X}$, or functions of them. In each model which is estimated, every equation is overidentified by the usual criteria applied in the manner discussed by Fisher.[1]

1. 1946-1959

The first model which was fitted to the postwar data contains the following structural equations:

$$\text{(Model IV.1)} \quad M = M[r, (rY), S_1, S_2, S_3]$$
$$X = X[Z, S_4, S_5]$$
$$Y = Y[E, NW, Y_{t-1}, (S_1Y_{t-1}), (S_2Y_{t-1}), (S_3Y_{t-1})]$$

or, alternatively

$$\text{(Model IV.1')} \quad \ln M = M'[\ln r, \ln Y, S_1, S_2, S_3]$$
$$X = X[Z, S_4, S_5]$$
$$Y = Y[E, NW, Y_{t-1}, (S_1Y_{t-1}), (S_2Y_{t-1}), (S_3Y_{t-1})]$$

Estimating this system gives the following results:

$$\text{(IV.1a)} \quad M = \underset{(2.1362)}{67.2713} \underset{(.0012)}{-.0055(rY)} \underset{(.0083)}{+.1769Y} \underset{(.7503)}{-1.8217S_1} \underset{(.7157)}{-2.2367S_2} \underset{(.7488)}{-1.1969S_3}$$

$$R^2 = .978$$
$$DW = .540$$

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[1] Fisher, op. cit.

$$(IV.1b)\quad X = \underset{(.0071)}{.8528} + \underset{(.0167)}{.0719}Z + \underset{(.0098)}{.0334}S_4 + \underset{(.0180)}{.1267}S_5 \qquad R^2 = .716,\ DW = 1.510$$

$$(IV.1c)\quad Y = \underset{(4.0813)}{38.7170} + \underset{(.0837)}{.7801}E + \underset{(.0118)}{.0967}NW + \underset{(.0741)}{.2995}Y_{t-1} - \underset{(.0062)}{.1017}(S_1Y_{t-1}) - \underset{(.0048)}{.0583}(S_2Y_{t-1}) - \underset{(.0043)}{.0694}(S_3Y_{t-1}) \qquad R^2 = .998,\ DW = 1.719$$

Using the logarithmic form of the demand function, we find

$$(IV.1a')\quad \ln M = \underset{(.1085)}{2.0781} - \underset{(.0104)}{.0484}(\ln r) + \underset{(.0196)}{.4759}(\ln Y) - \underset{(.0060)}{.0129}S_1 - \underset{(.0057)}{.0160}S_2 - \underset{(.0059)}{.0092}S_3 \qquad R^2 = .979,\ DW = .694$$

Number of observations: 49

Period covered: 1946 IV-1959 IV

Since the change from Equation IV.1a to Equation IV.1a' introduces no new exogenous variables into the structure, the supply and income estimates are unchanged.

Several aspects of this estimate are of interest. In the demand-for-money equations (Equations IV.1a and IV.1a'), the coefficients of the terms in r and Y are all significant by the t-test and display the expected signs. The signs of the coefficients of the seasonal variables are all negative, indicating that the demand for money is seasonally highest in the fourth quarter of the year, a result which we would expect due to the holiday season. The only nonsignificant coefficient in either demand estimate is that of S_3; it is about 1.6 times

as large as its standard error in both equations. Only two per cent of the variance of M (or ln M) is left unexplained by the demand function. However, the values of the Durbin-Watson statistics are such as to indicate the presence of significant serial correlation in the residuals of both estimates.

In the supply equation (IV.1b), all of the signs are positive, as expected. Estimated within this structure, the coefficient of Z attains a higher level of significance than its single-equation counterpart, being 4.3 times its standard error here, and 3.3 times its standard error in the single-equation tests. The level of explanation also improves, with 72 per cent of the variance of X being explained, as against 67 per cent in the single-equation formulation (see Equation III.2.6). There is no significant serial correlation in the residuals.

The income equation performs extraordinarily well, with expected signs in agreement with the signs of the regression coefficients of exogenous expenditure, net worth, and lagged income. Again, the signs of the seasonal terms indicate that income is seasonally highest in the fourth quarter. All coefficients are highly significant, and 99.8 per cent of the variance of Y is explained.

The next model to be tested is identical to Model IV.1 except that net worth is added to the demand function as a

means of taking into account transactions demand arising from the permanent portfolio as described above. This model may be written as follows:

$$\text{(Model IV.2)} \quad M = M[r,\ (rY),\ NW,\ S_1,\ S_2,\ S_3]$$
$$X = X[Z,\ S_4,\ S_5]$$
$$Y = Y[E,\ NW,\ Y_{t-1},\ (S_1Y_{t-1}),\ (S_2Y_{t-1}),\ (S_3Y_{t-1})]$$

Since net worth already appeared in the income function, its introduction into the demand function involves no change in the exogenous variables in the system, and the estimates of the supply and income functions are the same as Equations IV.1b and IV.1c above; therefore, we need not repeat them. The demand function is estimated as follows:

$$\text{(IV.2a)} \quad M = \underset{(2.8285)}{72.5590} \underset{(.0013)}{-.0043(rY)} \underset{(.0189)}{+.2066Y} \underset{(.0048)}{-.0160NW} \underset{(1.1245)}{+4.5411S_1} \underset{(1.8511)}{+6.6726S_2} \underset{(.6582)}{-.2495S_3}$$

$$R^2 = .981 \qquad DW = .912$$

In this estimate, the net worth term has a coefficient which is significant by the usual test, being more than twice as large in absolute value as its standard error. However, the sign is negative, rather than positive as would be expected a priori. In addition, the signs of the seasonal variables change (except for S_3), indicating that the demand for money is seasonally higher in the first and second quarters than in the fourth quarter, a result which is contrary to expectation. The problem is probably due to the presence of serious multicollinearity, especially between income and

net worth. Their simple correlation coefficient in this estimate is .977, while that between the money stock and net worth is .949, and between the money stock and income is .980. Since the introduction of net worth into the demand function appears to introduce problems of estimation, and since in any event the transactions demand arising from the management of permanent portfolios would be expected to be relatively small, it appears best to delete net worth from this function.

The investigation of lags. Using Model IV.1 as a point of reference, further structural estimates were made in order to investigate the existence and nature of lags in both the supply and demand functions. It will be recalled that some preliminary single-equation tests were made on the lag structure of the supply function, and it appeared that there was no response lag, based upon quarterly data. Both one-period and distributed lags were investigated. In the single-equation tests, the distributed lag construction performed slightly better than the discrete lag, and in this section of the study we shall only investigate the existence of a distributed supply lag, after which we shall look into the lag structure of money demand by testing a distributed-lag demand model.

Adding a distributed lag term to the supply function of Model IV.1 results in the following model:

(Model IV.3) $M = M[(rY), Y, S_1, S_2, S_3]$

$X = X[\bar{Z}, X_{t-1}, S_4, S_5]$

$Y = Y[E, NW, Y_{t-1}, (S_1Y_{t-1}), (S_2Y_{t-1}), (S_3Y_{t-1})]$

Since data on M*, and hence on X, are unavailable for some quarters during the postwar period, the addition of X_{t-1} to the regression results in the loss of a few of the observations which were included in the structural estimates reported above. Estimating Model IV.3 gives the following result:

$$\underset{(3.4755)}{69.5465} - \underset{(.0015)}{.0041}(rY) + \underset{(.0136)}{.1603}Y + \underset{(1.2163)}{2.1086}S_1 + \underset{(1.8633)}{2.0356}S_2 - \underset{(.7099)}{.7132}S_3 \qquad R^2 = .976,\ DW = .952 \tag{IV.3a}$$

$$\underset{(.1438)}{.8142} + \underset{(.0236)}{.0674}Z + \underset{(.1700)}{.0449}X_{t-1} + \underset{(.0120)}{.0351}S_4 + \underset{(.0269)}{.1226}S_5 \qquad R^2 = .729,\ DW = 1.855 \tag{IV.3b}$$

$$\underset{(4.3776)}{40.0128} + \underset{(.0859)}{.7618}E + \underset{(.0135)}{.1026}NW + \underset{(.0812)}{.2824}Y_{t-1} - \underset{(.0068)}{.1018}(S_1Y_{t-1}) - \underset{(.0051)}{.0612}(S_2Y_{t-1}) - \underset{(.0044)}{.0705}(S_3Y_{t-1}) \qquad R^2 = .998,\ DW = 1.676 \tag{IV.3c}$$

Number of observations: 44

Period covered: 1947 III-1959 IV

In this regression, the only difference from Model IV.1 is the addition of the lag term in the supply function (and, unavoidably, the loss of a few observations); hence, adding X_{t-1} is in the nature of a controlled experiment, enabling us to observe rather precisely the effect of adding the lag term and to make a fairly reliable judgment as to whether its addition to the structure is warranted.

The variable X_{t-1} performs poorly by the standards which we have set up. Its coefficient in Equation IV.3b is only

about one-fourth as large as its standard error. Even though we are wary of depending too heavily on single-equation criteria such as the t-test, this ratio of the coefficient to its standard error is so unfavorable that the exclusion of X_{t-1} from the structure on these grounds alone seems warranted. In addition, however, it adds very little to the degree of explanation achieved by the supply function; the coefficient of determination (R^2) is .716 for Equation IV.1b and rises only to .729 in Equation IV.3b. On the positive side, the sign of X_{t-1} agrees with our expectations, and the addition of this variable improves the Durbin-Watson statistic considerably; indeed, the addition of the dependent variable lagged to a regression is a common method of avoiding serial correlation in regression residuals. However, the Durbin-Watson statistic for Equation IV.1b is already high enough to indicate that serial correlation is absent at the one per cent level of significance, so that this improvement has little significance for the regression.

The effect of adding X_{t-1} on the other regression coefficients is interesting. The other coefficients in the supply equation do not change extensively in value, while the constant term drops in value somewhat. The strongest effect appears to be on the coefficients of the demand equation. The coefficients of both (rY) and Y decline in absolute value, while the signs of the seasonal variables become erratic, and

their coefficients lose significance. Naturally, none of the coefficients in the income equation change at all.

Estimating this form of the supply function within a structure results in some rather striking changes as compared with the equivalent single-equation regression (Equation III.2.6). The two regressions were performed on exactly the same observations, so that the only difference is that one is a structural estimate and the other a single-equation fit. In Equation III.2.6, the coefficient of the lag term is almost as large as its standard error; this led to the judgment that a distributed lag might be present and that the question deserved further investigation. Within the structure, the standard error of this coefficient actually increases, while the coefficient itself decreases in value from .142 to .045. It is also worth noting that 67 per cent of the variance of X is explained by Equation III.2.6, while Equation IV.3b explains 73 per cent of this variance.

Based upon the considerations discussed above, we conclude that the existence of a supply lag is not supported by the empirical data used in the structural tests (we have not reported the results of a regression using the log-linear form of the demand function, since this procedure does not change the estimate of the supply function). Thus Model IV.1 appears to be the most satisfactory representation of the monetary sector found thus far. Next, the presence of a distributed lag in the demand function is investigated. We proceed in

the same fashion as above, adding a distributed lag term to the demand equation of Model IV.1 and comparing the resulting estimate with the estimate of Model IV.1. We therefore define this new model as follows:

$$\text{(Model IV.4)}\quad M = M[(rY),\ Y,\ M_{t-1},\ S_1,\ S_2,\ S_3]$$
$$X = X[Z,\ S_4,\ S_5]$$
$$Y = Y[E,\ NW,\ Y_{t-1},\ (S_1Y_{t-1}),\ (S_2Y_{t-1}),\ (S_3Y_{t-1})]$$

Alternatively, we substitute a log-linear demand function into the above model, with the other equations remaining the same; this gives:

$$\text{(Model IV.4')}\quad \ln M = M'[\ln r,\ \ln Y,\ S_1,\ S_2,\ S_3]$$

Estimating this model results in the following regression equations:

$$\text{(IV.4a)}\quad \underset{}{M} = \underset{(4.9783)}{23.0600} - \underset{(.0007)}{.0025}(rY) + \underset{(.0126)}{.0618}Y + \underset{(.0728)}{.6860}M_{t-1} - \underset{(.7929)}{7.9845}S_1 - \underset{(.4428)}{3.2457}S_2 - \underset{(.4795)}{2.8311}S_3 \qquad R^2 = .992,\ DW = 1.885$$

$$\text{(IV.4b)}\quad X = \underset{(.0068)}{.8522} + \underset{(.0159)}{.0751}Z + \underset{(.0095)}{.0328}S_4 + \underset{(.0175)}{.1254}S_5 \qquad R^2 = .726,\ DW = 1.536$$

$$\text{(IV.4c)}\quad Y = \underset{(4.0813)}{38.7170} + \underset{(.0837)}{.7801}E + \underset{(.0118)}{.0967}NW + \underset{(.0741)}{.2995}Y_{t-1} - \underset{(.0062)}{.1017}(S_1Y_{t-1}) - \underset{(.0048)}{.0583}(S_2Y_{t-1}) - \underset{(.0043)}{.0694}(S_3Y_{t-1}) \qquad R^2 = .998,\ DW = 1.719$$

Using the logarithmic form of the demand function, we find:

$$(IV.4a') \quad \ln M = \underset{(.1734)}{.5512} - \underset{(.0072)}{.0200}(\ln r) + \underset{(.0355)}{.1481}(\ln Y) + \underset{(.0735)}{.7152}(\ln M_{t-1})$$

$$- \underset{(.0065)^1}{.0645}S_1 - \underset{(.0037)^2}{.0247}S_2 - \underset{(.0040)^3}{.0221}S_3 \qquad R^2 = .992 \quad DW = 1.652$$

$$(IV.4b') \quad X = \underset{(.0071)}{.8528} + \underset{(.0167)}{.0719}Z + \underset{(.0098)^4}{.0334}S_4 + \underset{(.0180)^5}{.1267}S_5 \qquad R^2 = .716 \quad DW = 1.510$$

Number of observations: 49

Period covered: 1946 IV-1959 IV

(note that the estimate of the supply function changes slightly when the logarithmic form of the demand function is substituted for the function in untransformed variables, since this involves the introduction of the new exogenous variable $\ln M_{t-1}$ and the deletion of the exogenous variable M_{t-1}).

These regressions furnish strong evidence in favor of concluding that a response lag exists on the demand side. The inclusion of the distributed-lag proxy term, M_{t-1}, resulted in a fit in which every variable displays a coefficient which is at least three times its standard error and of the expected sign. The degree of explanation achieved by the demand function rises to 99.2 per cent, and the Durbin-Watson statistic indicates that there is no significant serial correlation in the residuals; such a result would, of course, be expected from the introduction of the lagged dependent variable, especially when this variable is a stock. The coefficient of M_{t-1} is quite large and also very significant (over nine times as large as its standard error). The only questionable feature

of this demand estimate is the sharp decrease in the absolute values of the coefficients of (rY) and Y as compared to their values in Equation IV.1a. The coefficient of the income term is especially affected, declining from .177 to .062. This effect may be due, at least in part, to the problem of multicollinearity. The simple correlation coefficient between Y and M_{t-1} in this regression is .936, while that between Y and M is .981, and between M_{t-1} and M is .937. This close relationship between the explanatory variables Y and M_{t-1} may obscure the true contribution of income to the explanation of the demand for money. However, these facts are also due to the fact that we are using a functional form in which demand response to past values of the explanatory variables is allowed. We must therefore make "steady state" comparisons, as discussed below for a proper evaluation. We must conclude, therefore, that the evidence indicates a response lag in the demand for money.

There is very little change in the supply estimate when a lag term is included in the demand equation, and the income estimate is of course unchanged (it is reproduced here only for convenience). Both the coefficient of determination and the Durbin-Watson statistic are slightly higher in Equation IV.4b than in Equation IV.1b, the coefficient of Z is slightly larger in absolute value, while the shift coefficients decline slightly.

We have also reported the results of a regression in which a log-linear demand function is used with the dependent

variable lagged as a proxy for a distributed response lag.[1] Most of the comments which were made on the untransformed version apply to this estimate also; the signs are all as expected, the coefficients exhibit a high level of significance,

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[1] A short summary of Koyck's distributed lag formulation has been given above (p.92, n.1). The case which was described involved a linear function relating two unspecified variables, y and x.

This leaves unsettled the meaning of a distributed lag proxy variable in a nonlinear (multiplicative) function. We shall demonstrate here how such a term can be used, and we shall also include an additional explanatory variable, making the simplifying assumption that the distribution of the lag is the same in each variable.

We begin by postulating a multiplicative relationship between M, r and Y, with a distributed lag; thus the demand function would be

$$M = \alpha r_t^{\beta_o} Y_t^{\gamma_o} \; r_{t-1}^{\beta_1} Y_{t-1}^{\gamma_1} \; r_{t-2}^{\beta_2} Y_{t-2}^{\gamma_2} \ldots$$

We assume that

$$\beta_t = \delta\beta_{t-1}; \quad \gamma_t = \delta\gamma_{t-1}; \qquad 0 < \delta < 1$$

Thus we have

$$M = \alpha r_t^{\beta_o} Y_t^{\gamma_o} \; r_{t-1}^{\delta\beta_o} Y_{t-1}^{\delta\gamma_o} \; r_{t-2}^{\delta^2\beta_o} Y_{t-2}^{\delta^2\gamma_o} \ldots$$

Now we lag M one period and raise it to the δ^{th} power; this gives

$$M_{t-1}^{\delta} = \alpha^{\delta} \; r_{t-1}^{\delta\beta_o} Y_{t-1}^{\delta\gamma_o} \; r_{t-2}^{\delta^2\beta_o} Y_{t-2}^{\delta^2\gamma_o} \; r_{t-3}^{\delta^3\beta_o} Y_{t-3}^{\delta^3\gamma_o} \ldots$$

Dividing M_t by M_{t-1}^{δ}, we have

$$\frac{M_t}{M_{t-1}^{\delta}} = \alpha^{1-\delta} \; r_t^{\beta_o} Y_t^{\gamma_o}$$

$$M_t = \alpha^{1-\delta} \; r_t^{\beta_o} Y_t^{\gamma_o} M_{t-1}^{\delta}$$

$$\text{or} \quad \ln M_t = (1-\delta) \ln \alpha + \beta_o \ln r_t + \gamma_o \ln Y_t + \delta \ln M_{t-1}$$

the degree of explanation and Durbin-Watson statistic are both high, etc. We also observe the same diminution in the absolute values of the coefficients of the interest rate and income terms. Thus either form of the function would appear to be adequate; there is little basis in these estimates to choose one over the other. However, the coefficient of determination and the Durbin-Watson statistic of Equation IV.4b are both slightly more favorable than those for Equation IV.4a', and the Durbin-Watson statistic of Equation IV.4a is somewhat higher than that in Equation IV.4a'. In addition, it seems likely that a linear fit in the untransformed variables may give a better fit than a logarithmic formulation, due to aggregation characteristics and other problems, as explained above. We shall therefore choose Model IV.4 as the best approximation for the postwar period of the models set out above, while recognizing that the lag-linear version of this model is practically as satisfactory.

In evaluating the results of estimates containing lag terms, the stationary-state behavior which these estimates imply should be examined before final judgments are made as to their validity. This is simply to say that such estimates should not be regarded with skepticism simply because the introduction of lag terms causes significant changes in the values of other regression coefficients; rather, they should be put into steady-state form and compared with unlagged estimates on that basis. We may demonstrate this procedure

as follows: suppose we have some unspecified variable, x_t, which is a function of current and lagged values of another unspecified variable, y_t, such that the lag is approximately geometrically decaying. We may write

$$x_t = \alpha + \beta_1 y_t + \beta_2 x_{t-1}$$

In equilibrium, $x_t = x_{t-1}$ so that the above formulation becomes

$$x_t = \frac{\alpha}{1 - \beta_2} + \frac{\beta_1}{1 - \beta_2} y_t$$

Translating the above estimate of Model IV.4 into this form, we would have the following relationships at equilibrium:

$$M = 73.4392 - .0080(rY) + .1968Y - 25.4282S_1 - 10.3366S_2 - 9.0162S_3$$

$$X = .8522 + .0751Z + .0328S_4 + .1254S_5$$

$$Y = 55.2685 + 1.1136E + .138NW - .1452(S_1Y) - .353(S_2Y) - .0315(S_3Y)$$

For the log-linear form of the demand function, we have

$$\ln M = 1.9354 - .0702(\ln r) + .5200(\ln Y) - .2265S_1 - .0867S_2 - .0076S_3$$

$$X = .8528 + .0719Z + .0334S_4 + .1267S_5$$

Y is the same as above

Comparing the results of these manipulations with the estimate of Model IV.1, which is equivalent to Model IV.4

except that there is no lag term in the demand function, we note that the coefficients of the steady-state function are somewhat larger in absolute value than the coefficients of Model IV.1. The coefficient of (rY), for example, is about 1.45 times larger in the above estimate than in Equation IV.1a, while the coefficient of Y is about 1.11 times as great. Alternatively, the steady-state coefficient of (ln r) is 1.45 times as great as the comparable coefficient in Equation IV.1a', while the coefficient of (ln Y) is 1.09 times greater than its counterpart in this equation. We shall compare the short-term and steady-state elasticities which result from these estimates in Chapter V; here we simply point out that the relatively larger steady-state values of the coefficients resulting from our estimates using a distributed-lag demand term are reassuring, and we take this fact as positive evidence in favor of concluding that a distributed lag exists in the demand for money and that our estimate of Model IV.4 is not unreasonable.

Other considerations. In the single-equation regressions discussed in Chapter III, it was discovered that the highest degree of explanation was achieved by using a supply formulation involving the two shift variables and the interest rate and discount rate separately as explanatory variables. However, the signs exhibited by the coefficients of the latter two variables were the opposite of the signs that were expected, and the coefficient of the interest rate was insignificant, while the coefficient of the discount rate

appeared to be significant at a fairly high level. This was also contrary to expectation, and it was decided to estimate a structure using this form of the supply function in order to see whether the results would be more reasonable.[1] We therefore define the following model:

(Model IV.5) $M = M[(rY),\ Y,\ M_{t-1},\ S_1,\ S_2,\ S_3]$

$X = X[r,\ r_d,\ S_4,\ S_5]$

$Y = Y[E,\ NW,\ Y_{t-1},\ (S_1Y_{t-1}),\ (S_2Y_{t-1}),\ (S_3Y_{t-1})]$

Fitting this model to the data results in the following estimates:

$$(IV.5a)\quad M = \underset{(4.9785)}{23.0600} - \underset{(.0007)}{.0025}(rY) + \underset{(.0126)}{.0618}Y + \underset{(.0728)}{.6860}M_{t-1} - \underset{(.7929)}{7.9845}S_1 - \underset{(.4428)}{3.2457}S_2 - \underset{(.4795)}{2.8311}S_3 \qquad R^2 = .992,\ DW = 1.885$$

$$(IV.5b)\quad X = \underset{(.0204)}{.8311} + \underset{(.0267)}{.0482}r - \underset{(.0396)}{.0310}r_d + \underset{(.0126)}{.0244}S_4 + \underset{(.0295)}{.1000}S_5 \qquad R^2 = .724,\ DW = 1.558$$

Number of observations: 49

Period covered: 1946 IV-1959 IV

Since the estimate of the income equation is the same for this model as for Model IV.4, it will not be reproduced here.

Examining the supply equation, we see that there is no essential change in the over-all performance of the equation:

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[1] To the extent that the aforementioned difficulties are caused by multicollinearity, however, this basic problem will not be solved by structural estimation (except under the unlikely circumstance that the recomputed variables vary to such a degree from the raw input data that the problem is lessened).

coefficient of determination is, for all practical purposes, the same as for Equation IV.4b, and the Durbin-Watson statistics are almost the same. However, the coefficient of the discount rate is now insignificant by the t-test, and the coefficient of the interest rate is not quite twice as large as its standard error, although the interest rate and the discount rate have now taken on the proper signs, as compared with the single-equation estimate of this function. Even though we now observe the expected signs, therefore, this regression is judged to be inferior to the results of the estimation of Model IV.4, where the coefficient of Z was found to be 4.7 times as large as its standard error.

That this unrestricted regression should be less satisfactory than a regression with a restriction placed on some of the coefficients is not as implausible as it may appear. In general, of course, an unrestricted regression will give a better fit than a regression in which restrictions are imposed; at worst, the unrestricted coefficients would take on the values imposed by the restriction and the two regressions would be equivalent. We observe that the removal of the restriction represented by the variable Z results in a (very slightly) higher level of R^2 for the supply equation than previously, when adjusted for degrees of freedom. But it need not be considered surprising that the fit is considered inferior in other respects (in terms of the significance of the coefficients, for example). Our a priori hypothesis was that bankers, in

making decisions on applications for loans, were indifferent as to whether profits were changed by a given dollar change in gross return on loans (represented by the short-term interest rate) or by the same dollar change (in the opposite direction) in the cost of making the loan (represented by the discount rate). In other words, bankers were assumed to be indifferent, in terms of their decision-making process, as to the source of profits on loans. This is certainly a rational assumption; on the other hand, there might be reasons for interpreting changes in the interest rate and changes in the discount rate differently. Differing sets of expectations might be attached to the two variables, for example, with changes in the discount rate being thought of as much more "permanent" than changes in the interest rate. In other words, an argument could be made for either approach. The "profit-indifference" concept is perhaps more consonant with the static theory of the firm. However, we have elected to let the data decide the question in this case, and it appears that the unrestricted estimate, standing for differing responses to revenue and cost changes, is substantially inferior to the estimate based upon the restriction that response to revenue and cost must be the same.

Based upon the evidence presented above, it is concluded that the most satisfactory representation of the monetary sector during the postwar period is provided by Model IV.4, involving a distributed lag demand response but no lag in the

supply relationship, and based upon the restriction discussed above. This lag pattern is not surprising, since commercial bankers have operated under a "tight money" policy during most of the postwar period and might therefore be expected to be sensitive to changes in revenues and costs, while money demanders (especially households and smaller businesses), due to transactions costs, lack of awareness of investment opportunities, etc., may be less sensitive in this respect. We now turn to an examination of the prewar years.

2. 1924-1941

An attempt to do structural regressions for the prewar period presents problems not encountered in the postwar case. Specifically, the net worth and seasonally-unadjusted income data in quarterly form which were used in the postwar estimates are not available over the prewar period. For this reason, we are limited to one mid-year observation per year for the period 1924-1941, cutting the number of observations used from 38 (in the single-equation supply estimates for the prewar era) to 18. Consequently, the prewar estimates will be much less reliable statistically than are those for the postwar period. Even though only a limited degree of reliance can be put on these estimates, they are of interest because they represent the best that can be done using the available data and the approach adopted in this study.

We begin, as before, with the basic supply-demand model which the supply tests discussed in Chapter III and our prior

reasoning suggest. The first demand equation tried will contain as arguments income and the multiplicative variable (rY); we shall infer from our unfavorable results using net worth in this equation during the postwar period that net worth is unsatisfactory as an explanatory variable in the demand equation. The supply equation will first contain the variable Z and the dependent variable lagged (as in the single-equation estimates, a two-period lag will be used, since a number of missing observations make it impossible to obtain one-period lagged values for each observation on X); subsequently, a shift variable will be tested, an unrestricted estimate will be tried, etc. The income equation will contain current exogenous expenditure and current (i.e., beginning-of-the-year) net worth; here the lack of quarterly or semiannual data forces us to use income lagged one year (four quarters) as an "inertia variable" to make the estimate more efficient. Since all observations are made on the same quarter, there is no need to include seasonal variables in these tests. In symbolic form, therefore, the initial model to be tested is

$$\text{(Model IV.6)} \quad M = M[(rY),\ Y]$$

$$\text{or (Model IV.6')} \quad \ln M = M'[\ln r,\ \ln Y]$$

$$X = X[Z,\ X_{t-2}]$$

$$Y = Y[E,\ NW,\ Y_{t-4}]$$

In this, as in all of the regressions discussed below, there are 18 observations included and the period covered is 1924-1941,

with all of the data being referred to the midyear point except for net worth, for which the "current value" refers to the value as of the beginning of the year. The results of this regression are as follows:

$$(IV.6a)\quad M = -.3754 - .0233(rY) + .3758Y \qquad R^2 = .962$$
$$\qquad\qquad (1.6893)\ (.0020)\qquad (.0201) \qquad DW = 1.392$$

$$(IV.6b)\quad X = .6055 + .4328Z + .5543X_{t-2} \qquad R^2 = .765$$
$$\qquad\qquad (.2590)\ (.1754)\ (.1766) \qquad DW = 2.015$$

$$(IV.6c)\quad Y = 11.2933 + 1.6010E + .0603NW + .1484Y_{t-4} \qquad R^2 = .990$$
$$\qquad\qquad (3.8542)\ (.0701)\ (.0160)\ (.0576) \qquad DW = 2.027$$

Using the log-linear form of the demand function, we have

$$(IV.6a')\quad \ln M = -.4328 - .1465(\ln r) + .8539(\ln Y) \qquad R^2 = .968$$
$$\qquad\qquad (.2154)\ (.0113)\qquad (.0484) \qquad DW = 1.660$$

Since the estimate of the income function is unchanged in each regression discussed below, we shall only report the results of estimates of the supply and demand functions.

In this structural estimate, all of the signs of the coefficients agree with prior expectations. Furthermore, each of the coefficients is significant by the usual t-test, the poorest in this respect (the coefficient of Z in the supply equation) being 2.47 times as large as its standard error. However, both constant terms are negative, and the constant in Equation IV.62 is not significantly different from zero. The degree of explanation achieved is high, with almost all of the variance of the dependent variable explained

in the demand and income equations, and about 77 per cent of the variance of X explained in the supply equation. The performance of the supply function in this respect is better than for the postwar period. The Durbin-Watson statistics are all high enough to indicate that no serial correlation exists in the residuals of any equation at the one per cent level of significance. As in the postwar period, there is no strong evidence in favor of choosing either Equation IV.6a or IV.6a' as the best representation of the demand relationship, except that the Durbin-Watson statistic of the log-linear formulation is somewhat higher than that of the function using untransformed variables.

While this fit appears to be very satisfactory by our criteria, some variants of this model will also be tested to see whether or not even better results can be achieved. First, the shift variable S is included in the supply function. It will be recalled that our single-equation results using this variable were quite unsatisfactory (see Equation III.5.6), but the events of the early 1930's predispose us so strongly to expect that a structural change would have occurred then that it is worthwhile to perform additional structural estimates in order to investigate this question further. Our model becomes

(Model IV.7) $M = M[(rY), Y]$

or (model IV.7') $\ln M = M'[\ln r, \ln Y]$

$$X = X[Z, X_{t-2}, S]$$

$$Y = Y[E, NW, Y_{t-4}]$$

and performing the regression yields the following results:

$$\text{(IV.7a)}\quad \underset{(1.5459)}{M = -.3094} \underset{(.0018)}{- .0236(rY)} + \underset{(.0184)}{.3758Y} \qquad \begin{matrix} R^2 = .968 \\ DW = 1.407 \end{matrix}$$

or

$$\text{(IV.7a')}\quad \underset{(.2343)}{\ln M = -.3863} \underset{(.0124)}{- .1483(\ln r)} + \underset{(.0527)}{.8437(\ln Y)} \qquad \begin{matrix} R^2 = .962 \\ DW = 1.676 \end{matrix}$$

$$\text{(IV.7b)}\quad \underset{(.3227)}{X = .5884} + \underset{(.2574)}{.4298Z} + \underset{(.1937)}{.6140X_{t-2}} \underset{(.3179)}{- .1062S} \qquad \begin{matrix} R^2 = .747 \\ DW = 2.015 \end{matrix}$$

Addition of the shift term to this regression again results in a coefficient which is insignificant by the t-test, although the level of significance of the coefficient has improved somewhat compared to that found in the single-equation fit of this equation (Equation III.5.6). In addition, it reduces the level of significance exhibited by the coefficient of Z; this coefficient is now 1.67 times as large as its standard error, whereas it was 2.47 times as large as its standard error in Model IV.6. Based upon these results, it would appear that the shift variable S should be excluded from the regression. This evidence would support the view that no serious structural change took place during the early 1930's in the monetary supply mechanism.

Before making such a conclusion, however, we shall do a few more structural tests. The next test which is suggested by our previous work involves removal of the restriction on the supply equation. We shall first examine such a model

without a shift variable in the supply function, and then we shall add this variable and compare the results with Model IV.7 above.

(Model IV.8) $M = M[(rY), Y]$

or (Model IV.8') $\ln M = M'[\ln r, \ln Y]$

$$X = X[r, r_d, X_{t-2}]$$

$$Y = Y[E, NW, Y_{t-r}]$$

(IV.8a) $M = \underset{(1.6893)}{-.3754} - \underset{(.0020)}{.0233}(rY) + \underset{(.0201)}{.3758}Y$ $\quad R^2 = .962$, $DW = 1.392$

or

(IV.8a') $\ln M = \underset{(.2154)}{-.4328} - \underset{(.0113)}{.1465}(\ln r) + \underset{(.0484)}{.8539}(\ln Y)$ $\quad R^2 = .968$, $DW = 1.660$

(IV.8b) $X = \underset{(.3056)}{.4315} + \underset{(.1787)}{.3928}r - \underset{(.2385)}{.2605}r_d + \underset{(.2610)}{.3497}X_{t-2}$ $\quad R^2 = .783$, $DW = 2.071$

Removing the restriction on the supply function results in an increase of four points in the percentage of variance explained by this function. When we took this step in the postwar tests, there was essentially no change in the amount of variance explained. However, the coefficient of the discount rate becomes insignificant, and the coefficient of X_{t-2} is now only 1.34 times as large as its standard error. Now suppose we add the shift variable to this formulation; we get

(Model IV.9) $M = M[(rY), Y]$

or (Model IV.9') $\ln M = M'[\ln r, \ln Y]$

$$X = X[r, r_d, X_{t-2}, S]$$

$$Y = Y[E, NW, Y_{t-4}]$$

and the following estimate results:

$$\text{(IV.9a)}\quad \underset{}{M} = \underset{(1.5459)}{-.3094} - \underset{(.0018)}{.0236}(rY) + \underset{(.0184)}{.3758}Y \qquad \begin{matrix} R^2 = .968 \\ DW = 1.407 \end{matrix}$$

or

$$\text{(IV.9a')}\quad \ln M = \underset{(.2343)}{-.3863} - \underset{(.0124)}{.1483}(\ln r) + \underset{(.0527)}{.8437}(\ln Y) \qquad \begin{matrix} R^2 = .962 \\ DW = 1.676 \end{matrix}$$

$$\text{(IV.9b)}\quad X = \underset{(.3024)}{.4521} + \underset{(.2597)}{.6473}r - \underset{(.2422)}{.3131}r_d + \underset{(.2846)}{.1773}X_{t-2} - \underset{(.4029)}{.6541}S$$

$$\begin{matrix} R^2 = .804 \\ DW = 2.235 \end{matrix}$$

We note that, as other variables are added to the supply function, the level of significance of the coefficient of X_{t-2} declines steadily (compare Equations IV.7b, IV.8b, and IV.9b). Otherwise, this estimate yields fairly good results: the signs are all as expected (except for the constant term in the demand functions), most of the other coefficients are more than twice as large as their standard error (the coefficient of the discount rate being the sole exception), and the level of explanation reached is quite high--80 per cent of the variance of X is explained in Model IV.9. These results suggest the omission of X_{t-2} from the above model; this gives

$$\text{(Model IV.10)}\quad M = M[(rY),\ Y]$$

$$\text{or (Model IV.10')}\quad \ln M = M'[\ln r,\ \ln Y]$$

$$X = X[r,\ r_d,\ S]$$

$$Y = Y[E,\ NW,\ Y_{t-4}]$$

and the regression results are as follows:

$$\text{(IV.10a)} \quad M = \underset{(1.5776)}{-.3123} - \underset{(.0018)}{.0237}(rY) + \underset{(.0188)}{.3759}Y \qquad R^2 = .968,\ DW = 1.439$$

$$\text{(IV.10a')} \quad \ln M = \underset{(.2367)}{-.3854} - \underset{(.0125)}{.1482}(\ln r) + \underset{(.0532)}{.8435}(\ln Y) \qquad R^2 = .962,\ DW = 1.674$$

$$\text{(IV.10b)} \quad X = \underset{(.2956)}{.5024} + \underset{(.2292)}{.7428}r - \underset{(.2442)}{.3246}r_d - \underset{(.3629)}{.7800}S \qquad R^2 = .796,\ DW = 2.245$$

Eliminating the lagged dependent variable from the supply equation has resulted in the coefficient of the shift variable becoming significant, while the level of explanation of this equation remains unchanged, with $R^2 = .80$. The signs all agree with expectations, with the exception of the demand equation constant terms, and the coefficient of r_d is now 1.33 times as large as its standard error, which makes it significant at about the 10 per cent level (using a single-tailed test). Note also that in each formulation tried the coefficient of the interest rate has become a larger multiple of its standard error, with the highest level achieved in Equation IV.10b.

Because of the high level of explanation achieved in fitting Model IV.10, the significance levels exhibited by the coefficients in this estimate, and the fact that the signs are in agreement with our prior expectations, this model appears to be the most satisfactory representation of the prewar monetary sector tested thus far. It seems superior to Model IV.6, which gave the best results prior to the above test, but the

implications which can be drawn from the supply function above are somewhat different than those suggested by Model IV.6. Based upon our results using Model IV.10, we conclude that the evidence does favor the hypothesis that a structural shift occurred in the early 1930's; the coefficient of S in the above regression is of the expected sign and is more than twice as large as its standard error.

While we have decided that Model IV.10 is the "best" structural model of the prewar period among those tested, at least insofar as the structural supply function is concerned, no attention has been paid to the possibility of lags in the demand function. We shall neglect the possibility that such lags, if they exist, may interact with the system in such a way that our conclusions concerning the specification of the supply function may be overthrown, and shall test for the presence of a distributed lag in the demand function by adding M_{t-2} to this function (in untransformed and logarithmic form, alternatively) as an explanatory variable, making no other changes in Model IV.10. We use M_{t-2} as a proxy for M_{t-1}, the proper variable to use in testing for a geometrically-decaying distributed lag, since the latter is not available for all observations. The model then becomes:

$$\text{(Model IV.11)} \quad M = M[(rY),\ Y,\ M_{t-2}]$$

$$\text{or (Model IV.11')} \quad \ln M = M'[\ln r,\ \ln Y,\ \ln M_{t-2}]$$

$$X = X[r,\ r_d,\ S]$$

$$Y = Y[E,\ NW,\ Y_{t-4}]$$

The results of this structural estimation are as follows:

$$(IV.11a)\quad M = \underset{(.8966)}{-1.7941} - \underset{(.0023)}{.0142}(rY) + \underset{(.0389)}{.2035}Y + \underset{(.1161)}{.5361}M_{t-2} \qquad \begin{matrix} R^2 = .992 \\ DW = 1.523 \end{matrix}$$

$$(IV.11b)\quad X = \underset{(.3070)}{.4353} + \underset{(.2333)}{.6633}r - \underset{(.2502)}{.2479}r_d - \underset{(.3761)}{.6917}S \qquad \begin{matrix} R^2 = .773 \\ DW = 2.167 \end{matrix}$$

Using the logarithmic form of the demand function, we find:

$$(IV.11a')\quad \ln M = \underset{(.1028)}{-.3505} - \underset{(.0096)}{.0907}(\ln r) + \underset{(.0618)}{.4332}(\ln Y) + \underset{(.0744)}{.5364}(\ln M_{t-2}) \qquad \begin{matrix} R^2 = .993 \\ DW = 1.709 \end{matrix}$$

$$(IV.11b')\quad X = \underset{(.2962)}{.5005} + \underset{(.2297)}{.7406}r - \underset{(.2447)}{.3224}r_d - \underset{(.3697)}{.7775}S \qquad \begin{matrix} R^2 = .794 \\ DW = 2.245 \end{matrix}$$

The addition of the lagged dependent variable has the same sort of effect here as in the postwar case: some of the other coefficients in the regression decrease sharply in absolute value. Compared with the equations of Model IV.10, the coefficient of Y decreases by almost one-half, and the coefficient of the (rY) term drops in absolute value by about 40 per cent. The regression using logarithms exhibits the same type of result in the demand equation. We note, however, that Equation IV.11b', the supply relationship based upon the logarithmic form of the demand equation, is affected to a far smaller degree than is Equation IV.11b. Especially noteworthy is the comparison between the significance levels of the discount rate coefficients in the two equations.

While adding a lag term to the demand equation causes a sharp decrease in the value of the demand coefficients, we must again examine the steady-state values of these coefficients, before making a final evaluation of this regression. In equilibrium, we will have the following relationship, using untransformed variables:

$$M = -3.8674 - .0306(rY) + .4387Y$$

$$X = .4353 + .6633r - .2479r_d - .6917S$$

$$Y = 13.2612 + 1.8800E + .0708NW$$

Using the log-linear relationship, we have

$$\ln M = -.7560 - .1956(\ln r) + .9344(\ln Y)$$

$$X = .5005 + .7406r - .3224r_d - .7775S$$

Y is the same as above.

In this case the steady-state coefficient of (rY) is 1.29 times as large in absolute value as the comparable coefficient in the estimate of Model IV.10, which is equivalent to Model IV.11 except for the demand lag, and the coefficient of Y is 1.17 times as large. Using the log-linear relationship, the steady-state coefficient of (ln r) is 1.32 times larger than the coefficient in Equation IV.10a' while the coefficient of (ln Y) is 1.11 times as large.

The fact that all of these steady-state coefficients are somewhat larger than their counterparts in the estimates which

do not include lagged terms in the demand function is reassuring in view of the sharp changes in the regression coefficients caused by the introduction of such terms. We take this as evidence supporting the hypothesis that a lagged demand response existed during the prewar years. However, we reject the presence of a supply lag, based upon the erratic performance of the distributed lag proxy variable X_{t-2}. Since the log-linear form of the demand function causes less extensive change in some of the other structural coefficients (particularly in the supply relationship) than does the function based upon untransformed variables, we shall take Model IV.11' as being the best representation of the monetary sector during the prewar period.

3. Conclusions from the structural tests

This evaluation of structural supply and demand estimates may be summed up by listing and discussing some general conclusions suggested by the regressions which have been done.

a. Our empirical investigation has been based upon a theoretical approach which rejects the concept of a liquidity or asset demand for money as such, since there exist alternate means of holding assets in liquid form, without danger of default, and which pay a positive return. The study of liquidity preference should therefore investigate the relationship between this category of assets (at least for the postwar period, when default risk has been negligible), the rate of return on

such assets, and other variables. We reiterate a point made early in this study: that trend effects must be taken into account in such an investigation, and that early studies of the liquidity preference relationship fail to do so.

The form of the demand function which results from our theoretical analysis gives very good results when estimated within a structure, thus supporting our transactions-demand hypothesis. For the postwar period, a function which is linear in the variables (rY) and Y seems to give the best results, although there is very little difference in the quality of results achieved using this form and the results from using the logarithms of the variables r and Y. During the prewar years, a log-linear (constant elasticity) function is judged to be best.

Since the demand for money is held to be only a transactions demand, it is not surprising that net worth is unsatisfactory as a regression variable. Only a small transactions demand is expected to be associated with the permanent portfolios of economic units, and in addition, the close relationship between net worth and income causes serious multicollinearity problems.

b. The hypothesis that the supply of money should be considered to be an endogenous functional relationship instead of an exogenously-determined quantity, which was suggested by the single-equation tests discussed in Chapter III, receives further support from these structural estimates. The

supply ratio which we seek to explain is shown to be a function of the short-term interest rate, along with other variables; it is this short-term rate which links the supply function with the remainder of the model. In the "best" estimate of the postwar period (Model IV.4), the explanatory variable $(r-r_d)$ has a coefficient which is highly significant by the t-test, being over four times as large as its standard error.

c. The results lead to similar inferences concerning the lag structure in money supply and demand relationships for both the postwar and prewar periods. In both cases, the evidence indicated that there existed a lagged demand response (in addition to the response of demand to current variables), while no lag was found on the supply side. It should be remembered that only distributed-lag formulations were tried; no tests were made on formulations including discrete lag terms. As we noted above, the result is not a surprising one, since the generation (and extinction) of money is the business of commercial banks, while households account for a large portion of money demand, and they are apt to neglect to manage their cash position as closely as businesses or banks. In any event, the finding is an interesting confirmation of our expectations, and demonstrates that the monetary sector is rather flexible and sensitive on the supply side.

d. For both the postwar and prewar periods, shift variables in the supply functions performed well. This is not surprising, since these variables were designed to reflect broad economic

and social changes which are known to have occurred and which would be expected to have repercussions on the monetary sector.

e. There appears to be some asymmetry between the prewar and postwar periods in the supply response to the interest and discount rates. For the postwar years, our estimates indicated that there was no difference in the extent of response to movements in the interest rate and the discount rate; the only difference lay in the direction of this response. For the prewar period, however, the coefficient of the interest rate in the supply function is more than twice as large in absolute value than (and opposite in sign from) the coefficient of the discount rate. This effect may be due to the feverish demand for credit, heavy borrowing from the Federal Reserve System, etc. which were typical of the 1920's; it may also be due at least partly to multicollinearity.

C. An Evaluation of Friedman's Hypothesis

The structural estimates which have been presented above provide a useful tool for analyzing Friedman's hypothesis on the demand for money.[1] For convenience, the essence of this hypothesis will be restated here. Friedman believes, first, that a Keynesian (interest-reponsive) demand-for-money function cannot explain what he considers to be contradictory secular and cyclical behavior of income velocity. Secondly, he maintains

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[1]Milton Friedman, "The Demand for Money: Some Theoretical and Empirical Results," Journal of Political Economy (LXVI), August, 1959, pp. 327-351.

that even a classical money demand function must be recast into his "permanent income" approach before it can adequately account for this behavior. A more detailed discussion of Friedman's hypothesis is given in Chapter II; here we are concerned primarily with comparing the empirical results from our approach with his results.

Friedman subjects his hypothesis to a limited number of tests, the most severe being a visual comparison of the observed income velocity of money (using his definition of the money stock) with "computed velocity"; that is, an estimated velocity based upon a functional relationship with observed and permanent real income.[1] By demonstrating that computed velocity is a fair approximation to observed velocity, Friedman attempts to show that his hypothesis is supported by empirical evidence.

We have followed Friedman in calculating "computed velocity" from our model (i.e., from our structural estimates of income and the money stock), and comparing this series visually with observed velocity, for the periods 1924-1941 and 1946 IV-1959 IV (quarterly). By this means we attempt to demonstrate that our approach, using a Keynesian (i.e., interest-responsive) demand-for-money function (within a structure) and the usual definition of the money stock, results in a closer approximation than Friedman's. In other words, we here neglect our

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[1] Ibid., p. 340.

conceptual misgivings about the Friedman approach, allow him his definitions for the sake of the argument, and attempt to show that his approach appears to be empirically inferior. Since he does not give the data upon which his graph (Chart I, p. 340, reproduced below as Fig. IV.2) is based, we must rely upon a visual comparison of our results with his (see Figures IV.3 and IV.4 below).

The estimated velocity obtained from our structural model for the postwar period agrees very closely with observed velocity for the same period. Friedman's computed velocity agrees closely with observed velocity from 1946 through 1950, but after that date they diverge steadily. The amount of the gap widens until in 1957 the observed velocity (using his definition) is about 1.70, while computed velocity is only about 1.30, a difference of 0.40. In our quarterly calculations, the greatest difference between observed and computed velocity occurs in 1956 II, when it amounted to 0.12. For the prewar period, when relatively few observations were available for our estimates, our procedure results in poor approximations for only two years--1926 and 1932--with the widest gap (0.15) in 1926. Beginning with 1933, however, Friedman's procedure gives poor results for every year through 1941, with a consistent gap of about 0.30 to 0.40. Finally, there are much larger gaps than this in many of the years included in the Friedman study but not in the present analysis.

Fig. IV.2: Friedman's Computed Velocity Compared With Measured Velocity, United States, 1869-1957

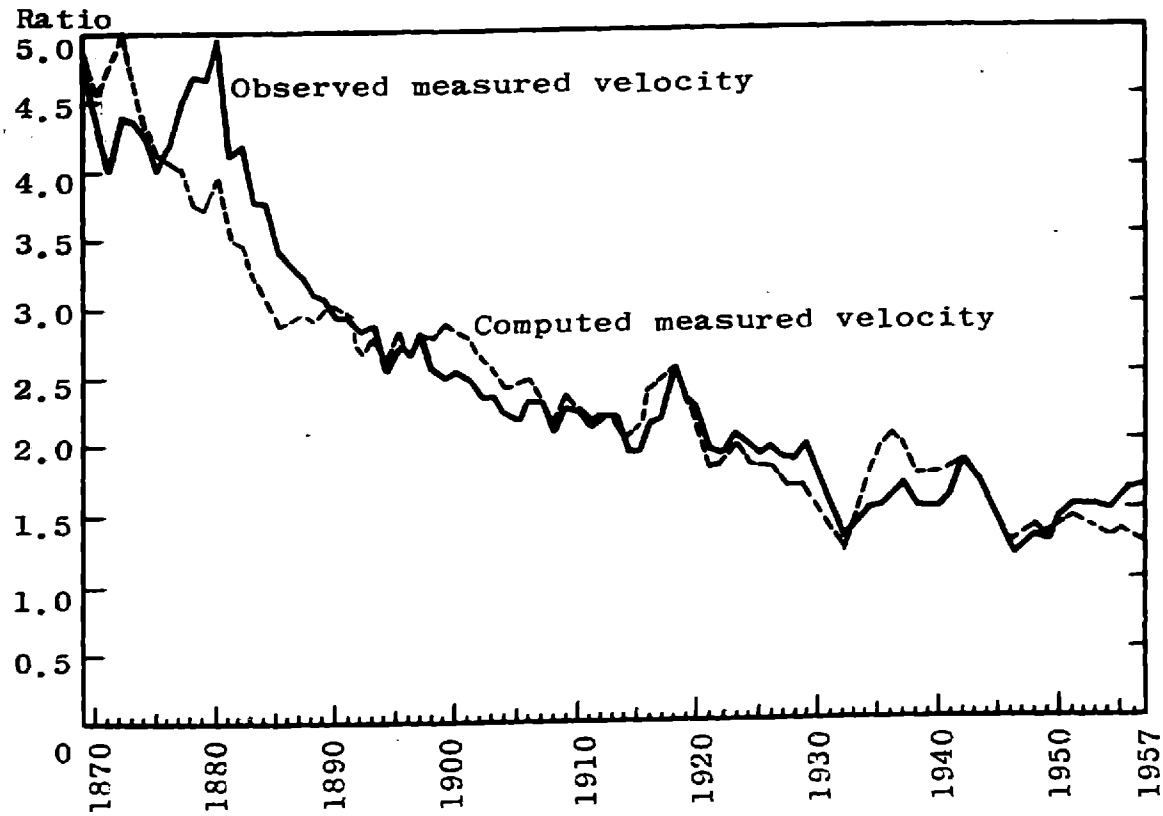


TABLE IV.1 OBSERVED AND COMPUTED INCOME VELOCITY OF MONEY IN THE UNITED STATES, BASED ON STRUCTURAL ESTIMATES OF THE MONETARY SECTOR, 1946 IV-1959 IV

Year	Y_{obs}	M_{obs}	$V_{obs} = \frac{Y_{obs}}{M_{obs}}$	Y_{comp}	M_{comp}	$V_{comp} = \frac{Y_{comp}}{M_{comp}}$
1959 IV	$515.2	$144.8	3.56	$513.4	$144.8	3.55
III	477.2	139.9	3.41	480.2	139.7	3.44
II	484.8	139.0	3.49	481.4	139.6	3.45
I	454.0	138.2	3.29	453.3	138.2	3.28
1958 IV	484.8	144.3	3.36	487.0	142.6	3.42
III	443.2	136.0	3.26	443.8	136.8	3.24
II	433.6	134.0	3.24	433.3	135.1	3.17
I	416.8	132.0	3.16	418.0	133.5	3.13
1957 IV	466.8	138.6	3.37	466.4	139.1	3.35
III	443.6	133.3	3.33	441.0	134.5	3.28
II	440.0	133.7	3.29	438.6	134.1	3.27
I	420.8	132.6	3.17	420.3	133.2	3.16
1956 IV	453.6	139.7	3.25	453.7	138.0	3.29
III	417.6	132.8	3.14	420.2	133.5	3.15
II	410.0	133.0	3.08	424.8	132.8	3.20
I	395.6	131.6	3.01	396.0	131.4	3.01
1955 IV	428.4	138.2	3.10	429.3	136.8	3.14
III	400.0	132.1	3.03	397.2	131.6	3.02
II	390.8	130.6	2.99	386.0	129.7	2.98
I	370.8	128.1	2.89	366.8	128.4	2.86
1954 IV	388.0	134.4	2.89	387.2	133.1	2.91
III	358.4	128.1	2.80	360.0	127.1	2.83
II	358.0	125.2	2.86	356.4	125.4	2.84
I	348.4	123.6	2.82	347.1	124.5	2.79

TABLE IV.1 (Continued)

Year	Y_{obs}	M_{obs}	$V_{obs} = \frac{Y_{obs}}{M_{obs}}$	Y_{comp}	M_{comp}	$V_{comp} = \frac{Y_{comp}}{M_{comp}}$
1953 IV	$377.6	$130.5	2.89	$380.7	$130.3	2.92
II	367.6	124.3	2.96	361.3	125.0	2.89
1952 IV	376.4	129.0	2.92	372.1	128.1	2.90
III	342.4	123.0	2.78	344.3	122.8	2.80
II	338.0	121.2	2.79	338.8	121.5	2.79
I	331.6	120.5	2.75	333.8	119.3	2.80
1951 IV	354.8	124.6	2.85	356.5	123.6	2.88
III	330.8	117.4	2.82	332.4	117.8	2.82
II	322.4	114.7	2.81	324.6	115.9	2.80
I	308.0	113.4	2.72	303.6	112.9	2.69
1950 IV	320.4	117.7	2.72	320.2	118.3	2.71
III	292.4	112.5	2.60	281.9	111.9	2.52
II	270.0	110.2	2.45	268.3	109.1	2.46
I	255.6	107.8	2.37	256.8	106.1	2.42
1949 IV	272.4	111.2	2.45	272.5	113.0	2.41
III	257.2	108.0	2.38	258.0	108.8	2.37
II	252.4	107.1	2.36	252.5	107.2	2.36
I	250.0	106.2	2.35	256.7	106.5	2.41
1958 IV	282.4	111.6	2.53	281.3	114.5	2.46
II	252.4	108.3	2.33	252.7	108.1	2.34
I	241.2	107.1	2.25	242.4	107.1	2.26
1947 IV	260.8	113.6	2.30	258.1	114.3	2.26
III	232.0	110.4	2.10	233.5	108.9	2.14
II	226.0	108.4	2.08	227.7	106.5	2.14
1946 IV	232.8	110.0	2.12	236.0	111.4	2.12

Source: Original estimates.

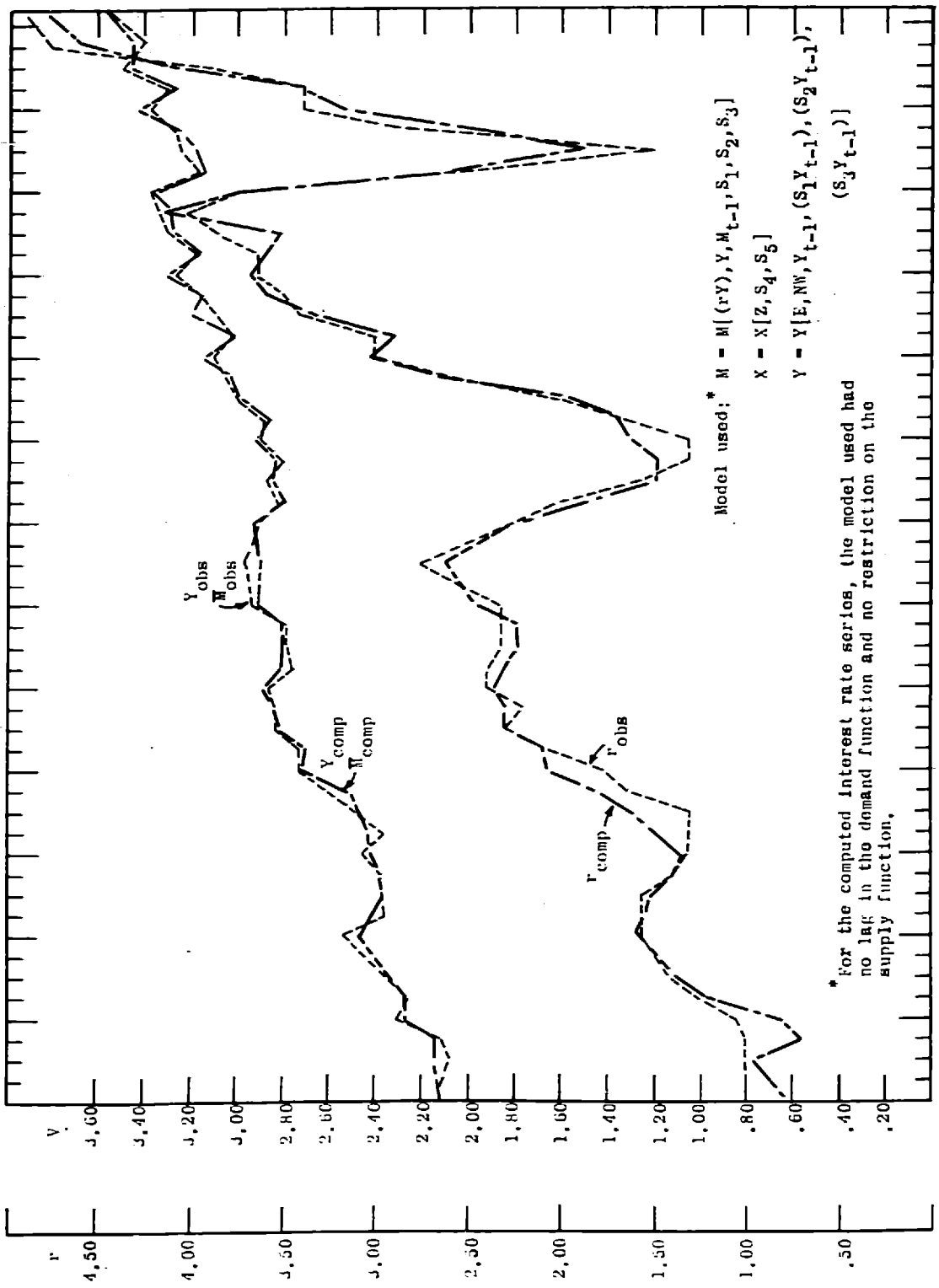
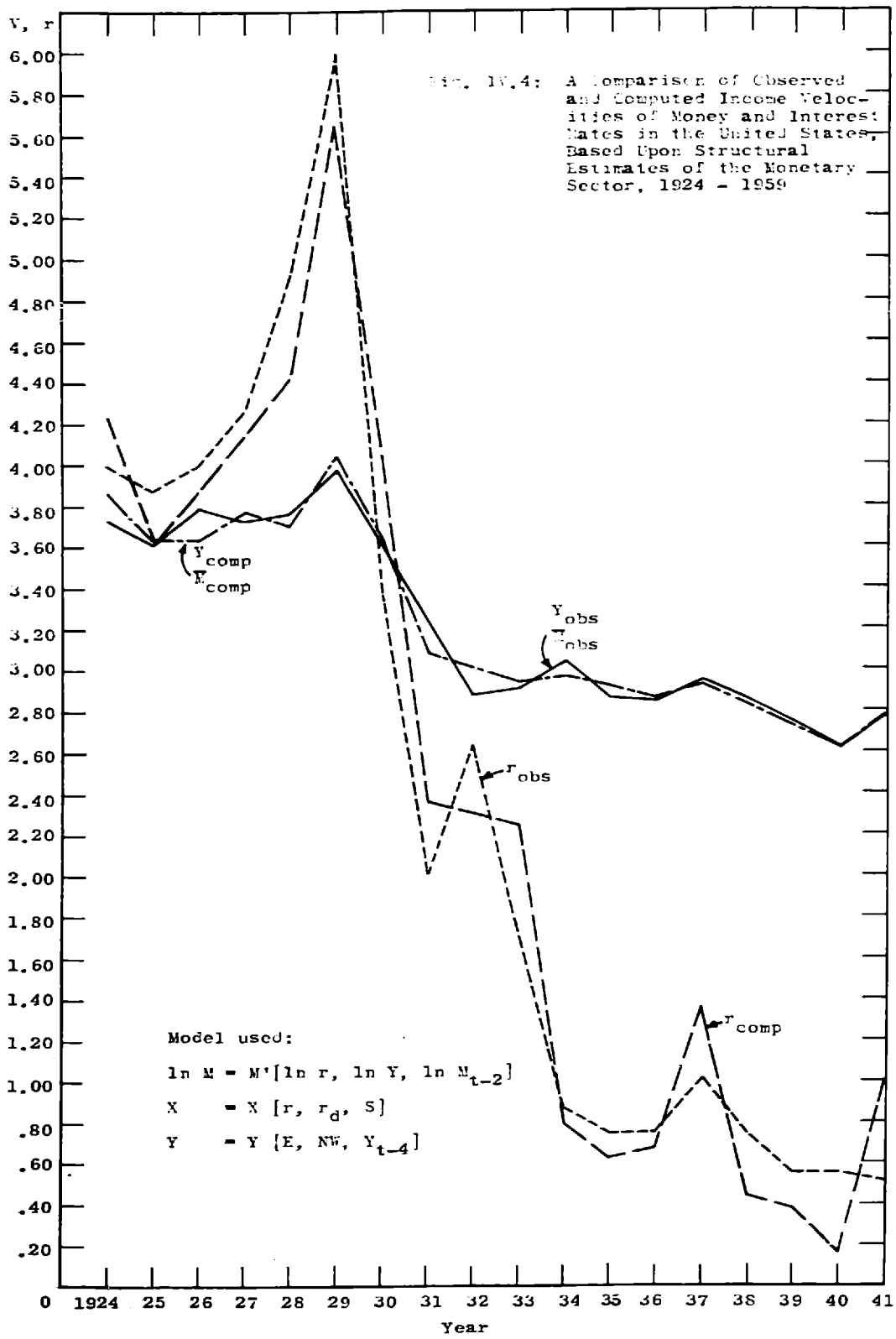


Fig. IV.3: A Comparison of Observed and Computed Income Velocities of Money and Interest Rates in the United States, Based Upon Structural Estimates of the Monetary Sector, 1946 IV - 1959 IV

TABLE IV.2 OBSERVED AND COMPUTED INCOME VELOCITY OF MONEY IN THE UNITED STATES, BASED ON STRUCTURAL ESTIMATES OF THE MONETARY SECTOR, 1924-1941

Year	Y_{comp}	M_{comp}	V_{comp}	Y_{obs}	M_{obs}	V_{obs}
1941	128.94	46.32	2.78	126.42	45.52	2.78
1940	100.00	37.97	2.63	101.44	38.66	2.62
1939	89.28	32.77	2.72	91.34	33.36	2.74
1938	84.32	29.93	2.82	84.68	29.73	2.85
1937	91.10	31.05	2.93	90.21	30.69	2.94
1936	81.84	28.66	2.86	82.48	29.00	2.84
1935	72.63	24.84	2.92	72.19	25.22	2.86
1934	64.25	21.61	2.97	64.87	21.35	3.04
1933	57.30	19.48	2.94	55.76	19.17	2.91
1932	60.21	19.98	3.01	58.34	20.24	2.88
1931	75.32	24.42	3.08	75.93	23.48	3.23
1930	93.35	25.72	3.63	90.86	25.08	3.62
1929	104.64	25.93	4.04	103.83	26.18	3.97
1928	94.33	25.66	3.68	97.19	25.88	3.76
1927	95.73	25.32	3.78	95.38	25.54	3.73
1926	93.87	25.80	3.64	96.93	25.60	3.79
1925	90.20	24.75	3.64	90.35	24.95	3.62
1924	86.83	22.47	3.86	85.94	23.06	3.73

Source: Original estimates


Y, r
6.00
5.80
5.60
5.40
5.20
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0
1924
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
Year
Fig. IV.4: A Comparison of Observed and Computed Income Velocities of Money and Interest Rates in the United States, Based Upon Structural Estimates of the Monetary Sector, 1924 - 1959
Y_{comp}
r_{comp}
Y_{obs}
r_{obs}
r_{obs}
r_{comp}
Model used:
ln M = M'[ln r, ln Y, ln M_{t-2}]
X = X [r, r_d, S]
Y = Y [E, NW, Y_{t-4}]

Our quarterly estimates of velocity are consistently extremely close to the observed values. On the other hand, the Friedman approach appears to yield consistent error in estimating velocity. Therefore Friedman's hypothesis seems to be inferior in terms of its empirical support. We believe we have demonstrated that an interest-responsive demand-for-money function, employed within the context of a structural model of the monetary sector, is effective in explaining the movement of velocity through time, contrary to Friedman's assertion.

CHAPTER V

ELASTICITY COMPARISONS

It is customary in studies of demand or supply relationships to compare the elasticities which result from the study with those found by other authors using different approaches, data for different periods, etc. We shall make such comparisons in this study also, at least for the demand function. The absence of other empirical studies of money supply prevents our making these comparisons on the supply side.

In addition to comparing this aspect of our results with the work of others, the approach we have taken enables us to make an additional set of comparisons: that of structural vs. single-equation elasticity estimates. Such comparisons are possible for both the demand and supply functions, and we shall begin by reporting the results of this comparison for each function, concluding the chapter with a summary of demand elasticities found by others and their relevance for our results.

A. Single-Equation vs. Structural Elasticities

It is well known that if the quantity demanded and the quantity supplied of a good are both functions of its price only, and if we observe equilibrium points traced out by shifts in both supply and demand curves, with supply shifting relatively more than demand, then single-equation regressions

of quantity on price will result in biased estimates of the price elasticity of demand; we expect the elasticity which results to be too low. This argument can be applied directly to monetary demand functions. We may think of the interest rate as the price of holding cash balances on the demand side (or the return for furnishing them on the supply side). Therefore single-equation least squares fits in which M is regressed on r alone result in elasticities of demand for money with respect to the interest rate which are expected to be too low relative to the true elasticity.

The same line of reasoning can be used to show that elasticities of supply will also be expected to be lower than the true elasticities if single-equation least squares estimates of supply functions are made under these circumstances. Finally, the estimated elasticities will be expected to be too high if price is regressed on quantity instead of quantity on price as above.

When other arguments in addition to price are introduced into these functions, we are unable to specify the direction in which any coefficient will be biased in single-equation fits. Hence the data which form a basis for this study provide a unique opportunity for comparing single-equation and structural estimates in order to see whether the single-equation demand and supply elasticities are biased upwards or downwards. The obvious procedure to follow is to make a controlled experiment utilizing a single-equation estimate of the "best" supply

and demand function as found in the structural tests, making the regressions on the same observations for both types of estimate and leaving everything else the same, so that the only difference is the method of estimation (single-equation least squares versus two-stage least squares).

1. 1946 IV-1959 IV - 1959 IV

For convenience, single-equation and structural elasticity estimates are compared in Tables V.1 and V.2 below. Both the regression coefficients and the resulting elasticities (calculated at the means) are given.

Several aspects of these elasticity estimates are of interest. First is the contrast between the rather low absolute values found for the short-run elasticities of demand with respect to the rate of interest and income compared with their steady-state values. Obviously, this is due to the difference in the values of the short-run and steady-state regression coefficients. As will be seen below, the elasticities found by other investigators tend to be somewhat larger than the short-run elasticities found in this study, although our steady-state elasticities are comparable in size (in fact, our income elasticity is greater than any other quoted). It should also be noted that the structural estimate of the interest elasticity of demand rises somewhat in absolute value (from -.0168 to -.0200, using the short-run estimate, or from -.0484 to -.0702, using the steady-state values) if the log-linear form of the demand function is used.

TABLE V.1 SINGLE-EQUATION AND STRUCTURAL ESTIMATES OF DEMAND COEFFICIENTS AND ELASTICITIES COMPARED, 1946 IV-1959 IV*

Variable		Average Value for Period	Coefficient		Elasticity**		Ratio of Structural to Single-Equation Elasticity
			Single-Equation	Structural	Single-Equation	Structural	
Short run	r	2.337	-.0021Y	-.0025Y	-.0141	-.0168	1.19
	Y	$358.122	(.0545-.0021r)	(.0618-.0025r)	.1429	.1613	1.13
Steady state	r	2.337	-.0075Y	-.0080Y	-.0505	-.0538	1.07
	Y	358.122	(.1951-.0075r)	(.1968-.0080r)	.5115	.5130	1.00

*Based upon the function $M = \alpha_1 + \beta_{11}(r^Y) + \beta_{12}Y + \beta_{13}M_{t-1} + \beta_{14}S_1 + \beta_{15}S_2 + \beta_{16}S_3$

**Calculated at the means of the variables involved.

Source: Original estimates

TABLE V.2 SINGLE-EQUATION AND STRUCTURAL ESTIMATES OF SUPPLY COEFFICIENTS AND ELASTICITIES COMPARED, 1946 IV-1959 IV*

Variable	Average Value for Period	Coefficients		Elasticity**		Ratio of Structural to Single-Equation Elasticity
		Single-Equation	Structural	Single-Equation	Structural	
r	2.337	.0531M*	.0751M*	.1379	.1950	1.41
r_d	2.031	-.0531M*	-.0751M*	-.1199	-.1695	1.41
M*	$138.189	---	---	.081	.081	1.00

*Based on the function $M = M^*\alpha_2 + M^*\beta_{21}(r-r_d) + M^*\beta_{22}S_4 + M^*\beta_{23}S_5$

**Calculated at the means of the variables involved.

Source: Original estimates

As far as is known, the elasticities given in Table IV.2 represent the only supply elasticities of money balances which have been estimated. These data indicate that the elasticity of supply with respect to the interest rate is much greater (in absolute value) than the elasticity of demand, a result which is not surprising since, as noted above, a large portion of money demanders are households, while money suppliers are commercial banks.

It is interesting to note the differences between the single-equation and structural estimates of elasticity. In the structural short-run demand estimate, the interest-elasticity is 19 per cent greater than in the single-equation estimate,

the income-elasticity is 13 per cent greater. The differences are not as great between the steady-state estimates. On the supply side, however, the differences are quite striking. Here we find that the structural estimates of interest- and discount-rate elasticities are 41 per cent greater in absolute value than the single-equation estimates. By the nature of our experiment, these differences can be due only to the method of estimation, since the explanatory variables used and the observations were precisely the same in both cases.

2. 1924-1941

Tables V.3 and V.4 contain data on the prewar elasticities of monetary supply and demand.

TABLE V.3 SINGLE-EQUATION AND STRUCTURAL ESTIMATES OF DEMAND ELASTICITIES COMPARED, 1924-1941*

Variable		Elasticity: Single-Equation	Elasticity: Structural	Ratio of Structural to Single-Equation Elasticity
Short run	r	-.0879	-.0907	1.03
	Y	.4259	.4332	1.02
Steady state	r	-.1947	-.1956	1.00
	Y	.9433	.9344	.99

*Based on the function $\ln M = \alpha_1 + \beta_{11}(\ln r) + \beta_{12}(\ln Y) + \beta_{13}(\ln M_{t-2})$

Source: Original estimates

TABLE V.4 SINGLE-EQUATION AND STRUCTURAL ESTIMATES OF SUPPLY COEFFICIENTS AND ELASTICITIES COMPARED, 1924-1941*

Variable	Average Value for Period	Coefficient		Elasticity**		Ratio of Structural to Single-Equation Elasticity
		Single-Equation	Structural	Single-Equation	Structural	
r	2.356	.6473M*	.7406M*	2.264	2.591	1.14
r_d	2.807	-.2325M*	-.3224M*	-.969	-1.160	1.20

*Based on the function $M = \alpha_2 M^* + \beta_{21} M^* r + \beta_{22} M^* r_d + \beta_{23} M^* S$

**Computed at the means of the variables involved. The mean of M* for this period was $40.641, while the mean of M was $27.373.

Source: Original estimates.

We note that the prewar elasticities are considerably larger in absolute value than the postwar elasticities. The prewar structural interest-elasticity of demand is about five times larger than the postwar elasticity (using short-run estimates), while the prewar income elasticity is over three times as large as its postwar counterpart. Using steady-state elasticities, the prewar interest-elasticity is almost four times the postwar, while the prewar income elasticity is nearly twice as large as the postwar elasticity. There is even a greater difference in the supply elasticities: the prewar interest-elasticity of supply is 13 times as large as the postwar elasticity, and the prewar elasticity with respect to

the discount rate is almost seven times as large in absolute value as its postwar equivalent.

The same type of relationship between structural and single-equation estimates is found in the prewar period as was true of the postwar era, although the differences are not as marked. Again it is found that the most striking differences occur in the supply function. The structural estimate of the discount-rate elasticity of supply shows the greatest deviation from its single-equation estimate; it is 20 per cent larger.

We may sum up these comparisons by noting that, when judged by the structural results, single-equation estimates yielded interest-rate (i.e., price) elasticities which were too low; in fact, this was true of all the elasticities (only the stationary-state structural elasticity of demand with respect to income was slightly smaller than its single-equation counterpart). This is the result we might anticipate had we used only one (endogenous) explanatory variable for both the supply and demand functions. It is interesting to find that the same result is obtained in the multivariate case. While we do not believe that our estimates are completely unbiased, due to our failure to take the endogenous portions of investment into account etc., as discussed elsewhere in this study, we take these results as an indication of the direction of bias which results from the neglect of simultaneity in multivariate models of the monetary sector. The other finding of general interest is that all of the elasticities appear to

have declined significantly in the postwar period as compared with the prewar years. It is not surprising to find the income-elasticity of demand decreasing as income increases, but the decline in interest-elasticity is rather puzzling.

Elementary demand analysis teaches that the elasticity of demand with respect to price for a good will be relatively high if there are many close substitutes in existence, and relatively low if few such substitutes exist. In the 1930's, it would appear that fewer close alternatives to money existed than in any other period covered by the study; banks were failing, the rate of interest on short-term government securities was essentially zero, etc. In the postwar period, however, one of the remarkable phenomena in the monetary sector has been the growth of specialized financial institutions offering securities of a wide variety of yields and risks. The broad government securities market resulting from the existence of a large public debt offers the moneyholder additional investment alternatives. It is tempting to conclude from this that our results are perverse and that the elasticity of demand for money with respect to the price of holding it must have risen since the prewar period.

To do so, however, is to neglect the distinction between money as a store of wealth and money as a means of payment, and, therefore, to overlook the question of dominance. It may be supposed that, during the 1930's, when financial institutions in general were regarded with some suspicion by the public,

no true money-dominating asset existed. This may at least be true of the severe period of bank failures in the early part of the decade. In such a case, the store-of-wealth aspect of money would be relatively important, and money would compete with the various categories of time deposits, government and other securities, etc., as a means of holding wealth; this would result in a relatively high price elasticity of demand. During the postwar period, when many more forms of liquid asset-holding have come into being, there is little doubt that money as a means of holding assets is dominated by time deposits, since the latter are risk-free, perfectly liquid in practice, and income-yielding. By our hypothesis, money is now of interest primarily (perhaps even solely) as a means of payment. Money as a means of payment is a different economic good than money as a store of value; in fact, in the former sense, it is unique. Having no close substitutes, it may be expected to exhibit a relatively low price-elasticity of demand, as it does for the postwar years.

B. Comparisons with Other Findings

It is of interest to compare our structural estimates of demand elasticities with elasticities implied by other studies. Unfortunately, the periods covered by most of these studies differ somewhat, especially when compared with our work; in addition, there are differences in the choice of variables, form of the function used, etc., which further complicate these comparisons.

The studies from which we are able to obtain estimates of demand elasticities for money stocks are those of Latané, Bronfenbrenner-Mayer, and Klein-Goldberger, all of which have been referred to earlier in the present study. Since the Bronfenbrenner-Mayer study is done using the 4-6 month commercial paper rate, the same rate as is used in our investigation, and since their demand function is linear in the logarithms, estimates of elasticities are closely comparable to ours, and may be read directly from the results which they report. In the case of the Latané study, the results of a regression of the reciprocal of income velocity on the reciprocal of the long-term interest rate[1] are reported, the period covered being 1919-1952. This yields the following function relating the money stock to income and the long-term interest rate from which the velocities can be obtained:[2]

$$M = \frac{.008Y}{r} + .09Y$$

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[1]The actual series used includes the corporate high-grade bond yield from 1936-1952, and the yield on high-grade railroad bonds before 1936.

[2]Latané brings his 1954 work up to date in his article entitled "Income Velocity and Interest Rates: A Pragmatic Approach," Review of Economics and Statistics (XLII), November, 1960, pp. 445-449. In this article he set forth a functional relationship equivalent to

$$M = \frac{Y}{.77r + .38}$$

which is supposed to represent the relationship between velocity and the long-term rate of interest over the whole period 1909-1958. This relationship is said to be "not inconsistent" with the linear relationship between $\frac{M}{Y}$ and $\frac{1}{r}$ reported above. Yet the two estimates yield considerably different elasticities (we shall show both in our comparisons).

In the case of the Klein-Goldberger model, more troublesome problems are met in attempting to compute comparable elasticities. As has been discussed above, this model contains two "liquidity functions"--one for households and one for businesses--which attempt to explain these sectors' holdings of liquid assets (defined as currency and demand deposits, savings deposits, United States government bonds, and savings and loan shares). Thus we are unable to find demand elasticities for money balances alone. However, demand elasticities for "liquidity" with respect to interest rates and disposable income (in the case of household balances) can be obtained from the data used by Klein and Goldberger, which are published in their study, and from their estimates of the functions:

$$L_1 = .0.14Y_d + 76.03(r_L - 2.0)^{-0.84}$$

and $$L_2 = -0.34 + 0.26W_1 - 1.02r_s - 0.26(P - P_{t-4}) + 0.61(L_2)_{t-4}$$

where W_1 is private employee compensation (deflated) and P is a price index of gross national product.

The elasticities which result from these various studies, together with the elasticities based upon our estimates, are summarized in Table V.5:

TABLE V.5 A COMPARISON OF THE ELASTICITIES OF DEMAND FOR MONEY RESULTING FROM OTHER STUDIES WITH THOSE RESULTING FROM THE PRESENT STUDY

Study Quoted	Period Covered	Arguments in Demand Function	Elasticity of Demand with Respect to r_s	r_L	Y	NW
Latane (1954)*	1919-1952	r_L, GNP	-	-.5787	.8276	-
Latane (1960)*	1909-1958	r_L, GNP	-	-1.7146	1.2833	-
Bronfenbrenner-Mayer						
Idle Balances	1919-1956	r_s, NW, M_{t-4}	-.5304	-	-	1.6849
Idle Balances (steady-state)	1919-1956	r_s, NW, M_{t-4}	-1.1568	-	-	3.6748
Total Balances	1919-1956	r_s, NW, M_{t-4}, GNP	-.0928	-	.3440	-.1158
Total Balances (steady-state)	1919-1956	r_s, NW, M_{t-4}, GNP	-.3334	-	1.2359	-.4161
Klein-Goldberger						
Household liquid assets	1928-1952 (excl. 1942-44)	r_L, Y_d	-	-1.060	.1740	-
Business liquid assets	1928-1952 (excl. 1942-44)	$r_s, W_1, P, (L_2)_{t-4}$	-.0696	-	-	-
Teigen (structural)	1946 IV-1959 IV	r_s, GNP, M_{t-1}	-.0168	-	.1613	-
Teigen (structural) steady-state	1946 IV-1959 IV	r_s, GNP, M_{t-1}	-.0538	-	.5130	-
Teigen (structural)	1924-1941	r_s, GNP, M_{t-2}	-.0907	-	.4332	-
Teigen (structural) steady-state	1924-1941	r_s, GNP, M_{t-2}	-.1956	-	.9344	-

*In calculating elasticities for functional relationships in which the elasticities are not constant, a common practice is to find the elasticities at the means of all of the variables concerned. We have consistently followed this practice in Table V.5 above. In doing so, however, a procedural problem is raised, which can best be illustrated by a general example. Suppose we have a linear relationship between price and quantity of some good, as follows:

$$q = a(p) = a + bp$$

$$\text{Then} \quad \eta_p \equiv \frac{\partial q}{\partial p}\frac{\bar{p}}{\bar{q}} = b\,\frac{\bar{p}}{\bar{q}}$$

When calculating elasticities from regression results, the problem is whether to use $\bar{q}$ as obtained from the input series, or, since $\bar{p}$ implies a value for q by the regression relationship, whether to use this relationship so that

$$\eta_p = \frac{b\bar{p}}{a + b\bar{p}}$$

If the fit is very close, of course, these alternatives give approximately equivalent results. In the case of the functions used by Latane, however, the calculated elasticities differ considerably depending upon which method is chosen. The reason is that his functions are "average relationships" obtained by first regressing the velocity term on the interest term and then the interest term on the velocity term, after which a function is constructed which lies between these linear relationships and, in some sense, represents the average relationships among the three variables r, M, and Y (note that the extent to which these regressions differ is an indication of the degree of simultaneity involved). The elasticities reported in Table V.5 are computed using the means of the input series for all variables. For comparison, we report below the elasticities which result from using the regression relationship as a measure of $\bar{M}$:

		η_r	η_Y
(1)	1954 study: $\bar{M} = \frac{.008}{\bar{r}}\bar{Y} + .09\bar{Y}$	-.7028	1.0000
(2)	1960 study: $\bar{M} = \frac{\bar{Y}}{.77\bar{r} + .38}$	-.8869	1.0000

It will be noted that the dimension of the interest rate is different in the two studies; it is taken to be a fraction in the earlier study, but not in the latter. It is also noteworthy that these functions are constructed in such a way as to yield an income-elasticity of demand equal to unity, for any set of values of Y and r, if elasticities are estimated by using Y and r to approximate M.

It seems most sensible to compare our prewar estimates with those of the other studies, since the periods covered by these studies include all of the years used for our prewar estimates plus some additional years at each end of the period. Following this approach, our estimate of the interest-elasticity of demand for the short run, -.091, agrees quite closely with the interest-elasticity of -.093 found by Bronfenbrenner-Mayer in their estimate using total money balances. However, they cover the period 1919-1956 so that most of the years used for the postwar estimates reported in the present study are included. Since we found a considerably lower interest-elasticity of demand for the postwar period, the two estimates reported above are not as consistent as they first appear. It is also notable that the Bronfenbrenner-Mayer steady-state estimate is a good deal larger in absolute value than ours.

The interest-elasticities of demand implied by the Latane studies are quite high, and compare in that respect to the Bronfenbrenner-Mayer idle-balance estimates. It is surprising that the extension of the original Latane study 10 years backward (from 1919 to 1909) and six years forward (from 1952 to 1958) should result in a tripling of the interest-elasticity of demand, especially when our work indicates that this elasticity has become smaller. This peculiarity of the Latane study is partly due to the manner in which the elasticities are calculated (see the footnote to Table V.5) and may be due partly to the fact that different functional forms are used in the two studies.

Bronfenbrenner and Mayer have used the interest rate and a net worth term as explanatory variables in their function explaining "idle balances;" as shown in Table V.5, the elasticity of demand with respect to net worth for idle balances is positive and relatively large. When income is introduced into the function in the explanation of the demand for total balances, however, the elasticity of demand with respect to net worth becomes negative (and the coefficient of this term in the regression becomes insignificant). It is very possible that this result is due to the problems of estimation caused by the simultaneous use of net worth and income as explanatory variables which we have discussed above. In the idle-balances formulation, the performance of the net worth term may be due to the fact that it is acting as a proxy for income (in our regressions, the simple correlation coefficient between income and net worth was about .98), while the introduction of income with net worth probably causes serious problems of multicollinearity. Therefore a great deal of significance probably should not be attached to these Bronfenbrenner-Mayer elasticities with respect to income and net worth.

While the Klein-Goldberger results are not directly comparable with any of the other estimates, it is interesting to compare the interest-elasticity of demand for household liquid assets and for business liquid assets. One would tend to expect that businesses, being perhaps aware of or having access to many more alternative opportunities than households

for investing funds, would exhibit a more interest-elastic demand. This is not the case, however; household demand appears to be a great deal more interest-elastic.

In terms of income-elasticity of demand, our prewar results show a higher value than any other study except the Latané studies and the (suspect) Bronfenbrenner-Mayer steady-state estimate from their total-balances function. The Klein-Goldberger estimate, which is based upon disposable income, is quite low when compared with the others.

In reviewing the results of this discussion of elasticity estimates, two phenomena were noted which seem to be of greatest interest. First was the rather striking comparison between single-equation and structural estimates. The model used in the present study yielded elasticities which were considerably greater in absolute value than their single-equation counterparts. This was especially noticeable in the supply equation, where the structural elasticities were about 40 per cent greater than those based on single-equation estimates. It is not possible to generalize from this single instance, but we find here that the characteristics of single-equation estimates of demand or supply relationships which depend only on price, discussed at the beginning of this chapter, are also true of these multivariate relationships.

The second observation of interest concerns the decline in demand and supply elasticities in the postwar period as compared to the prewar years which was disclosed by our

estimates. Most surprising seems to be the decline in the interest-elasticity of demand for money. We have hypothesized that this shift may be due to a change in the role of money which, in fact, makes it a somewhat different, and more nearly unique, economic good. The change which we suppose to have occurred is from money as a store of value to money as a means of payment.

Finally, we have computed elasticities for both short-run and steady-state situations, and as would be expected, the latter are a good deal larger in value than the former.

In concluding, the precise nature of the elasticity estimates we have made should be emphasized. An objective of this study is to make unbiased estimates of elasticities of supply and demand for money. That objective was set down with simultaneous-equations bias in mind, and we believe that we have eliminated bias of this type to a great extent by use of the supply-demand system we have formulated. To the extent that this model is misspecified, however, our estimates are biased by specification error. The specification error is due to the fact that the income equation fails to interact with the rest of the model; some comments on the reason for this formulation and the extent of the expected bias have been made earlier in the study, and in short, we believe that the bias is not great, especially for short-run elasticity calculations.

CHAPTER VI

IMPLICATIONS FOR MONETARY POLICY

The previous several chapters of this study have been devoted to the derivation of a model describing the behavior of the monetary sector. It has been shown, for example, that supply and demand interact to determine jointly the stock of money and the short-term rate of interest. While such a simple model as we have built may be adequate to demonstrate conceptual phenomena such as these interactions, its use as a vehicle for the operational analysis of monetary policy is a questionable procedure because of the obvious misspecification involved in our failure to link the monetary sector with the "goods" sector of the economy.

This has two implications for use of the model in analyzing policy questions: first, it is impossible to determine the effects of monetary variables on income. As a consequence, the degree to which monetary policy can affect income cannot be evaluated. Since the raison d'être of monetary policy is found in its influence on income, this model is useless as a policy-evaluation device if judged by its ability to demonstrate these effects. Secondly, failure to account for these interactions between money and the rate of interest, on one hand, and income, on the

other, introduces specification error into the structural estimates and biases whatever analysis of policy is attempted using the model.

With such serious misgivings about drawing policy implications from the model, some justification for presenting evidence on the leverage of monetary policy derived from our estimates, as we do below, must be given. It is felt that the most serious misspecification lies in considering gross private domestic investment to be exogenous. While there are many categories of investment subsumed under this heading, and certainly many factors enter into the investment decisions of firms and consumers, whether in respect to new plant and equipment, inventories, modernization of existing facilities, or housing, it is felt that some measure of the rate of interest must influence these decisions, and the rate of interest is the point of linkage between the real and monetary sectors of the economy.

We recognize the importance of this linkage, both for a correctly-specified model and for a completely satisfactory analysis of policy, but we disregard it in this study for a number of reasons. The first is a practical one: by necessity, the present study is limited in scope. Although it is widely agreed that interest rates affect investment and therefore income, the precise mechanism through which this occurs is not well understood. Therefore the inclusion of investment as an endogenous variable would require an extensive investigation of this mechanism and the expansion of

our model into a general-equilibrium model of Klein-Goldberger proportions, or larger. This is not possible in the present study, because of limitations on time and other resources. Secondly, we believe that some useful inferences concerning the initial effect of monetary policy action on the monetary variables can be drawn. The validity of these inferences rests upon the belief that there is an appreciable time lag (in the order of several months) between changes in policy instruments and changes in income.[1] During the period of this lag, the effect of changes in the monetary variables upon income may be assumed to be non-existent or of negligible importance, and our model may therefore be useful as a representation of short-run relationships in the monetary sector. It is in this light, and with all of the reservations discussed above and in previous sections of this study, that the following evidence on monetary policy is presented and should be evaluated.

A. The Ends and Means of Monetary Policy

While the monetary authorities use the instruments of monetary policy in order to influence the course of income, they do so by attempting to manipulate monetary variables,

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[1] For some empirical evidence on the length of this lag, see E. Cary Brown, Robert M. Solow, Albert Ando, and John Kareken, "Lags in Fiscal and Monetary Policy" (study made for the Commission on Money and Credit, 1961). (Mimeographed.)

particularly the money stock.[1] The policy instruments which are used for this purpose are the discount rate, open market operations, and changes in reserve requirements for member banks.[2]

While all of these tools of monetary policy could be used in principle for any of the short-run, cyclical, or secular

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[1]A number of authorities might be cited on the subject of the goals of monetary policy. Ralph A. Young, writing on behalf of the Board of Governors of the Federal Reserve System in The Federal Reserve System: Purposes and Functions (fourth edition; Washington, D. C.: 1961), states, "Reserve banking or monetary policy attempts to provide a financial climate conducive to sustainable growth in output, employment, and consumption under conditions of relative price stability." (p. 123). In Neil H. Jacoby (ed.), United States Monetary Policy (Columbia University: The American Assembly, 1958), Professor Jacoby writes, "Broadly speaking, 'monetary' policy can be conceived to embrace all measures undertaken by government to affect the expenditure or use of money by the public ....a narrower concept of 'monetary' policy is, however, customary in American economic writing and thinking. By this phrase we ordinarily refer to the regulation of the supply of money (currency and bank deposits) through discretionary actions of the Federal Reserve System. 'Monetary policy' in this stricter sense therefore focuses on the objectives, the tools, and the processes of regulation of the supply of money and credit." (p. 2). [Italics are the author's]. In his essay in this volume, entitled "Tools and Processes of Monetary Policy," Dr. Young writes, "The primary responsibility of the Federal Reserve System is to manage the money supply of the United States economy in the public interest." (p. 13).

[2]Details of the mechanics involved in the operation of these tools of monetary policy may be found in any textbook on money and banking. For example, see Charles L. Prather, Money and Banking (seventh edition; Homewood, Illinois: Richard D. Irwin, Inc., 1961), especially Chapters 16 and 19; Day and Beza, op. cit., pp. 158-178; also, the Board of Governors' book, The Federal Reserve System: Purposes and Functions, provides a good summary from the point of view of the Federal Reserve System. Chapters III and VII are of special interest.

growth phenomena to which the money stock must adjust, in practice each one has come to be used for a particular kind of problem, although some overlapping occurs. It has been the practice to use open market operations to achieve short-run goals, such as the provision or diminution of reserves to facilitate seasonal increases or decreases in the money supply. The Board of Governors states:

> "The bulk of Federal Reserve operations affecting the reserve position of banks relate to short-term variations in the economy's need for bank credit and are effected by the use of open market operations."[1]

Open market operations are not restricted to meeting day-by-day or seasonal needs; they constitute an important counter-cyclical weapon, and in this respect they are used in conjunction with discount rate changes. Finally, reserve requirements for member banks are sometimes changed as a means of damping cyclical income changes. However, the secular trend in these requirements is downward, indicating that the main usefulness of such requirements now is to provide leverage for monetary policy; they are lowered periodically to provide more reserves for the secular growth of the economy and the money supply.

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[1]Board of Governors of the Federal Reserve System, The Federal Reserve System: Purposes and Functions (fourth edition; Washington, D. C.: 1961), p. 32.

The bulk of this chapter will be devoted to a discussion of the leverage of monetary policy, measured within the framework of the "best" structural models derived and estimated in Chapter IV. It is therefore important to understand the manner in which Federal Reserve policy is put into effect through the use of the policy instruments, and how such policy action is reflected in the models.

1. Policy aspects of the structural model

Our simple supply-demand model of the monetary sector contains two explicit policy variables: the discount rate and M*. Changes in M* are multiples of changes in supplied reserves; that is, they result from open market operations initiated by the Federal Reserve System. The discount rate is set directly by the System also; each Reserve Bank sets the rate for its district every 14 days, subject to review by the Board of Governors. The third policy tool, reserve requirement change, enters the model through M*, as does open market operations. In this case, however, there are both direct and indirect effects. A change in reserve requirements changes M* directly through a change in k*, the adjusted weighted average reciprocal reserve ratio, and not through any immediate change in total or supplied reserves. The indirect effect occurs when member banks which previously may have had some excess reserves now may find that these are not sufficient to meet the new requirements (this example assumes that the requirements have been raised). These banks

must acquire additional reserves, and may do so in a number of ways: by selling securities from their portfolios, by borrowing federal funds, etc. If the banking system as a whole needs new reserves (that is, if at the time of the rise in requirements, there are not sufficient excess reserves in the system to meet the additional requirement), they must be supplied either through increased borrowing from the Federal Reserve System by the member banks, by calling loans, or by open-market operations initiated by the System. If the latter course is followed, supplied reserves will rise, as will M^*, while if borrowing increases, neither R^S nor M^* will change as a result. Thus the initial policy change in reserve requirements, reflected in a change in k^*, may be accompanied by a change in supplied reserves and in M^*.

2. Guides to policy action

Having examined the mechanics of open-market policy in relationship to the specification of our monetary model, we must now consider the qualitative aspects of policy decisions. That is, the following question is examined: what guides the Federal Reserve System in deciding on the nature and extent of open-market operations, changes in the discount rate, and changes in reserve requirements, and is the model used in this study consistent with these policy criteria?

There exists a fairly large literature on the philosophy underlying open-market policy, and only a very brief summary will be given here. At the beginning of the Federal Reserve

System, a "productive loans" policy was followed, under which commercial banks were supposed to lend only for productive purposes, with the Federal Reserve lending to the member banks whenever they had legitimate credit demands. This system was supposed to generate the correct amount of money and credit automatically; however, as it turned out, the system caused destabilizing swings in the money stock.[1]

As a consequence, the Federal Reserve System adopted a posture in the 1930's with respect to monetary control which it has used ever since. The System began to initiate reserve changes and pursue an active, rather than a completely passive, policy focusing on the net reserve position of member banks as a guide. The net reserve position for a member bank is the difference between that bank's excess reserves and its borrowings from the Federal Reserve System. The aggregate net reserves position for the banking system is the sum of individual banks positions. In our notation, the net reserve position may be expressed as $(R^s - R^r)$, as shown in Chapter III. The Federal Reserve System uses this aggregate net reserve position as its immediate guide for monetary management.[2]

The Federal Reserve System is interested in the aggregate net reserve position of the member banks because this represents a measure of the amount of supply capacity in the system at

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[1]For a discussion of the history of the philosophy of monetary polich under the Federal Reserve System, as well as extensive references to the literature, see William G. Dewald, "Monetary Control and the Distribution of Money" (unpublished Ph.D. dissertation, The University of Minnesota, Minneapolis, Minnesota, 1961).

[2]Young, op. cit., esp. pp. 35ff.

any time relative to monetary goals. While the System's immediate goal is to achieve a predetermined level for the money supply at a given time, only part of the supply mechanism (namely, R^S) is under direct and immediate control by the monetary authorities.[1] Thus the Federal Reserve must try to guess what the banks and the public will do in response to its own monetary policy actions, and these actions must therefore be tailored so as to elicit a response such that the combined result will be the desired level of the money stock (and short-term interest rate). The reserve position at any given time may be considered a datum for the final decision with respect to policy action, but in addition, other information--specifically, response parameters characterizing the

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[1]We have consciously avoided mentioning manipulation of the rate of interest as a policy objective of the Federal Reserve System, since policy statements of the System generally disavow any intent to use monetary policy toward this end. See, for instance, the discussion in Board of Governors, The Federal Reserve System: Purposes and Functions, pp. 120-122. On p. 122 it is stated:

"While the course of interest rates is necessarily influenced by reserve banking action, monetary policy decisions are themselves based primarily on judgment as to the flow of bank credit and money that is appropriate for the economy, and not on judgment as to some level and pattern of interest rates that is deemed to be appropriate [italics not in the original]. To the greatest extent possible, the setting of interest rates is left to the interplay of supply and demand forces expressed in the credits and security markets."

Despite such disclaimers, it must be recognized that the Federal Reserve System, as an arm of the executive branch of the government, has an interest in establishing the rate of interest at a level which will foster the basic economic objectives of full employment, price stability, growth, and balance of payments equilibrium, and it may be inferred that the level of the interest rate is taken into account in monetary policy decisions, especially during the present period of balance of payment difficulties.

probable behavior of the commercial banks and the public--must be brought to bear. Putting all of this information together, the monetary authorities arrive at a decision concerning the direction and amount of open market operations and changes in other control variables which they believe will be necessary to achieve the desired monetary objective.

The basic tenet of the reserve position theory appears to be that the monetary authorities can manipulate the money stock through control of the aggregate reserve position; banks are supposed to have some level of net free reserves which they desire to maintain under given economic conditions and other circumstances. If expansion is desired, added free reserves are supplied by the Federal Reserve System, and these will presumably be converted into loans to the extent that the level of free reserves desired by the banks is now less than the actual level. Conversely, if contraction is desired, a reduction in free reserves through Federal Reserve action will presumably cause banks to attempt to regain equilibrium by selling securities, failing to renew loans, etc. The extent of policy action is geared to the amount by which it is estimated that the money stock will change in response to this action.[1]

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[1]Dewald, op. cit., p. 5.

3. The role of policy instruments under reserve position theory

a. Open Market Operations

Open market operations are the most important means used by the Federal Reserve System to effect monetary policy decisions. The Board of Governors states:

> "The effectuation of credit and monetary policy has been the principal objective of open market operations since the early 1950's....Open market operations are administered so as to affect bank reserve positions, and hence the flow of bank credit and money."[1]

It is therefore through R^S and M^* that the most direct link exists between our model and the reserve position theory which underlies Federal Reserve policy decisions. In this respect it is important to understand that, while the Federal Reserve keeps its policy eye on the net reserve position of member banks, and has for the past three decades understood the linkage which exists between its policy actions in the open market and the money stock in terms of the concept summarized as "net reserve position," yet it is able only to change the amount of reserve which it supplies through open market operations. But the commercial banks can also affect total reserves by borrowing, and they respond endogenously to other economic variables such as the rate of interest, expectations, etc. Therefore there arises some "slippage" between Federal Reserve operations on reserves and changes in the money stock. Furthermore,

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[1]Board of Governors, The Federal Reserve System: Purposes and Functions, pp. 34-35.

the degree to which this slippage occurs may vary. It is in this sense that the money stock is considered to be endogenous. In manipulating reserves through open market operations, based upon their evaluation of the net reserve position, the Federal Reserve authorities are controlling precisely only R^S, or its equivalent, M^*, variables which are related to the total money-producing capacity of the banking system. The decision concerning the amount of money actually created or extinguished in response to a given injection or diminution is an endogenous one and is made by the member banks in response both to pressures on the supply side initiated by the monetary authorities and to the needs of businesses and consumers.

b. The Discount Rate

The role of the discount rate in monetary policy has changed since the inception of the Federal Reserve System as the shift from a "productive loans" philosophy of reserve supply took place. The discount rate was first conceived as the chief instrument of policy control over member bank reserves; that is, the member banks were supposed to take the initiative in obtaining new reserves as the needs of manufacturing and commerce changed, with the Federal Reserve exercising control at the discount window through the level of the discount rate.[1] But since the monetary authorities have

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[1]Albert G. Hart and Peter B. Kenen, Money, Debt, and Economic Activity (third edition; Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961), p. 448.

begun to initiate reserve changes, the discount rate has acquired additional dimensions. Its new role can be illustrated by the following comment by an official of the Board of Governors:

> "Technically, the discount rate is the publicly announced charge applied by the Federal Reserve Banks on discounts or advances to member banks. As such, it measures for the member banks the cost of reserve funds obtained by such borrowing. Because there is a close interrelationship between the level of Reserve Bank discount rates and short-term money rates in the market, and because the establishment of the rate entails a Federal Reserve judgment as to whether the current flow of bank credit and money is consistent with the country's transactions and liquidity needs, discount rate changes are commonly viewed as an important index of the direction of Federal Reserve policy."[1]

Another statement representing the view of the Board of Governors is found in their book, The Federal Reserve System: Purposes and Functions, where they write:

> "The financial community thinks of Reserve Bank discount rates as pivotal rates in the credit market. The key role assigned to them derives largely from the fact that they have been established by the administrative action of a public body having special information and competence to judge whether expansion of bank credit and money is consistent with the economy's over-all cash needs for transactions and liquidity. In the light of this fact, it is only natural that the business and financial community should commonly interpret a change in the level of Reserve Bank discount rates as an important indication of the trend in Federal Reserve policy."
>
> "There are no simple rules for interpreting changes in discount rates, however. In some circumstances a change in discount rates may express a shift in direction of Federal Reserve policy toward restraint or ease. In other instances it may reflect a further step in the same direction. In still other cases, when market rates of interest have moved away from close relationship with the existing discount rate, a change in the level of rates may represent merely a technical adjustment of discount rates to market rates so that the System's discount mechanism will function effectively in line with current policy."[2]

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[1] Young, op. cit., p. 25.

[2] Board of Governors, The Federal Reserve System: Purposes and Functions Pp. 46-47.

Therefore it appears that the discount rate is no longer interpreted only as a measure of the cost of supplying funds to the banking system. It has acquired new dimensions, but they do not change the interpretation of the discount rate as a regression variable; the same sign should be expected as when it is interpreted only as a measure of the cost of lending (an interpretation which has not been abandoned in considering the "new" role of the discount rate).

However, it is difficult to say whether the discount rate should be expected to be a more or less powerful tool of policy as a result. On the one hand, its use as an indicator of policy should reinforce its effect as a cost variable. An increase in the discount rate will not only mean an increase in the cost to member banks of borrowing in order to make loans. It may also mean that monetary policy is becoming more restrictive, and that increased pressure on bank reserve positions from the monetary authorities may be expected; this may cause commercial bankers to become more conservative in their lending decisions. But the discount rate is often changed merely in order to maintain a certain relationship with the market rate of interest, and it is not clear how such changes would affect our supply ratio, and how they would be distinguished by commercial bankers from those changes which signal policy shifts.[1] However, any such increase means that

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[1] See Hart and Kenen, op. cit., p. 449, on the problems of interpretation which arise when discount rate changes are made for a number of different reasons. A further discussion of the criteria for discount rate changes may be found in Commission on Money and Credit, op. cit., p. 65.

borrowed reserves cost more than formerly, and to the extent that cost changes affect loan decisions, this will show up in the proper way in the supply regression.

We may summarize this discussion of the tools and goals of monetary policy by noting that our simple structural model of the monetary sector takes account of the three instruments through which monetary policy is effected: the discount rate, open market operations, and changes in reserve requirements. The discount rate enters directly as a variable in the model, and both open market operations and changes in reserve requirements are made explicit through changes in the variable M^*. Changes in reserve requirements enter through changes in the multiplier k^*, while open market operations are represented in the model by changes in supplied reserves.[1] In the next section, we shall attempt to estimate the degree to which changes in these instrumental variables may be expected to result in changes in the stock of money and in the rate of interest, based upon the structural estimates discussed in Chapter IV.

B. The Leverage of Monetary Policy

This study is not concerned with the current controversy over the effectiveness of monetary policy, in the sense that

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[1] It was noted above that changes in reserve requirements might also eventually affect the level of total reserves, in the case in which an increase in the reserve ratio when no excess reserves existed would either force banks to borrow or require the Federal Reserve to buy securities in the open market. However, this is a secondary effect, while this discussion deals with the immediate impact of each of these policy instruments.

its effectiveness is being discussed in terms of cyclical asymmetry, the rise and current role of financial intermediaries, differential effects, etc. Instead, the leverage of monetary policy will be examined within the framework of the structural model defined above. By the term leverage, reference is made to a measure of the degree to which the monetary authorities can reach their immediate goal of manipulation of the money stock, using the instruments at their disposal. This measure might be thought of in general terms as the extent of change in the money stock relative to some given change in the policy variables by the monetary authorities.

1. Measurement of policy leverage

The leverage of monetary policy will be measured in this study by deriving expressions for the total derivative of each of the endogenous monetary variables (M and r) with respect to each of the policy variables in our model (M^* and r_d). In order to take the interaction of the entire system into account, these expressions are derived by solving a set of simultaneous linear equations in which the unknowns are the total derivatives of each of the structural equations.[1] They are made operational by substituting our estimates of the appropriate coefficients from the "best" models estimated in Chapter IV and selected values of the variables which enter directly.

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[1]For a discussion of this approach, see Paul A. Samuelson Foundations of Economic Analysis (Cambridge, Massachusetts: Harvard University Press, 1953), Chapter II.

Our model is well suited to this type of analysis from a structural standpoint, since it contains policy variables which stand for the instruments used by the Federal Reserve System to achieve monetary goals. We are able to derive expressions which tell us how the endogenous variables react, through interaction of the system, to changes in each of the policy variables. However, the numerical estimates which result must be interpreted by reference to some standard.

It is tempting to postulate some numerical value for these derivatives to which we can compare our results as a means of determining, for example, whether or not the money stock is exogenously controlled, practically speaking. For instance, the value of the derivative $\frac{dM}{dM^*} = 1$ naturally suggests itself as a standard for judging exogeneity, since this value, if it were found to exist, would mean that changes in M^* would be transmuted into changes in M of the same amount. But it is clear that this is a false measure of exogeneity, since the monetary authorities could control the money stock precisely for any value of the derivative, as long as that value were predictable. Thus our objective is simply to find the equilibrium values of these derivatives $[\frac{dM}{dM^*}, \frac{dr}{dM^*}, \frac{dM}{dr_d}$, and $\frac{dr}{dr_d}]$ for various points in time, and to observe the degree of constance which they exhibit, on the grounds that a lack of constancy implies lack of predictability. An exception to this assumption might be the case of steady secular changes in the value of these derivatives; this is discussed below.

a. The Derivation of Equilibrium Total Derivatives

For ease in interpreting the derivatives discussed below, the structural equations upon which they are based are written in linear form as follows:

(1) 1946 IV-1959 IV

$$(VI.1)\quad M = \alpha_1 + \beta_{11}(rY) + \beta_{12}Y + \beta_{13}M_{t-1} + \beta_{14}S_1 + \beta_{15}S_2 + \beta_{16}S_3$$

$$(VI.2)\quad M = \alpha_2 M^* + \beta_{21}M^*r - \beta_{21}M^*r_d + \beta_{22}M^*S_4 + \beta_{23}M^*S_5$$

$$(VI.3)\quad Y = \alpha_3 + \beta_{31}E + \beta_{32}NW + \beta_{33}Y_{t-1} + \beta_{34}(S_1Y_{t-1}) + \beta_{35}(S_2Y_{t-1}) + \beta_{36}(S_3Y_{t-1})$$

(2) 1924-1941

$$(VI.1')\quad M = e^{\alpha_1} r^{\beta_{11}} Y^{\beta_{12}} M_{t-2}^{\beta_{13}}$$

$$(VI.2')\quad M = \alpha_2 M^* + \beta_{21}M^*r + \beta_{22}M^*r_d + \beta_{23}M^*S$$

$$(VI.3')\quad Y = \alpha_3 + \beta_{31}E + \beta_{32}NW + \beta_{33}Y_{t-4}$$

The total differential of each of these functions is found in the usual manner. For the postwar money demand function, we have

$$(VI.4)\quad M^D = M(r, Y, M_{t-1}, S_1, S_2, S_3) \text{ so that}$$

$$(VI.5)\quad dM^D = \frac{\partial M}{\partial r}dr + \frac{\partial M}{\partial Y}dY + \frac{\partial M}{\partial M_{t-1}}dM_{t-1} + \frac{\partial M}{\partial S_1}dS_1 + \frac{\partial M}{\partial S_2}dS_2 + \frac{\partial M}{\partial S_3}dS_3$$

But when we convert this expression into a total derivative, the last three terms on the right-hand side will all be zero, since the S_i are dummy variables. In addition, derivatives with respect to lag terms are zero, since these variables are "givens" for the present period. Therefore we have, in effect:

$$(VI.6) \quad dM^D = \frac{\partial M}{dr}dr + \frac{\partial M}{\partial Y}dY$$

For the prewar period, the demand function in general form may be written as

$$(VI.4') \quad M^D = M(r, Y, M_{t-2})$$

and so the expression for the differential of this function is identical with (VI.6):

$$(VI.6') \quad dM^D = \frac{\partial M}{\partial r}dr + \frac{\partial M}{\partial Y}dY.$$

The necessary partial derivatives are obtained from Equations VI.1 and VI.1'. First we differentiate Equation VI.1 partially with respect to r and Y, and we get:

$$\frac{\partial M}{\partial r} = \beta_{11}Y;$$

$$\frac{\partial M}{\partial Y} = \beta_{11}r + \beta_{12}$$

Substituting these into Equation VI.6 gives the following total differential:

$$(VI.7) \quad dM^D = \beta_{11}Y\,dr + (\alpha_{11}\,r + \beta_{12})dY$$

For the prewar demand function, we differentiate Equation VI.1' partially with respect to r and Y and get

$$\frac{\partial M}{\partial r} = \gamma\beta_{11} r^{\beta_{11}-1} Y^{\beta_{12}} M_{t-2}^{\beta_{13}} ;$$

$$\frac{\partial M}{\partial Y} = \gamma\beta_{12} r^{\beta_{11}} Y^{\beta_{12}-1} M_{t-2}^{\beta_{13}}$$

In these derivatives, and below, we have set $\gamma \equiv e^{\alpha_1}$ for convenience, since α_1 was the constant term in our log-linear regressions.

These partial derivatives are substituted into Equation VI.6' and we have

$$(VI.7') \quad dM^D = \gamma\beta_{11} r^{\beta_{11}-1} Y^{\beta_{12}} M_{t-2}^{\beta_{13}} dr + \gamma\beta_{12} r^{\beta_{11}} Y^{\beta_{12}-1} M_{t-2}^{\beta_{13}} dY$$

In the same manner, the total differential of the postwar supply function is derived by first finding the general form from the relationship

$$(VI.8) \quad M^S = X(M^*, r, r_d, S_4, S_5)$$

We shall disregard the terms related to the shift variables, as before. We find that

$$(VI.9) \quad dM^S = \frac{\partial X}{\partial M^*} dM^* + \frac{\partial X}{\partial r} dr + \frac{\partial X}{\partial r_d} dr_d$$

The general form of the prewar supply function is essentially the same as for the postwar period. Taking partial derivatives of Equations VI.2 and VI.2', we have

$$\frac{\partial X}{\partial M^*} = \alpha_2 + \beta_{21} r - \beta_{21} r_d + \beta_{22} S_4 + \beta_{23} S_5 \qquad \text{(Postwar)}$$

$$\frac{\partial X}{\partial M^*} = \alpha_2 + \beta_{21} r + \beta_{22} r_d + \beta_{23} S \qquad \text{(Prewar)}$$

$$\frac{\partial X}{\partial r} = \beta_{21} M^*$$

$$\frac{\partial X}{\partial r_d} = -\beta_{21} M^* \quad \text{(Postwar)}$$

$$\frac{\partial X}{\partial r_d} = \beta_{22} M^* \quad \text{(Prewar)}$$

We note that the partial derivative $\frac{\partial X}{\partial M^*}$ is equal to the right-hand side of the money supply equation taken without error, when that equation is written in such a way that $\frac{M}{M^*}$ is the dependent variable. Therefore, as a first approximation we may write

$$\frac{\partial X}{\partial M^*} = \frac{M}{M^*}$$

Substituting these partial derivatives into Equation VI.9 results in the following total differentials:

$$\text{(VI.10)} \quad dM^S = \frac{M}{M^*} dM^* + \beta_{21} M^* dr - B_{21} M^* dr_d \qquad \text{(postwar)}$$

or $$\text{(VI.10')} \quad dM^S = \frac{M}{M^*} dM^* + \beta_{21} M^* dr + \beta_{22} M^* dr_d \qquad \text{(prewar)}$$

Finally, the total differential of the income equation is found from the general expressions

$$\text{(VI.11)} \quad Y = Y(E, NW, Y_{t-1}, S_1, S_2, S_3) \qquad \text{(postwar)}$$

$$\text{(VI.11')} \quad Y = Y(E, NW, Y_{t-4}) \qquad \text{(prewar)}$$

Again we ignore the shift terms (the S_i) and the lag terms. This results in the following total differential applying to both periods:

$$(VI.12) \quad dY = \frac{\partial Y}{\partial E} dE + \frac{\partial Y}{\partial NW} dNW$$

Differentiating Equation VI.3 partially with respect to each of the relevant arguments in Equations VI.12 and VI.12', we have

$$\frac{\partial Y}{\partial E} = \beta_{31}$$

$$\frac{\partial Y}{\partial NW} = \beta_{32}$$

and substituting these into Equation VI.12 results in the following total differential:

$$(VI.13) \quad dY = \beta_{31} dE + \beta_{32} dNW$$

In order to find the equilibrium total derivatives $(\frac{dM}{dM^*})^o$ and $(\frac{dr}{dM^*})^o$ the set of three equations which results from substituting dM^* into the denominators of Equations VI.7(or VI.7'), VI.10 (or VI.10') and VI.13 (or VI.13'), is solved, first for $(\frac{dM}{dM^*})^o$ and then for $(\frac{dr}{dM^*})^o$. The same procedure is followed to find $(\frac{dM}{dr_d})^o$ and $(\frac{dr}{dr_d})^o$. The process of solution can be simplified by noting that some additional terms in these differential equations are zero. Specifically, the derivatives $\frac{dr_d}{dM^*}$ and $\frac{dM^*}{dr_d}$, which appear in the expression for the total derivative of the supply function, are taken to be zero, since

both r_d and M* are policy variables which are not related to each other functionally.

Therefore we have the following set of equations to be solved for $(\frac{dM}{dM^*})^o$ and $(\frac{dr}{dM^*})^o$ for the postwar period:

$$\text{(VI.14)} \quad \frac{dM}{dM^*} - \beta_{11}{}^{Y} \frac{dr}{dM^*} - (\beta_{11}{}^{r} + \beta_{12}) \frac{dY}{dM^*} = 0$$

$$\text{(VI.15)} \quad \frac{dM}{dM^*} - \beta_{21}{}^{M^*} \frac{dr}{dM^*} = \frac{M}{M^*}$$

$$\text{(VI.16)} \quad \frac{dY}{dM^*} = \beta_{31} \frac{dE}{dM^*} + \beta_{32} \frac{dNW}{dM^*}$$

For the prewar years, the system is as follows:

$$\text{(VI.14')} \quad \frac{dM}{dM^*} - \gamma\beta_{11}{}^{r}\beta_{11}{}^{-1}{}_{Y}\beta_{12}{}_{M}\beta_{13} \frac{dr}{dM^*} - \gamma\beta_{12}{}^{r}\beta_{11}{}_{Y}\beta_{12}{}^{-1}{}_{M_{t-2}}\beta_{13}\frac{dY}{dM^*} = 0$$

$$\text{(VI.15')} \quad \frac{dM}{dM^*} - \beta_{21}{}^{M^*} \frac{dr}{dM^*} = \frac{M}{M^*}$$

$$\text{(VI.16')} \quad \frac{dY}{dM^*} = \beta_{31} \frac{dE}{dM^*} + \beta_{32} \frac{dNW}{dM^*}$$

These systems can easily be solved by the use of Cramer's rule; this method of solution is described in any of a number of books on mathematical economics.[1] Before solving these sets of equations, we call attention to the fact that they each contain an expression for the derivative $\frac{dY}{dM^*}$ (and the sets of

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[1] See, for example, R. G. D. Allen, Mathematical Economics, 2nd ed. (London: Macmillan and Co., Ltd., 1959), pp. 457-460; James M. Henderson and Richard E. Quandt, Microeconomic Theory: A Mathematical Approach (New York: McGraw-Hill Book Company, Inc., 1958), pp. 260-261.

equations which will be derived below in order to solve for equilibrium derivatives with respect to the discount rate will contain an expression for $\frac{dY}{dr_d}$). Since our model is specified in such a way that income is a function only of variables which are assumed to be exogenous, there is no interaction between the income function and the remainder of the model, so it is implied by the model that the derivatives $\frac{dY}{dM^*}$ and $\frac{dY}{dr_d}$ are equal to zero.

It is recognized that the model is misspecified in this respect. We justify our inferences concerning the leverage of monetary policy which are drawn from our estimates by arguing, as we have above, that there is a time lag between changes in the instrument variables M^* and r_d and changes in income, although their effects will be felt in the monetary sector almost immediately. Thus in evaluating the expressions which are derived below, we set these derivatives equal to zero and use the short-run values of the coefficients which are reported in Chapter IV. Our numerical estimates refer only to the "impact effect" of changes in parameters, in other words.

Recognizing this fact, we could have simplified the sets of equations from which we derive solutions for the equilibrium derivatives by setting the derivatives of income with respect to the instruments equal to zero and reducing these systems to simple "two by two" sets of equations which could be solved directly by substitution. We have not done so because we wish to use the general expressions for the equilibrium derivatives

which result from solving the larger system as a means of indicating the direction of bias in estimates which would result if we used steady-state values for the coefficients but assumed that income is a function of exogenous variables only.

With this in mind, we solve the system represented by Equations VI.14, VI.15, and VI.16 for $\frac{dM}{dM^*}$ in order to derive an expression for the equilibrium postwar derivative $(\frac{dM}{dM^*})^o$. The following expression results:

$$(VI.17) \quad (\frac{dM}{dM^*})^o = \frac{\beta_{11}Y\frac{M}{M^*} - \beta_{21}M^*(\beta_{11}r + \beta_{12})(\frac{dY}{dM^*})}{\beta_{11}Y - \beta_{21}M^*}$$

For the prewar period, we find the following expression:

$$(VI.17') \quad (\frac{dM}{dM^*})^o = \frac{\frac{M}{M^*}(\gamma\beta_{11}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}})}{\gamma\beta_{11}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}} - \beta_{21}M^*} - \frac{\beta_{21}M^*(\gamma\beta_{12}r^{\beta_{11}}Y^{\beta_{12}-1}M_{t-2}^{\beta_{13}})(\frac{dY}{dM^*})}{\gamma\beta_{11}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}} - \beta_{21}M^*}$$

We may simplify this latter expression by noting that

$$M = \gamma r^{\beta_{11}}Y^{\beta_{12}}M_{t-2}^{\beta_{13}}\epsilon_1$$

so that we have

$$(VI.17'') \quad \left(\frac{dM}{dM^*}\right)^o \cong \frac{\frac{M}{M^*}\hat{\beta}_{11} r^{-1} M - \hat{\beta}_{12}\hat{\beta}_{21} MM^* Y^{-1}\left(\frac{dY}{dM^*}\right)}{\hat{\beta}_{11} r^{-1} M - \hat{\beta}_{21} M^*}$$

$$= \frac{\left(\frac{M}{M^*}\right)\hat{\beta}_{11} MY - \hat{\beta}_{12}\hat{\beta}_{21} rMM^*\left(\frac{dY}{dM^*}\right)}{Y(\hat{\beta}_{11} M - \hat{\beta}_{21} rM^*)}$$

Alternatively, solving for the equilibrium derivative $\left(\frac{dr}{dM^*}\right)^o$ gives the following expressions: for the postwar period we get

$$(VI.18) \quad \left(\frac{dr}{dM^*}\right)^o = \frac{\frac{M}{M^*} - (\hat{\beta}_{11} r + \hat{\beta}_{12})\left(\frac{dY}{dM^*}\right)}{\hat{\beta}_{11} Y - \hat{\beta}_{21} M^*}$$

and for the prewar period

$$(VI.18') \quad \left(\frac{dr}{dM^*}\right)^o = \frac{\frac{M}{M^*} - \gamma\hat{\beta}_{12} r^{\hat{\beta}_{11}} Y^{\hat{\beta}_{12}-1} M_{t-2}^{\hat{\beta}_{13}} \left(\frac{dY}{dM^*}\right)}{\gamma\hat{\beta}_{11} r^{\hat{\beta}_{11}-1} Y^{\hat{\beta}_{12}} M_{t-2}^{\hat{\beta}_{13}} - \hat{\beta}_{21} M^*}$$

The latter expression can be simplified in the same manner as above:

$$\left(\frac{dr}{dM^*}\right) \cong \frac{\frac{M}{M^*} - \hat{\beta}_{12} Y^{-1} M\left(\frac{dY}{dM^*}\right)}{\hat{\beta}_{11} r^{-1} M - \hat{\beta}_{21} M^*} = \frac{r\left[\frac{M}{M^*} Y - \hat{\beta}_{12} M\left(\frac{dY}{dM^*}\right)\right]}{Y(\hat{\beta}_{11} M - \hat{\beta}_{21} rM^*)}$$

We may now examine these expressions to determine the direction of bias which would result from their evaluation using steady-state values of the coefficients but setting the

$$(VI.17'') \quad \left(\frac{dM}{dM^*}\right)^o \cong \frac{\frac{M}{M^*}\hat{\beta}_{11}r^{-1}M - \hat{\beta}_{12}\hat{\beta}_{21}MM^*Y^{-1}\left(\frac{dY}{dM^*}\right)}{\hat{\beta}_{11}r^{-1}M - \hat{\beta}_{21}M^*}$$

$$= \frac{\left(\frac{M}{M^*}\right)\hat{\beta}_{11}MY - \hat{\beta}_{12}\hat{\beta}_{21}rMM^*\left(\frac{dY}{dM^*}\right)}{Y(\hat{\beta}_{11}M - \hat{\beta}_{21}rM^*)}$$

Alternatively, solving for the equilibrium derivative $\left(\frac{dr}{dM^*}\right)^o$ gives the following expressions: for the postwar period we get

$$(VI.18) \quad \left(\frac{dr}{dM^*}\right)^o = \frac{\frac{M}{M^*} - (\beta_{11}r + \hat{\beta}_{12})\left(\frac{dY}{dM^*}\right)}{\hat{\beta}_{11}Y - \hat{\beta}_{21}M^*}$$

and for the prewar period

$$(VI.18') \quad \left(\frac{dr}{dM^*}\right)^o = \frac{\frac{M}{M^*} - \gamma\beta_{12}r^{\hat{\beta}_{11}}Y^{\hat{\beta}_{12}-1}M_{t-2}^{\hat{\beta}_{13}}\left(\frac{dY}{dM^*}\right)}{\gamma\beta_{11}r^{\hat{\beta}_{11}-1}Y^{\hat{\beta}_{12}}M_{t-2}^{\hat{\beta}_{13}} - \hat{\beta}_{21}M^*}$$

The latter expression can be simplified in the same manner as above:

$$\left(\frac{dr}{dM^*}\right) \cong \frac{\frac{M}{M^*} - \hat{\beta}_{12}Y^{-1}M\left(\frac{dY}{dM^*}\right)}{\hat{\beta}_{11}r^{-1}M - \hat{\beta}_{21}M^*} = \frac{r\left[\frac{M}{M^*}Y - \hat{\beta}_{12}M\left(\frac{dY}{dM^*}\right)\right]}{Y(\hat{\beta}_{11}M - \hat{\beta}_{21}rM^*)}$$

We may now examine these expressions to determine the direction of bias which would result from their evaluation using steady-state values of the coefficients but setting the

derivative $\frac{dY}{dM^*} = 0$. In evaluating the equilibrium derivatives using short-run values of the coefficients, we are assuming that the derivative $\frac{dY}{dM^*}$ is in fact approximately zero; to the extent that income responds immediately to changes in monetary instrument variables, these estimates will be biased in the same direction as is true for the long-run case.

Since ias arises from the assumption that $\frac{dY}{dM^*} = 0$ (or, in the case to be discussed below, from the assumption that $\frac{dY}{dr_d} = 0$), it is obvious that we are incorrect in assuming that $\frac{dE}{dM^*} = 0$ and/or that $\frac{dNW}{dM^*} = 0$, since we know from VI.12 that $\frac{dY}{dM^*} = \frac{\partial Y}{\partial E}\frac{dE}{dM^*} + \frac{\partial Y}{\partial NW}\frac{dNW}{dM^*}$. We set $\frac{dNW}{dM^*} = 0$ because open market operations are assumed not to change the total amount of net worth, affecting instead its composition. Thus the most serious misspecification appears to arise from setting $\frac{dE}{dM^*} = 0$ (or setting $\frac{dE}{dr_d} = 0$, as we do later); all of the items we have lumped under the heading "exogenous expenditure" are not in fact exogenous. This is particularly true of gross private domestic investment. While the precise interrelationships of interest rates, credit availability, and the different categories of investment are not well understood, the usefulness of monetary policy in terms of its ultimate goal of affecting income depends upon the two derivatives $\frac{dY}{dM^*}$ and $\frac{dY}{dr_d}$ having values different from zero, i.e., the derivatives $\frac{dI}{dM^*}$ and $\frac{dI}{dr_d}$ must be different from zero. We would expect that $\frac{dI}{dM^*} > 0$ and $\frac{dI}{dr_d} < 0$, which means that in fact,

$\frac{dE}{dM^*} > 0$ and $\frac{dE}{dr_d} < 0$, or $\frac{dY}{dM^*} > 0$ and $\frac{dY}{dr_d} < 0$.

We may use this knowledge plus our estimates of the betas from Chapter IV to discover the direction in which bias, if it exists, would occur.

Looking first at the expression for $(\frac{dM}{dM*})^o$ in Equation VI.17, we note from our estimate of Model IV.4 that the steady-state coefficients which we need have the following values:

$$\beta_{11} = -.0080$$

$$\beta_{12} = .1968$$

$$\beta_{21} = .0751$$

From this we see that the expression $(\beta_{11}r + \beta_{12})$ will be positive for all relevant values of r. This means that the entire numerator of Equation VI.17 is negative. Therefore the effect of setting $\frac{dY}{dM*} = 0$ is to make steady-state estimates of $(\frac{dM}{dM*})^o$ smaller than the true value, for any given values of r, Y, and M*, since in reality $\frac{dY}{dM} > 0$. The same is true for Equation VI.17', the expression for the prewar equilibrium derivative $(\frac{dM}{dM*})^o$. Since β_{11} is negative and β_{12} and β_{21} both positive, setting $\frac{dY}{dM*} = 0$ makes the numerator smaller than its true value in absolute terms, and the equilibrium derivate is underestimated.[1]

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[1] In addition to this bias, our estimates of the betas must be biased due to our failure to specify the structure properly before making our structural estimates. We shall not attempt to assess the amount or direction of this bias. It is assumed that it does not overthrow our conclusions about the cases being discussed.

Turning to the expressions for $(\frac{dr}{dM^*})^o$, the term $(\beta_{11}r + \beta_{12})$ in the postwar expression (Equation VI.18) is positive and is about .17 or .18 in value, depending upon r. Since $\frac{M}{M^*}$ is usually quite close to 1.000 during this period, the numerator is positive for any reasonable value for $\frac{dY}{dM^*}$. Consequently, setting $\frac{dY}{dM^*} = 0$ overstates the derivative $(\frac{dr}{dM^*})^o$ somewhat. It is obvious that the same is true of Equation VI.18', the expression for the prewar period. Thus we find that, in general, ignoring income interactions tends to understate the effects of policy actions on the money supply and to overstate their effect on the rate of interest.

We now set up a system of equations which will allow us to solve for $(\frac{dM}{dr_d})^o$ and $(\frac{dr}{dr_d})^o$. From Equations VI.7 and VI.7', VI.10 and VI.10', and VI.12, we derive the following system of equations representing the postwar period:

$$\text{(VI.19)} \quad \frac{dM}{dr_d} - \beta_{11}Y\frac{dr}{dr_d} - (\beta_{11}r + \beta_{12})\frac{dY}{dr_d} = 0$$

$$\text{(VI.20)} \quad \frac{dM}{dr_d} - \beta_{21}M^*\frac{dr}{dr_d} = -\beta_{21}M^*$$

$$\text{(VI.21)} \quad \frac{dY}{dr_d} = \beta_{31}\frac{dE}{dr_d} + \beta_{32}\frac{dNW}{dr_d}$$

For the prewar years, we have

$$\text{(VI.19')} \quad \frac{dM}{dr_d} - \gamma\beta_{11}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}}\frac{dr}{dr_d} - \gamma\beta_{12}r^{\beta_{11}}Y^{\beta_{12}-1}M_{t-2}^{\beta_{13}}\frac{dY}{dr_d} = 0$$

$$\text{(VI.20')} \quad \frac{dM}{dr_d} - \beta_{21}M^*\frac{dr}{dr_d} = \beta_{22}M^*$$

$$\text{(VI.21')} \quad \frac{dY}{dr_d} = \beta_{31}\frac{dE}{dr_d} + \beta_{32}\frac{dNW}{dr_d}$$

We solve first for expressions for the derivative $(\frac{dM}{dr_d})^o$. For the postwar years, the result is as follows:

$$(VI.22)\quad (\frac{dM}{dr_d})^o = \frac{-M^*[\beta_{11}\beta_{21}Y + \beta_{21}(\beta_{11}r + \beta_{12})(\frac{dY}{dr_d})]}{\beta_{11}Y - \beta_{21}M^*}$$

For the prewar years, we find the following expression:

$$(VI.22')\quad (\frac{dM}{dr_d})^o = \frac{M^*\gamma\beta_{11}\beta_{22}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}}}{\gamma\beta_{11}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}} - \beta_{21}M^*}$$

$$- \frac{M^*\gamma\beta_{12}\beta_{21}r^{\beta_{11}}Y^{\beta_{12}-1}M_{t-2}^{\beta_{13}}(\frac{dY}{dr_d})}{\gamma\beta_{11}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}} - \beta_{21}M^*}$$

$$\cong \frac{M^*[\beta_{11}\beta_{22}r^{-1}M - \beta_{12}\beta_{21}Y^{-1}(\frac{dY}{dr_d})]}{\beta_{11}r^{-1}M - \beta_{21}M^*}$$

$$= \frac{M^*[\beta_{11}\beta_{22}MY - \beta_{12}\beta_{21}r(\frac{dY}{dr_d})]}{Y(\beta_{11}M - \beta_{21}rM^*)}$$

Insolving for the derivative $(\frac{dr}{dr_d})^o$, we get the following expression for the postwar period:

$$(VI.23)\quad (\frac{dr}{dr_d})^o = \frac{-\beta_{21}M^* - (\beta_{11}r + \beta_{12})(\frac{dY}{dr_d})}{\beta_{11}Y - \beta_{21}M^*}$$

The prewar expression is as follows:

$$(VI.23') \quad \left(\frac{dr}{dr_d}\right)^o = \frac{\beta_{22}M^* - (\gamma\beta_{12}r^{\beta_{11}}Y^{\beta_{12}-1}M_{t-2}^{\beta_{13}})\left(\frac{dY}{dr_d}\right)}{\gamma\beta_{11}r^{\beta_{11}-1}Y^{\beta_{12}}M_{t-2}^{\beta_{13}} - \beta_{21}M^*}$$

$$= \frac{\beta_{22}M^* - \beta_{12}Y^{-1}M\left(\frac{dY}{dr_d}\right)}{\beta_{11}r^{-1}M - \beta_{21}M^*}$$

$$= \frac{r[\beta_{22}YM^* - \beta_{12}M(\frac{dY}{dr_d})]}{Y(\beta_{11}M - \beta_{21}rM^*)}$$

The direction of bias implied by setting $\frac{dY}{dr_d} = 0$ in these formulations may be discovered in the same manner as above. We assume that, in fact, $\frac{dY}{dr_d} < 0$. Given this assumption, it is easy to see that both of the terms within the brackets in Equation VI.22 are negative; therefore, the value of the numerator is reduced if the second term vanishes. In this case, then, setting $\frac{dY}{dr_d} = 0$ results in underestimation of the steady-state value of $\left(\frac{dM}{dr_d}\right)^o$. The same is true, as would be expected, for the prewar years, as an examination of Equation VI.22' will indicate. In the case of the derivative $\left(\frac{dr}{dr_d}\right)^o$, on the other hand, the two terms in the numerators of the fractions are of opposite sign. In both expressions for this derivative, the negative term in the numerator will be greater in absolute value than the positive term for all likely values of the derivative $\frac{dY}{dr_d}$.

Therefore our misspecification results in values of this equilibrium derivative being overstated. To sum up, we have found for both instrument variables that their effect on the money stock tends to be understated, and their effect on the rate of interest overstated, by assuming that the derivatives of income with respect to these variables are equal to zero.

Having derived expressions for each equilibrium derivative, we are now in a position to evaluate them by substituting the structural (short-term) estimates of the betas and selected values for the appropriate regression variables. This is the approach by which we measure the leverage of monetary policy as discussed above. Before doing so, a final reservation about this procedure should be mentioned. Strictly speaking, our evaluation of the extent to which change in the policy variables M* and r_d affect M and r is valid only for very small changes in these instruments. Thus any inferences about the real world which are drawn from these estimates must be tempered by considerations relating to the scale of policy measures.

b. The Evaluation of Equilibrium Total Derivatives

We are now ready to evaluate the equilibrium derivatives which were derived in the previous section; for this purpose we shall use our structural estimates of the appropriate short-run coefficients and selected values for the variables which appear directly in the expressions. Of course, these

derivatives could be evaluated as of any point in time within the period covered by the estimates. We shall arbitrarily evaluate them as of the beginning and end points of the prewar and postwar periods, at two intermediate points in each period, and at the means. The data to be used are given in Tables VI.1 and VI.2.

TABLE VI.1: SHORT-RUN STRUCTURAL COEFFICIENTS USED IN THE EVALUATION OF EQUILIBRIUM DERIVATIVES

Coefficient	Postwar	Prewar
β_{11}	-.0025	-.0907
β_{12}	.0618	.4332
β_{21}	.0751	.7406
β_{22}	Not required	-.3224

Source: Chapter IV

TABLE VI.2: VALUES OF VARIABLES USED IN THE EVALUATION OF EQUILIBRIUM DERIVATIVES (M, Y, AND M* IN BILLIONS OF DOLLARS)

Period	M	r	Y	M*	$\frac{M}{M^*}$
Postwar*					
1959 IV	$144.82	4.88	$515.2	$151.82	.954
1955 II	130.61	2.00	390.8	143.36	.911
Means	124.34	2.34	358.1	138.19	.899
1951 II	114.74	2.31	322.4	132.18	.868
1946 IV	110.04	1.00	232.8	126.23	.872
Prewar**					
1941	45.52	.50	126.4	89.65	.508
1935	25.22	.75	72.2	63.19	.399
Means	27.37	2.36	86.9	40.64	.994
1924	26.18	6.00	103.8	10.39	2.519
1924	23.06	4.00	85.9	20.25	1.139

*As of the call date nearest the end of the quarter.
**As of June 30.
Source: Appendix

We shall proceed by first analyzing the leverage of open market policy and discount rate policy during the postwar period, and then making the same analysis for the prewar era.

(1) 1946 IV-1959 IV

Open market policy. Substituting the postwar structural estimates of β_{11}, and β_{21} into Equation VI.17 results in the following expression:

$$(VI.24)\quad \left(\frac{dM}{dM^*}\right)^o = \frac{-.0025Y\left(\frac{M}{M^*}\right)}{-.0025Y - .0751M^*} = \left(\frac{M}{M^*}\right)\frac{.0025Y}{.0025Y + .0751M^*}$$

Evaluating this equation at the selected points, we find the values for the equilibrium total derivative which are given in Table VI.3.

TABLE VI.3: VALUES OF $\left(\frac{dM}{dM^*}\right)^o$, k*, AND $\left(\frac{dM}{dR^s}\right)^o$ AT SELECTED POINTS (POSTWAR)

Period	$\left(\frac{dM}{dM^*}\right)^o$	k*	$\left(\frac{dM}{dR^s}\right)^o = k^*\left(\frac{dM}{dM^*}\right)^o$
1959 IV	.096	9.948	.955
1955 II	.076	8.954	.681
Means	.071	n.a.	n.a.
1951 II	.065	7.652	.497
1946 IV	.050	8.718	.436

Source: Original estimates

An examination of Equation VI.24 and these estimates suggest a number of interesting inferences regarding the leverage

of open market policy during the postwar period. First, from Equation VI.24 we see that the degree of leverage of open market operations is a positive function of income and the money stock, and is inversely related to M*. This is as we would expect; as the money stock grows relative to M*, the money equivalent of supplied reserves, we would expect operations on reserves by the monetary authorities to have an increasingly potent effect on the money supply. In the same manner, as income rises relative to M and M* and the banking system's capacity to supply funds becomes limited, open market operations could be expected to become more powerful. Conversely, when banks are holding a large quantity of reserves relative to the money stock, open market monetary policy designed to increase M might be expected to diminish in effectiveness.

While the rate of change is a function of M, M*, and Y, Equation VI.24 indicates that $(\frac{dM}{dM^*})^o$ is always positive in value, so that an increase in M* always increases M to some degree, and vice versa. In other words, given the specification of our model, monetary policy as expressed through open market operations is never perverse.

As shown in Table VI.3, the derivative $(\frac{dM}{dM^*})^o$ has doubled in value over the postwar period. As of the end of 1959, a one-dollar change in M* resulted in approximately a 10-cent change in the money stock. It is interesting to carry this analysis one step further. Since $M^* = k^*R^s$, the derivative $(\frac{dM}{dR^s})^o$, representing the change in the money stock

resulting from changes in supplied reserves, may be calculated simply by multiplying $(\frac{dM}{dM^*})^o$ by k^*. As a result, we find that the change in the money supply brought about by a one-dollar change in supplied reserves has more than doubled during the postwar years, the added variation being due, of course, to the change in k^* over the period. By definition, $k^* = \frac{k}{(1-c-h)}$. Over the postwar period, the term (1-c-h), representing certain behavior parameters, has not varied a great deal, lying between .615 and .677. Thus most of the variation in $(\frac{dM}{dR^s})^o$ has resulted from changes in reserve requirements, which are also controlled by the Federal Reserve System; a smaller amount is due to changing habits of money holders. Because of the downward trend in reserve requirements, the leverage of open market policy is increasing, and at the end of 1959, a one-dollar change in reserves brought about through open market operations would have resulted in approximately a one-dollar change in the money stock, according to these estimates.

The effects of open market policy on the short-term interest rate are summarized in Table VI.4:

TABLE VI.4: VALUES OF $(\frac{dr}{dM^*})^o$ AND $(\frac{dr}{dR^s})^o$ AT SELECTED POINTS (POSTWAR)

Period	$(\frac{dr}{dM^*})^o$	K^*	$(\frac{dr}{dR^s})^o = K^*(\frac{dr}{dM^*})^o$
1959 IV	-.075	9.948	-.748
1955 II	-.078	8.954	-.695
Means	-.080	n.a.	n.a.
1951 II	-.081	7.562	-.612
1946 IV	-.087	8.718	-.758

Source: Original estimates

From Equations VI.17 and VI.18, we note that, when $\frac{dY}{dM^*} = 0$

$$(VI.25) \quad \left(\frac{dr}{dM^*}\right)^o = \frac{1}{\beta_{11} Y} \left(\frac{dM}{dM^*}\right)^o$$

Since $\left(\frac{dM}{dM^*}\right)^o$ is always positive, and our estimate of β_{11} is negative in sign, it follows that $\left(\frac{dr}{dM^*}\right)^o$ is always negative; an increase in supplied reserves always results in a decline in the short-term interest rate, according to our model. The data in Table VI.4 may be interpreted to mean that a $1 billion change in M* will result in a change of about .08 points in the level of the short-term rate, in the opposite direction. In terms of reserves, a $1 billion change in supplied reserves causes a change of about .75 points in the level of the short-term rate in the opposite direction (the above data are as of 1959 IV). Finally, we note that the strength of the effect of open market operations in the short-term interest rate depends upon the level of income, the size of the money stock, and the level of supplied reserves in the system.

Discount rate policy. To measure the efficiency of discount rate policy in the postwar period, our structural estimates of β_{11} and β_{21} are substituted into Equations VI.22 and VI.23. Again we find that these two derivatives are multiples of each other when $\frac{dY}{dr_d} = 0$; so that they are always of opposite sign:

$$(VI.26) \quad \left(\frac{dr}{dr_d}\right) = \frac{1}{p_{11}Y} \left(\frac{dM}{dr_d}\right)^o$$

We first examine the effect of changes in the discount rate upon the money stock. Substituting our structural estimates into Equation VI.22 results in the following equation:

$$(VI.27) \quad \left(\frac{dM}{dr_d}\right)^o = \frac{(-.0025)(.0751)(-M^*)(Y)}{-.0025Y - .0751M^*} = - \frac{.00019M^*Y}{.0025Y + .0751M^*}$$

Table VI.5 contains the estimates of $\left(\frac{dM}{dr_d}\right)^o$ obtained by evaluating this equation at the same points as before.

TABLE VI.5: VALUES OF $\left(\frac{dM}{dr_d}\right)^o$ AT SELECTED POINTS (POSTWAR)

Period	$\left(\frac{dM}{dr_d}\right)^o$
1959 IV	-1.171
1955 II	- .907
Means	- .834
1951 II	- .754
1946 IV	- .555

Source: Original estimates

In this model, the derivative $\left(\frac{dM}{dr_d}\right)^o$ is a function of income and of M*; the higher M* and Y, the greater is the absolute value of the derivative, and vice versa. This can easily be seen by holding either M* or Y constant and dividing the numerator and denominator of VI.27 by the other. The fact that this derivative has increased steadily in absolute

value since World War II is therefore due to the secular increases in M* and Y (see Table VI.2). The data in Table VI.5 are to be interpreted to mean that a one-point change in the discount rate would have resulted in a money-stock change of about $1.17 billion in the opposite direction at the end of 1959.

This derivative is always negative in sign, since M* and Y do not have negative values. Our expectations are therefore confirmed: since r_d is a measure of the cost of loans, changes in r_d should be associated with changes of M in the opposite direction. We would also tend to expect that discount-rate policy increases in effectiveness as income rises, for given values of the other variables. Cyclical phenomena may contribute to this result. It is more difficult to explain why the size of the derivative should be a function of the variable M*, being higher in absolute value when M* is high. This could also be a reflection of cyclical effects; bankers may be more responsive to discount rate changes during cyclical highs, when supplied reserves would tend to be relatively high, than during lows, when they would tend to be smaller.

The effects of discount-rate changes on the short-term interest rate are shown in Table VI.6; the values of the derivative are calculated from Equation VI.28.

$$(VI.28)\quad \left(\frac{dr}{dr_d}\right)^{\circ} = \frac{-.0751M^*}{-.0025Y - .0751M^*} = \frac{.0751M^*}{.0025Y + .0751M^*}$$

TABLE VI.6: VALUES OF $(\frac{dr}{dr_d})^o$ AT SELECTED POINTS (POSTWAR)

Period	$(\frac{dr}{dr_d})^o$
1959 IV	.899
1955 II	.917
Means	.921
1951 II	.925
1946 IV	.942

Source: Original estimates

Since $(\frac{dM}{dr_d})^o$ was always negative, $(\frac{dr}{dr_d})^o$ must always be positive, as shown by Equation VI.26. The data in Table VI.6 indicate that a one-point change in the discount rate is associated with a change in the short-term interest rate of about .90 points in the same direction. Furthermore, the interest rate appears to have been becoming slightly less sensitive to discount rate changes over the postwar period. The positive relationship between the interest and discount rates is expected for two reasons. First, a rise in the discount rate (for example), by making loans more costly, reduces deposits and causes a relative scarcity of credit, forcing the interest rate to rise. Secondly, there is a tendency for the interest and discount rates to move together apart from considerations involving the scarcity of credit; this a symptom of the imperfect nature of competition in commercial banking.[1]

[1] In his study of California branch-banking experience, D. A. Alhadeff says, "It seems clear that the traditional

(2) 1924-1941

Open market policy. The expression for $(\frac{dM}{dM^*})^o$ in Equation VI.17' applies to the prewar period. Substituting the prewar structural estimates of β_{11} and β_{21} into this equation results in the following expression:

$$(VI.29)\quad (\frac{dM}{dM^*})^o = \frac{(\frac{M}{M^*})(-.0907)(M)(Y)}{Y(-.0907M - .7406M^*)} = (\frac{M}{M^*})\frac{.0907M}{(.0907M + .7406rM^*)}$$

Table VI.7 contains estimates of the value of this derivative for selected prewar points.

TABLE VI.7: VALUES OF $(\frac{dM}{dM^*})^o$, k*, AND $(\frac{dM}{dR_S})^o$ AT SELECTED POINTS (PREWAR)

Period	$(\frac{dM}{dM^*})^o$	k*	$(\frac{dM}{dR_S})^o = k^*(\frac{dM}{dM^*})^o$
1941	.056	5.177	.291
1935	.024	9.300	.227
Means	.034	n.a.	n.a.
1929	.123	9.792	1.206
1924	.038	9.916	.381

Source: Original estimates

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theory relating loan rate changes to discount rate changes via transmitted cost effects cannot be completely accepted. The largest banks, and particularly those connected with the financial centers, tend to pass on changes in money costs to their customers. This is practically automatic for many large borrowers who negotiate long-standing term loans. A common clause in term loan contracts provides for interest rate changes on a sliding scale with discount rate changes." Monopoly and Competition in Banking (Berkeley: University of California Press, 1954), p. 169.

The values calculated for $(\frac{dM}{dM^*})^o$ for the prewar years vary in size considerably more than those representing the postwar years. The figure for 1935, for example, is interpreted as meaning that a one-dollar change in M*, the "money equivalent" of supplied reserves, would cause a change in the money stock of less than three cents, In 1929, on the other hand, a change of over 12 cents would have resulted. This variation in $(\frac{dM}{dM^*})^o$ is due to a number of factors. The most important is the large variation in M* and r as compared with the postwar period. Related to this and very important in its own right is the wide variation in $\frac{M}{M^*}$ alone. For example, in 1929, $\frac{M}{M^*}$ reached its prewar peak of 2.52 while M* stood at the low level of $10.39 billion. At this time, r was also at the very high level of 6 per cent. These figures reflect the tremendous amount of commercial bank borrowing from the Federal Reserve, and the heavy demand for credit, which was then occurring. This high ratio of the money stock to M* plus the low absolute level of M* gave monetary policy its relatively high degree of leverage in 1929. In addition to the influence of M and M*, reserve requirements varied widely during this period, and behavioral parameters changed somewhat; for example, the proportion of the money stock held as currency by the public increased sharply during the early 1930's, and declined only gradually through 1941. As a result, k* stood at 9.92 in June, 1924, but was only 5.18 in June, 1941. All of these factors contributed to the relatively wide variation

in the values shown for the prewar equilibrium derivatives $(\frac{dM}{dM*})^o$ and $(\frac{dM}{dR^s})^o$.

Values for the prewar equilibrium derivative $(\frac{dr}{dM*})^o$ are calculated from the expression given by Equation VI.30. These values are shown in Table VI.8.

$$(VI.30)\quad (\frac{dr}{dM*})^o = \frac{(\frac{M}{M*})rY}{Y(-.0907M - .7406rM*)} = \frac{-(\frac{M}{M*})r}{.0907M + .7406rM*}$$

TABLE VI.8: VALUES OF $(\frac{dr}{dM*})^o$ AND $(\frac{dr}{dR^s})^o$ AT SELECTED POINTS (PREWAR)

Period	$(\frac{dr}{dM*})^o$	k*	$(\frac{dr}{dR^s})^o = k*(\frac{dr}{dM*})^o$
1941	-.007	5.177	-.035
1935	-.008	9.300	-.074
Means	-.032	n.a.	n.a.
1929	-.311	9.792	-3.048
1924	-.073	9.916	-.728

Source: Original estimates

These data also demonstrate the ineffectiveness of monetary policy during the 1930's as opposed to the 1920's. A change of M* of $1 billion in 1941 would have resulted in a drop of the short-term interest rate of .007 points, while in 1929, a drop of .31 points would have resulted. This could be construed as evidence in favor of the "liquidity trap" hypothesis, according to which there is a minimal level for

the interest rate at some positive value below which it cannot be driven by the injection of money into the system.

Discount rate policy. The leverage of discount rate policy during the prewar period is measured by substituting structural estimates of β_{11}, β_{21}, and β_{22} into Equations VI.22' and VI.23'. Let us first evaluate $(\frac{dM}{dr_d})^o$:

$$(VI.31)\quad (\frac{dM}{dr_d})^o = \frac{(-.0907)(-.3224)(M^*)(M)(Y)}{Y(-.0907M - .7406rM^*)} = -\frac{(.0292)(M)(M^*)}{.0907M + .7406rM^*}$$

Table VI.9 contains the values of $(\frac{dM}{dr_d})^o$ obtained by substituting the appropriate figures for the variables into this equation.

TABLE VI.9: VALUES OF $(\frac{dM}{dr_d})^o$ AT SELECTED POINTS (PREWAR)

Period	$(\frac{dM}{dr_d})^o$
1941	-3.192
1935	-1.245
Means	- .442
1929	-.164
1924	- .258

Source: Original estimates

These figures are to be interpreted to mean that a one-point change in the discount rate would result (in 1941) in a $3.2 billion dollar change in the money stock in the opposite direction. The mean value of -.422 is about half of the postwar mean value of -.834 for this derivative. However,

the average postwar money stock of $124.5 billion is 4.5 times as large as the average prewar stock of $27.4 billion. In other words, on the average, a one-point discount rate change in the postwar period could effect an 0.7 per cent change in the money stock, while in the prewar period the average money stock change was 1.6 per cent. Apparently the discount rate was somewhat more potent as a policy tool during the prewar period, although this result may be at least partially due to the fact that the postwar estimate of the discount rate coefficient was restricted, while the restriction was removed for the prewar estimates. Another finding of interest is that the discount rate was least effective in terms of its impact on the money stock in 1929.

The impact of changes in the discount rate on the level of the short-term interest rate is shown by the data in Table VI.10, computed from Equation VI.32.

$$(VI.32)\quad \left(\frac{dr}{dr_d}\right)^{\circ} = \frac{-.3224(r)(Y)(M^*)}{Y(-.0907M - .7406rM^*)} = \frac{.3224rM^*}{.0907M + .7406rM^*}$$

TABLE VI.10: VALUES OF $\left(\frac{dr}{dr_d}\right)^{\circ}$ AT SELECTED POINTS (PREWAR)

Period	$\left(\frac{dr}{dr_d}\right)^{\circ}$
1941	.387
1935	.409
Means	.421
1929	.414
1924	.421

Source: Original estimates

During most of the prewar period, a change of one point in the level of the discount rate was associated with a change of about .40 points in the same direction in the level of the short-term interest rate, according to our estimates. As in the postwar period, the value of this derivative declined slightly over time, although in both periods the relationship could be considered constant. However, its mean value is less than half of the postwar mean value. Apparently the rate of interest responds more sharply to a given discount rate change during the postwar period than previously.

c. Conclusions

On the basis of the values calculated above for the equilibrium derivatives, certain inferences may be drawn concerning the leverage and other aspects of monetary policy.

It was found that the most interesting measure, $(\frac{dM}{dM^*})^o$, varied in value during both the prewar and postwar periods, with the greatest degree of variation occurring during the prewar years. In the postwar period, an upward trend has been characteristic of this derivative, due to rather steady increases in income and the money stock. In the prewar era, the value of this derivative did not exhibit this upward trend because of the influence of the business cycle; the derivative was close to zero in value during the 1930's, in fact.

This lack of constancy implies that the Federal Reserve System may be able to control the money stock directly; as long as $(\frac{dM}{dM^*})^o$ varies over time, the System cannot know

precisely what effect its open market operations will have on the money stock. It appears that this derivative will always be positive, however, and it could be argued that this fact plus knowledge of the derivative's approximate value and the rate at which it trends upward over time are adequate to give the Federal Reserve System a degree of short-run control over the money stock which makes it, in effect, exogenously determined in the sense that the monetary authorities can cause a desired change in M in the short run by the manipulation of reserves.

Practical application of this potential control may be of long-run rather than short-run significance, however, due to the scale of operations which our estimates of the derivative $(\frac{dM}{dR_S})^o$ indicate is necessary to bring about an "impact" effect of any consequence on the money stock. In other words, these circumstances may result in approximate exogenous control of M by the monetary authorities given a sufficiently long period of time (in the order of, say, a year or more), but if we mean by exogeneity the ability of the authorities to effect a more immediate change in M by reserve changes (defining "immediate" arbitrarily as "within two or three months"--i.e., before income has had an opportunity to change significantly in response to monetary changes), our estimates indicate that the reserve changes required are too large to be practical. At the end of 1959, for example, a one-dollar change in supplied reserves was associated with (approximately)

a one-dollar change in the quantity of money. At that time, the seasonally-unadjusted money stock stood at approximately $145 billion. To obtain an "immediate" change of one per cent in M by open market operations, supplied reserves would have to change by about $1.5 billion. In Table VI.11 below, the net change in holdings of United States government securities by the Federal Reserve System resulting from open market operations is shown by month for 1959. In no month was this net change great enough to bring about such an "immediate" change in the money stock. To attain a five

TABLE VI.11: NET CHANGES IN HOLDINGS OF U.S. GOVERNMENT SECURITIES BY THE FEDERAL RESERVE SYSTEM (MILLIONS OF DOLLARS)

Month	Change	Month	Net Change
January	-$632	July	499
February	- 365	August	147
March	147	September	-126
April	206	October	68
May	202	November	291
June	139	December	-273

Source: Forty-Sixth Annual Report of the Board of Governors of the Federal Reserve System, 1959, p.128.

per cent change in M, for example, would require a change of over $7 billion in supplied reserves (in December, 1959, member banks held $18.9 billion in total reserves).[1]

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[1] Federal Reserve Bulletin.

Such a change is far above the levels of open market operations shown in Table VI.11. While member banks held almost $47 billion in United States government securities at that time (the Federal Reserve System held $26.6 billion of assets in this form),[1] the portion of these totals held as Treasury Bills--the common means by which open market policy was then accomplished--was only $4.6 billion for member banks and $2.6 billion for the Federal Reserve System, out of a total of about $32 billion in bills outstanding.[2] Therefore it seems doubtful that a really large "immediate" change in the money stock could have been achieved through open market policy action under conditions existing at the end of 1959; the scale of open market operations required would undoubtedly have had undesirable effects on other variables and institutions.

In the above comparisons, we are simply attempting to demonstrate that the money stock cannot be considered exogenous in the sense that the Federal Reserve System may be unable to effect significant gross changes in M in the desired direction within any given short period, due to the interactions of the system which we have demonstrated and the scale of open market operations required. As was stated above, this conclusion is based upon the assumption that the period in question is too short for income to be affected; by the nature

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[1] Forty-Seventh Annual Report of the Board of Governors of the Federal Reserve System (Washington, D.C.), p. 116.

[2] Federal Reserve Bulletin.

of our analysis. This lag must be at least two or three months in length, and perhaps longer. It does not follow from this that monetary policy is ineffective. In a period of rapidly expanding income, for example, a restraining influence may be exercised effectively simply by holding the money stock approximately constant. This implies that any judgments about the effectiveness of monetary policy would have to be based upon relative rates of change of the money stock and income which are capable of achievement, or some such comparison, rather than inferences concerning the size of gross changes in M which the Federal Reserve is able to effect. But we do believe that such inferences bear upon the question of exogeneity.

The postwar estimates show that a $1 billion change in supplied reserves is associated with a change of between .60 and .75 points in the level of the short-term interest rate. This may be taken as evidence that the Federal Reserve System is able to affect the level of this rate to a fairly significant degree even under the present scale of open market operations, and this aspect of open market policy may be quite effective.

In this study, the postwar discount rate exhibits more strength as a policy variable than was expected, although this inference is drawn from estimates based upon a period over which it was used rather sparingly. In any event, they indicate that a half-point change in the discount rate (the usual increment by which it is changed) was associated with (approximately) a $600 million change in the money stock, as of the last

quarter of 1959. This is equivalent to a $600 million change in supplied reserves, which is almost as large a change as occurred in January, 1959, the month of largest change during 1959 in Federal Reserve System holdings of government securities. This suggests that the discount rate, when used with the same amplitude and frequency as in past years, is able to achieve effects of the same size as open market operations of the usual scale. However, the discount rate may have effects on expectations, other interest rates, etc., which cannot be evaluated completely here but which may limit its usefulness as a very flexible tool of monetary policy. For example, a one-point change in the discount rate apparently is associated with a change of .90 in the level of the short-term interest rate.

During the prewar years, the evidence indicates that open market monetary policy was ineffective in the 1930's, either in terms of the money stock or the interest rate. In the 1920's, however, and especially in 1929, the leverage of monetary policy was quite high, due largely to the high level of borrowing by commercial banks from the Federal Reserve System. On the other hand, the prewar discount rate appears to have been more potent than for the postwar years; in 1941, a change of one-half point in the discount rate would have resulted in a change of about $1.6 billion (about 3.5 per cent) in the money stock, while this amount of change in 1959 would have yielded a change in M or 0.80 per cent. However, the

leverage of discount rate change on r is considerably less in the prewar years than in the postwar period.

In general, these results lead us to conclude that the money stock cannot be considered to be exogenous in practice, since the effect on M of Federal Reserve manipulation of M* (and of r_d) varies with other economic variables. This complements our earlier conclusion; that the money stock and short-term interest rate interact with each other (as well as with income) and that these relationships could only be represented by a structural model.

CHAPTER VII

CONCLUDING REMARKS

In this final chapter, no attempt will be made to summarize the findings of the study in any detail. At each step of the study, the results have been summed up, and a restatement of these summaries seems unduly repetitious.

Alternatively, we shall comment briefly on what seem to be the results of greatest general interest, and then focus our attention upon the problems which we have assumed away for purposes of this study. It is a symptom of our failure to derive a completely satisfactory representation of the relationships between the monetary and the real sectors of the economy that we conclude the study by sketching the outlines of a more inclusive and satisfactory approach.

A. Findings of Importance

In surveying the results which have been set out in the past several chapters, there are three which appear to merit emphasis because of their significance for the study of monetary relationships. Each has been discussed in previous sections of this study, so we shall merely list them here and append only a brief discussion of each.

First in order of study, but not necessarily of importance, is the derivation of a functional relationship

describing, in very simple form and gross-aggregate terms, the money-supply process of commercial banks. Statistical support was demonstrated for the hypothesis that commercial banks act as risk-averting profit maximizers, utilizing a greater portion of their total capacity to produce money when the return for doing so is high relative to the cost, and vice versa. While our formulation is not necessarily an optimal one, its obvious rationale and simple form suggest that the subject of money supply is certainly amenable tc empirical analysis and that the usual assumption of exogeneity with respect to the stock of money is untenable.

Implied by this finding, but deserving emphasis in its own right, is the conclusion that the money stock and its "price," the short-term interest rate, interact upon each other and can therefore be studied satisfactorily only within the context of a structural model. The derivation and estimation of such a structure constituted the body of the study. Given the existence of a supply relationship, as well as interactions between the monetary sector and other sectors of the economic system, it is apparent that the empirical study of questions relating to monetary policy, for example, cannot be carried out satisfactorily without reference to a structural model at least as large as the one constructed for this study, and preferably more inclusive. Conversely, the existence of functional supply and demand relationships in the monetary

sector suggests that this sector must be represented by an interacting substructure in aggregative models of the economic system in order to avoid specification error in such models.

Finally, our findings furnish evidence on the nature of the demand for money. Under our hypothesis, transactions requirements form the only rational basis for demanding cash balances in a system where other perfectly liquid, risk-free assets which pay a positive return are available; however, transactions demand is taken to be interest-responsive. The statistical evidence presented in Chapter IV supports this hypothesis. The hypothesis is consistent with (and actually implied by) the theory of portfolio choice under risk developed by Tobin. From this theory, and our hypothesis of money demand as developed in Chapter IV, we conclude that the permanent portfolio of a rational asset-holder will contain no money (except the transactions balances which arise temporarily as a result of transfers among other forms of liquid assets) but will range from risky, high-yield assets to time deposits, according to the investor's preference function between yield and risk and the opportunities available to him. Any income which exceeds anticipated transactions needs will be put into the permanent portfolio; furthermore, if transactions costs are not prohibitive in relation to return, money balances intended for transactions use will be converted into time deposits until they are needed.

B. Suggestions for Further Study

We have emphasized repeatedly throughout this study that our approach was incomplete in a number of respects, particularly in our failure to specify the income function in such a way that it interacted with the rest of the structure. Not only does this introduce specification error, but it prevents us from analyzing the effects of the manipulation of monetary policy variables on income. Thus there are clear indicators pointing to the direction in which further study should proceed. Unfortunately, these indicators point to some of the thorniest problems of empirical economics, and we do not pretend to know whether these problems can be solved satisfactorily. We shall merely identify them here.

Of greatest importance in this respect is the endogenous treatment of investment. We have lumped all of the categories of investment together in our model under the heading "gross private domestic investment" and have treated them as exogenous. Proper treatment would involve the segregation of investment into (at least) inventory, plant and equipment, and new residential components, and the derivation of functional relationships to explain each of these categories. Of course, a good deal of work on this problem has already been accomplished by a number of investigators, and this body of knowledge can be drawn upon. While it has been the practice for several years to de-emphasize the role of the interest rate in investment

decisions, particularly those of businesses, recent work has shown that the interest-elasticity of investment may be significant.[1] Conceptually, we would expect that inventory investment would respond to the short-term rate, plant and equipment expenditures to the long rate, and new housing construction to the rate on mortgages, and it is through these relationships that monetary policy is presumed to work on income.

The treatment of investment which is suggested above introduces the additional problem of specifying the relationship among the various interest rates. This is also an area in which recent theoretical and empirical work can make a contribution.[2]

While the investment relationships would require the greatest amount of attention in any extension of the present study, it is felt that the supply formulation is capable of

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[1]Some empirical evidence supporting this conclusion is contained in Brown, Solow, Ando, and Kareken, op. cit. See also Harry G. Johnson, "Monetary Theory and Policy," American Economic Review (LII), June, 1962, pp. 335-384, for some summary comments on the role of interest rates as a determinant of investment. He remarks that "The most definite new empirical evidence there is confirms the long-time theoretically established sensitivity of residential construction to interest-rate changes....The failure of empirical research to disclose such sensitivity may...be the consequence of too simple a theoretical approach, the attempt to relate a flow of expenditure on assets to the cost of credit without adequate recognition of the range of alternative assets or the complexities of stock-adjustment processes....a more sophisticated theory of real investment [seems] necessary for successful empirical work." (pp. 372-373).

[2]See Johnson, op. cit., pp. 347-348, for a summary and references.

improvement. The relationship used above explains less than three-quarters of the variance of the dependent variable. It might be possible to make improvements from a number of directions. The incorporation of additional explanatory variables is certainly worth trying; for example, bankers' expectations relative to the future course of the interest and discount rates, as well as expectations as to the course of income, might well be significant in making loan decisions. Alternatively, a more sophisticated approach, of the type suggested by Brunner for example, might be tried.[1] This could involve the formulation of detailed behavioral hypotheses for individual banks and aggregation over all banks (or various groups of banks) for purposes of empirical testing.

This implies a third, and last, direction for improvement of the present study. Instead of the completely aggregative approach taken here, the structural model could be disaggregated in varying degrees in order to achieve better fits and a greater degree of realism. This approach has already been suggested for the treatment of investment. It could also probably be applied with profit to the demand for money. If the data permitted, a breakdown of total demand into business and consumer demand categories would be reasonable, while the possibility of further breakdown of business demand into demand by large and by small businesses could be investigated.

These are some very tentative, preliminary, and general thoughts on possible future avenues of investigation. They are appropriately placed here as an indication that the close of this report marks the end only of a preliminary step in the study of the relationships between money, interest, and income.

A P P E N D I X

TABLE 1: MONETARY DATA, 1922-1960

Year and Quarter	Call Date	Money Stock*	Demand Deposits Adjusted in Member Banks*	Demand Deposits at Non-Member Banks*	Currency in the Hands of the Public*	Net Demand Deposits at Member Banks*	Fraction of M Held as Currency	Fraction of M Held as Demand Deposits in Non-Member Banks	Moving Average: Fraction of M Held as Currency	Moving Average: Fraction of M Held as D''_p
		M	D'_p	D''_p	C	D^n	$\frac{C}{M}$	$\frac{D''_p}{M}$	c	h
1922 II	Jun 30	$21.39	$13.14	$ 4.92	$ 3.34	$15.54	.156	.230	.166	.230
1923 II	Jun 30	22.70	13.60	5.40	3.70	16.07	.163	.238	.160	.238
1923 IV	Dec 31	22.87	13.63	5.54	3.70	16.38	.162	.242	.163	.240
1924 II	Jun 30	23.06	13.91	5.53	3.62	16.84	.157	.240	.159	.241
1924 IV	Dec 31	24.59	15.04	5.90	3.66	18.47	.149	.240	.153	.240
1925 II	Jun 30	24.95	15.23	6.18	3.54	18.28	.142	.248	.145	.244
1925 IV	Dec 31	26.06	15.94	6.39	3.72	19.26	.143	.245	.142	.247
1926 II	Jun 30	25.60	15.79	6.24	3.57	15.79	.139	.244	.141	.245
1926 IV	Dec 31	25.55	15.78	5.98	3.78	15.78	.148	.234	.144	.239
1927 II	Jun 30	25.54	16.06	5.96	3.51	16.06	.138	.234	.143	.234
1927 IV	Dec 31	26.43	16.59	6.19	3.65	16.59	.138	.234	.138	.234
1928 II	Jun 30	25.88	16.14	6.26	3.48	16.14	.135	.242	.136	.238
1928 IV	Dec 31	26.67	16.50	6.74	3.43	16.50	.129	.253	.132	.247
1929 II	Jun 29	26.18	16.32	6.38	3.48	16.32	.133	.244	.131	.248
1929 IV	Dec 31	26.37	16.65	6.31	3.41	16.65	.129	.239	.131	.241
1930 II	Jun 30	25.08	16.04	5.82	3.21	16.04	.128	.232	.129	.236
1930 IV	Dec 31	24.57	15.87	5.25	3.45	15.87	.141	.214	.134	.223
1931 II	Jun 30	23.48	15.21	4.78	3.50	15.21	.149	.204	.145	.209
1931 IV	Dec 31	21.88	13.66	3.92	4.30	13.66	.197	.179	.173	.191
1932 II	Jun 30	20.24	12.43	3.35	4.46	12.43	.220	.166	.209	.172
1932 IV	Dec 31	20.40	12.69	3.20	4.51	12.69	.221	.157	.221	.161
1933 II	Jun 30	19.17	12.09	2.45	4.63	12.09	.242	.128	.232	.142
1933 IV	Dec 31	19.82	12.67	2.53	4.61	12.67	.233	.128	.237	.128

*Billion of dollars

Table 1: Monetary Data, 1922-1960 (Continued)

Year and Quarter	Call Date	M	D'_p	D''_p	C	D^n	$\frac{C}{M}$	$\frac{D''_p}{M}$	c	h
1934 II	Jun 30	$21.35	$14.26	$ 2.64	$ 4.46	$17.07	.209	.123	.221	.126
1934 IV	Dec 31	23.11	15.69	2.97	4.46	18.85	.193	.129	.201	.126
1935 II	Jun 29	25.22	17.53	3.04	4.64	21.05	.184	.121	.189	.125
1935 IV	Dec 31	27.03	18.80	3.50	4.73	22.17	.175	.129	.180	.125
1936 II	Jun 30	29.00	20.28	3.70	5.02	23.99	.173	.128	.174	.129
1936 IV	Dec 31	31.00	21.65	4.06	5.30	25.45	.171	.131	.172	.129
1937 II	Jun 30	30.69	21.40	3.72	5.57	24.85	.181	.121	.176	.126
1937 IV	Dec 31	29.60	20.39	3.71	5.50	23.74	.186	.126	.184	.123
1938 II	Jun 30	29.73	20.89	3.56	5.28	23.89	.178	.120	.182	.123
1938 IV	Dec 30	31.76	22.29	3.88	5.59	25.98	.176	.122	.177	.121
1939 II	Jun 30	33.36	23.59	3.94	5.84	27.44	.175	.118	.176	.120
1939 IV	Dec 30	36.19	25.68	4.28	6.24	30.33	.172	.118	.174	.118
1940 II	Jun 29	38.66	27.88	4.24	6.54	32.51	.169	.110	.171	.114
1940 IV	Dec 31	42.27	30.43	4.70	7.14	35.26	.169	.111	.169	.111
1941 II	Jun 30	45.52	32.68	4.82	8.02	37.41	.176	.106	.173	.109
1941 IV	Dec 31	48.61	33.75	5.49	9.37	39.71	.193	.113	.185	.110
1946 II	Jun 29	105.99	67.46	12.51	26.06	74.30	.246	.118	.267	.118
1946 IV	Dec 31	110.04	70.24	13.27	26.53	77.33	.241	.121	.246	.118
1947 II	Jun 30	108.43	69.60	12.75	26.09	75.57	.241	.118	.241	.121
1947 III	Oct 6	110.40	70.79	13.19	26.42	78.74	.239	.120	.241	.118
1947 IV	Dec 31	113.60	73.53	13.76	26.49	80.74	.233	.121	.240	.119
1948 I	Mar 31	107.10	69.78	13.17	24.15	77.31	.226	.123	.236	.120
1948 II	Jun 30	108.34	70.05	12.80	25.48	77.40	.235	.118	.229	.122
1948 IV	Dec 31	111.60	72.15	13.57	25.88	80.30	.232	.117	.235	.118
1949 I	Mar 30	106.20	68.97	12.95	24.28	77.42	.229	.122	.232	.117
1949 II	Jun 30	107.14	69.40	12.63	25.12	76.46	.234	.118	.230	.120
1949 III	Sep 28	108.00	70.70	12.83	24.48	79.14	.227	.119	.232	.120
1949 IV	Oct 31	111.17	73.20	13.30	24.67	81.30	.222	.120	.231	.118

Table 1: Monetary Data, 1922-1960 (Continued)

Year and Quarter	Call Date	M	D'_p	D''_p	C	D^n	$\frac{C}{M}$	$\frac{D''_p}{M}$	c	h
1950 I	Mar 29	$107.80	$71.25	$13.02	$23.53	$80.18	.218	.121	.224	.119
1950 II	Jun 28	110.23	72.85	13.00	24.37	81.19	.221	.118	.220	.120
1950 III	Sep 27	112.50	75.00	13.30	24.20	83.46	.215	.121	.220	.119
1950 IV	Dec 30	117.67	78.70	14.13	24.84	87.01	.211	.120	.218	.119
1951 I	Mar 28	113.40	77.00	13.66	22.74	87.44	.201	.121	.213	.120
1951 II	Jun 30	114.74	77.30	13.58	23.86	87.25	.208	.118	.206	.120
1951 III	Sep 26	117.40	79.07	14.07	24.27	88.59	.207	.120	.204	.119
1951 IV	Dec 31	124.55	83.10	14.39	26.06	91.95	.209	.124	.207	.119
1952 I	Mar 26	120.50	78.75	14.70	27.05	90.83	.225	.122	.208	.122
1952 II	Jun 30	121.23	80.35	14.70	26.19	91.22	.216	.121	.217	.123
1952 III	Sep 24	123.00	81.55	15.16	26.29	92.92	.214	.123	.220	.122
1952 IV	Dec 31	129.00	85.54	16.21	27.25	96.62	.211	.126	.215	.122
1953 II	Jun 30	124.27	81.77	15.32	27.18	91.38	.219	.123	.211	.126
1953 IV	Dec 31	130.54	86.13	16.58	27.84	96.06	.213	.127	.219	.123
1954 I	Mar 31	123.60	82.93	15.65	25.03	93.78	.203	.127	.213	.127
1954 II	Jun 30	125.23	82.78	15.54	26.90	93.93	.215	.124	.208	.127
1954 III	Sep 29	128.10	85.34	15.95	26.81	94.97	.209	.125	.209	.125
1954 IV	Dec 31	134.40	89.84	16.96	27.60	100.69	.205	.126	.212	.124
1955 I	Mar 30	128.10	87.57	16.18	24.35	97.51	.190	.126	.207	.125
1955 II	Jun 30	130.61	87.21	16.24	27.16	98.05	.208	.124	.198	.126
1955 III	Sep 28	132.10	88.36	16.59	27.15	98.22	.206	.126	.199	.125
1955 IV	Dec 31	138.20	92.44	17.79	27.98	101.26	.202	.129	.207	.125
1956 I	Mar 28	131.60	89.15	16.67	25.78	99.27	.196	.127	.204	.127
1956 II	Jun 30	133.03	88.14	16.92	27.97	99.29	.210	.127	.199	.128
1956 III	Sep 26	132.80	88.77	16.87	27.16	99.72	.205	.127	.203	.127
1956 IV	Dec 31	139.73	93.32	18.43	27.97	102.50	.200	.132	.207	.127
1957 I	Mar 27	132.60	91.31	16.85	24.40	98.73	.184	.127	.202	.130
1957 II	Jun 26	133.72	88.91	16.99	27.83	99.14	.208	.127	.197	.130
1957 III	Sep 25	133.30	89.10	17.13	27.07	98.75	.203	.129	.196	.127
1957 IV	Dec 31	138.56	92.19	18.42	27.94	101.12	.202	.133	.206	.128

Table 1: Monetary Data, 1922-1960 (Continued)

Year and Quarter	Call Date	M	D'_p	D''_p	C	D^n	$\frac{C}{M}$	$\frac{D''_p}{M}$	c	h
1958 I	Mar 26	$132.00	$88.78	$17.04	$26.18	$99.07	.198	.129	.202	.131
1958 II	Jun 23	133.96	89.19	17.27	27.50	102.41	.205	.129	.200	.131
1958 III	Sep 24	136.00	90.64	17.67	27.70	101.76	.204	.130	.202	.129
1958 IV	Dec 31	144.25	96.22	19.66	28.37	105.67	.197	.136	.205	.129
1959 I	Mar 25	138.20	91.79	18.46	27.95	102.47	.202	.134	.200	.134
1959 II	Jun 24	139.00	93.72	18.90	26.74	102.85	.192	.136	.200	.135
1959 III	Sep 30	139.90	92.73	19.34	27.83	104.07	.199	.138	.197	.135
1959 IV	Dec 31	144.82	95.27	20.61	28.95	106.09	.200	.142	.196	.137
1960 I	Mar 30	136.90	91.79	19.05	26.06	101.00	.190	.139	.200	.140
1960 II	Jun 29	136.10	91.04	18.75	26.31	101.02	.193	.138	.195	.141
1960 III	Sep 28	137.60	90.05	19.20	28.36	103.02	.206	.140	.192	.139
1960 IV	Dec 31	144.46	94.59	20.99	28.88	104.87	.200	.145	.200	.139

Table 1

Definition and Discussion of Variables

The money stock, defined as demand deposits adjusted in commercial banks plus currency in the hands of the public (M). The data are in seasonally-unadjusted form, measured as of the quarterly call dates shown. Source: The Federal Reserve Bulletin, various issues over the period 1922-1960.

Demand deposits adjusted in member banks (D_p'). The series is seasonally unadjusted and refers to each quarterly call date. Source: Monetary and Banking Statistics, pp. 72-75 for the prewar data, and various issues of the Federal Reserve Bulletin for the postwar figures.

Demand deposits adjusted in nonmember banks (D_p''). This series is seasonally unadjusted and refers to the stock of these deposits as of each quarterly call date. Source: This series is derived by subtracting demand deposits adjusted in member banks from demand deposits adjusted in all banks as reported in Monetary and Banking Statistics, pp. 34-35, and in various issues of the Federal Reserve Bulletin.

Currency in the hands of the public (C). This consists of all Treasury and Federal Reserve currency and coin in circulation except that held as vault cash by the banking system. The series is derived by subtracting demand deposits adjusted (Cols. 5 plus Col. 6) from the total money stock (Col. 3). While separate series on currency in circulation are available, this procedure was followed in order to keep all components of the money stock consistent with each other. This series is seasonally unadjusted and refers to currency in circulation as of each quarterly call date.

Net demand deposits at member banks (D^n). These are demand deposits against which member banks are required to hold reserves. Net demand deposits differ from demand deposits adjusted chiefly in that the former include United States Government deposits at member banks (since August, 1935). During the prewar period, data on net demand deposits as of quarterly call dates were obtained from Money and Banking Statistics (Washington, D.C.: Board of Governors of the Federal Reserve System, 1943), pp 72-75. For the postwar period, the data were obtained from various issues of the Federal Reserve Bulletin. Because of changes in the method of reporting these series, the postwar data are averages of daily figures. From 1946 II until September, 1952, this average covered one-half of a calender month; that is, averages for the first and second

halves of each month were reported. For this period, the figure used is the average for the second half of March, June, September, and December. Beginning at October, 1952, a monthly average of daily figures was reported, and the figure used here is the monthly average for March, June, September, and December. This system was used through December, 1959; beginning with the first quarter of 1960, a four-week average of daily figures was reported, and the figure used for this study is for the four-week average period ending nearest each call date.

TABLE 2: RESERVES AND BANKING DATA, 1922-1960

Year and Quarter*	Time Deposits at Member Banks**	Time Deposit Reserve Requirement	Time Deposit Required Reserves**	Total Required for Member Banks**	Reserves Required for Demand Deposits in Member Banks** R^r	Net Demand Deposits in Member Banks** D^n	$k=\frac{D^n}{R^r}$	Borrowing by Member Banks from the Federal Reserve System** B
1922 II	$ 7,175	.030	$ 215	$ 1,789	$ 1,574	$15,539	9.872	$ 592
1923 II	8,378	.030	251	1,850	1,599	16,065	10.047	944
1923 IV	8,651	.030	260	1,884	1,624	16,377	10.084	808
1924 II	9,204	.030	276	1,974	1,698	16,838	9.916	443
1924 IV	9,805	.030	294	2,161	1,867	18,468	9,892	408
1925 II	10,382	.030	311	2,151	1,840	18,277	9,933	565
1925 IV	10,653	.030	320	2,256	1,936	19,260	9,948	740
1926 II	11,173	.030	335	2,232	1,897	18,805	9,913	617
1926 IV	11,440	.030	343	2,250	1,907	18,922	9,922	792
1927 II	12,210	.030	366	2,313	1,947	19,250	9,887	559
1927 IV	12,765	.030	383	2,424	2,041	20,104	9,850	696
1928 II	13,439	.030	403	2,345	1,942	19,191	9,882	1,228
1928 IV	13,329	.030	400	2,430	2,030	19,944	9,825	1,296
1929 II	13,168	.030	395	2,333	1,938	18,977	9,792	1,302
1929 IV	12,984	.030	390	2,428	2,038	19,797	9,714	1,015
1930 II	13,476	.030	404	2,383	1,979	19,170	9,687	472
1930 IV	13,201	.030	396	2,375	1,979	18,969	9,585	513
1931 II	13,247	.030	397	2,308	1,911	18,357	9,606	232
1931 IV	11,227	.030	337	1,994	1,657	16,067	9,696	921
1932 II	10,560	.030	317	1,820	1,503	14,482	9,635	878
1932 IV	10,461	.030	314	1,933	1,619	15,193	9,384	592
1933 II	8,890	.030	267	1,817	1,550	14,156	9,133	205
1933 IV	9,036	.030	271	1,870	1,599	14,821	9,269	155

*All values are taken as of the call dates given in Table 1.

**Million of dollars

Table 2: Reserves and Banking Data, 1922-1960

Year and Quarter	Time Deposits at Member Banks	Time Deposit Reserve Requirement	Time Deposit Required Reserves	Total Reserves Required for Member Banks	R^r	D^n	$k=\frac{D^n}{R^r}$	B
1934 II	$ 9,681	.030	$ 290	$ 1,951	$ 1,661	$17,067	10.275	40
1934 IV	9,767	.030	293	2,282	1,989	18,851	9,478	19
1935 II	10,054	.030	302	2,565	2,263	21,045	9,300	16
1935 IV	10,041	.030	301	2,743	2,442	22,160	9,078	14
1936 II	10,477	.030	314	2,916	2,602	23,986	9,218	20
1936 IV	10,726	.045	483	4,622	4,139	25,450	6.149	17
1937 II	11,110	.055	611	6,035	5,424	24,845	4.581	17
1937 IV	11,288	.060	677	5,814	5,138	23,741	4.621	15
1938 II	11,328	.050	566	5,149	4,583	23,890	5.213	12
1938 IV	11,307	.050	565	5,519	4,954	25,983	5.245	6
1939 II	11,504	.050	575	5,878	5,303	27,441	5.175	5
1939 IV	11,647	.050	582	6,444	5,862	30,326	5.173	3
1940 II	11,869	.050	593	6,924	6,331	32,514	5.136	3
1940 IV	12,122	.050	606	7,411	6,805	35,262	5.182	3
1941 II	12,295	.050	615	7,841	7,226	37,411	5.177	3
1941 IV	12,296	.060	738	9,365	8,627	39,708	4.603	4
1946 II	26,115	.060	1,567	15,143	13,576	74,297	5.473	72
1946 IV	27,190	.060	1,631	15,577	13,946	77,333	5.545	30
1947 II	28,014	.060	1,681	15,374	13,693	75,573	5.519	50
1947 III	28,172	.060	1,690	15,863	14,173	78,741	5.556	332
1947 IV	28,340	.060	1,700	16,400	14,700	80,740	5.493	54
1948 I	28,556	.060	1,713	15,984	14,271	77,313	5.417	467
1948 II	28,823	.060	1,729	16,647	14,918	77,399	5.188	53
1948 IV	29,160	.075	2,187	19,277	17,090	80,300	4.699	45
1949 I	29,008	.075	2,176	18,432	16,256	77,416	4.762	208
1949 II	29,264	.075	2,048	16,919	14,871	76,456	5.143	21
1949 III	29,099	.050	1,455	15,176	13,721	79,137	5.768	192
1949 IV	28,840	.050	1,442	15,550	14,108	81,300	5.763	11

Table 2: Reserves and Banking Data, 1922-1960

Year and Quarter	Time Deposits at Member Banks	Time Deposit Reserve Requirement	Time Deposit Required Reserves	Total Reserves Required for Member Banks	R^r	D^n	$k = \frac{D^n}{R^r}$	B
1950 I	$29,370	.050	$1,469	$15,150	$14,360	$80,184	5.861	$253
1950 II	29,625	.050	1,481	15,498	14,017	81,191	5.792	30
1950 III	29,218	.050	1,461	15,821	14,360	83,455	5.812	140
1950 IV	29,336	.050	1,467	16,509	15,042	87,014	5.785	79
1951 I	29,220	.050	1,461	18,367	16,906	87,437	5.172	374
1951 II	29,712	.050	1,486	18,604	17,118	87,249	5.097	55
1951 III	29,987	.050	1,499	18,822	17,323	88,588	5.114	195
1951 IV	30,623	.050	1,531	19,667	18,136	91,953	5.070	26
1952 I	31,112	.050	1,556	19,241	17,685	90,827	5.136	299
1952 II	31,788	.050	1,589	19,573	17,984	91,217	5.072	69
1952 III	32,118	.050	1,606	19,747	18,141	92,921	5.122	282
1952 IV	32,890	.050	1,645	20,520	18,875	96,624	5.119	165
1953 II	34,117	.050	1,706	19,459	17,753	91,376	5.147	75
1953 IV	35,213	.050	1,761	19,397	17,636	96,055	5.447	43
1954 I	35,902	.050	1,795	18,689	16,894	93,775	5.551	175
1954 II	36,900	.050	1,845	18,412	16,567	93,928	5.670	38
1954 III	37,542	.050	1,877	17,724	15,847	94,970	5.993	78
1954 IV	37,950	.050	1,898	18,618	16,720	100,689	6.022	15
1955 I	38,234	.050	1,912	17,871	15,959	97,513	6.110	652
1955 II	38,810	.050	1,941	18,139	16,198	98,045	6.053	115
1955 III	38,950	.050	1,948	18,212	16,264	98,223	6.039	888
1955 IV	39,165	.050	1,958	18,903	16,945	101,264	5.976	137
1956 I	39,512	.050	1,976	18,276	16,300	99,266	6.090	1,196
1956 II	40,171	.050	2,009	18,449	16,440	99,287	6.039	302

Table 2: Reserves and Banking Data, 1922-1960

Year and Quarter	Time Deposits at Member Banks	Time Deposit Reserve Requirement	Time Deposit Required Reserves	Total Reserves Required for Member Banks	R^r	D^n	$k = \frac{D^n}{R^r}$	B
1956 III	$40,477	.050	$2,024	$18,450	$16,426	$ 99,719	6.071	$1,532
1956 IV	40,909	.050	2,045	19,089	17,044	102,503	6.014	48
1957 I	42,557	.050	2,128	18,512	16,384	98,728	6.026	819
1957 II	43,653	.050	2,183	18,543	16,360	99,139	6.060	1,003
1957 III	44,478	.050	2,224	18,694	16,470	98,749	5.996	1,100
1957 IV	45,290	.050	2,265	19,091	16,826	101,123	6.010	57
1958 I	47,530	.050	2,377	17,857	15,480	99,069	6.400	855
1958 II	49,893	.050	2,495	18,158	15,663	102,411	6.538	1,078
1958 III	50,852	.050	2,543	17,785	15,242	101,757	6.676	1,514
1958 IV	51,132	.050	2,557	18,574	16,017	105,668	6.597	54
1959 I	51,857	.050	2,593	17,815	15,222	102,472	6.732	1,949
1959 II	52,892	.050	2,645	18,054	15,409	102,847	6.674	2,619
1959 III	52,884	.050	2,794	18,175	15,381	104,069	6.766	1,358
1959 IV	52,827	.050	2,641	18,629	15,988	106,088	6.635	581
1960 I	52,798	.050	2,640	17,465	14,825	101,001	6.813	3,216
1960 II	53,977	.050	2,700	17,883	15,183	101,024	6.654	2,069
1960 III	55,590	.050	2,780	18,157	15,377	103,017	6.699	1,996
1960 IV	57,272	.050	2,864	18,993	16,129	104,868	6.502	130

Table 2

Definitions and Discussion of Variables

Time deposits at member banks. The series is seasonally unadjusted and refers to quarterly call dates. Postal savings accounts at member banks through June, 1935, are included. Source: Monetary and Banking Statistics, pp. 72-75, for the prewar data, and various issues of the Federal Reserve Bulletin for the postwar data.

Time deposit reserve requirements. This is the percentage of their time deposits which member banks are required to hold as reserves. These requirements were uniform for all classes of member banks over the period of the study. Source: Federal Reserve Bulletin.

Time deposit required reserves. The amount of reserves which member banks were required to hold against time deposits as of each call date was computed by multiplying time deposits at member banks as of that date by the time deposit reserve requirement in effect.

Total required reserves for member banks. This seasonally unadjusted series includes reserves required for both time deposits and demand deposits at member banks as of each quarterly call date. Source: Various issues of the Federal Reserve Bulletin and Annual Report of the Board of Governors of the Federal Reserve System.

Reserves required for demand deposits in member banks. This seasonally-unadjusted series is derived by subtracting reserves required for time deposits in member banks from total required reserves for member banks.

The reciprocal of the weighted average reserve ratio (k). This series is derived by dividing net demand deposits (i.e., those demand deposits in member banks for which reserves must be held) by reserves required for demand deposits. Each value is the effective value as of a quarterly call date.

Borrowing by member banks from the Federal Reserve System (B). This seasonally unadjusted series is taken as of each quarterly call date. Source: Various issues of the Federal Reserve Bulletin for postwar data, and Monetary and Banking Statistics, pp. 73-75 for prewar figures.

TABLE 3: CALCULATION OF M*, 1922-1960

Year and Quarter[a]	Total Reserves of Member Banks[b]	Supplied Reserves[b] R^s	kR^s[b]	$M^* = \frac{kR^s}{1-c-h}$[c]
1922 II	$1,820	$ 1,013	$10,000	$16.556
1923 II	1,852	657	6,601	10.965
1923 IV	1,898	830	8,370	14,020
1924 II	1,944	1,225	12,147	20.245
1924 IV	2,220	1,518	15,016	24.738
1925 II	2,172	1,296	12,873	21,068
1925 IV	2,212	1,152	11,460	18.756
1926 II	2,229	1,277	12,659	20.617
1926 IV	2,194	1,059	10,507	17.029
1927 II	2,249	1,324	13,077	20.990
1927 IV	2,487	1,408	13,869	22.084
1928 II	2,325	694	6,858	10.955
1928 IV	2,389	693	6,809	10.965
1929 II	2,356	659	6,453	10.391
1929 IV	2,355	950	9,228	14.694
1930 II	2,389	1,513	14,656	23.080
1930 IV	2,471	1,562	14,972	23.285
1931 II	2,381	1,752	16,830	26.053
1931 IV	1,961	703	6,812	10.717
1932 II	1,982	787	7,583	12.250
1932 IV	2,509	1,603	15,043	24.341
1933 II	2,297	1,825	16,668	26.626
1933 IV	2,729	2,303	21,347	33.617
1934 II	3,840	3,510	36,065	55,230
1934 IV	4,096	3,784	35,865	53.291
1935 II	4,979	4,661	43,347	63.188
1935 IV	5,587	5,272	47,859	68.862
1936 II	5,633	5,299	48,846	70.080
1936 IV	6,606	6,106	37,546	53.714
1937 II	6,900	6,272	28,732	41.163
1937 IV	7,027	6,335	29,274	42.242
1938 II	8,024	7,446	38,816	55.850
1938 IV	8,724	8,153	42,762	60.915
1939 II	10,018	9,438	48,842	69.378
1939 IV	11,653	11,068	57,255	80.869
1940 II	13,781	13,185	67,718	94.710
1940 IV	14,026	13,417	69,527	96.565
1941 II	13,051	12,433	64,366	89.646
1941 IV	12,450	11,708	53,892	76.443
1946 II	15,910	14,271	78,105	127.000
1946 IV	16,139	14,478	80,281	126.228

[a] All values are taken as of the call dates given in Table 1.

[b] Million dollars.

[c] Billion dollars

Table 3: Calculation of M^*, 1922-1960 (Continued)

Year and Quarter	Total Reserves of Member Banks	R^s	kR^s	$M^* = \frac{kR^s}{1-c-h}$
1947 II	$16,112	$14,381	$79,369	$124.403
1947 III	16,784	14,762	82,018	127.953
1947 IV	17,899	16,145	88,684	138.353
1948 I	16,639	14,459	78,324	121.621
1948 II	17,389	15,607	80,969	124.760
1948 IV	20,479	18,247	85,743	132.524
1949 I	19,118	16,734	79,687	122.407
1949 II	17,867	15,798	81,249	124.998
1949 III	15,947	14,299	82,477	127.279
1949 IV	16,568	15,115	87,108	133.806
1950 I	15,657	13,935	81,673	124.312
1950 II	15,934	14,423	83,538	126.573
1950 III	16,709	15,108	87,808	132.841
1950 IV	17,681	16,135	93,341	140.786
1951 I	19,014	17,179	88,850	133.208
1951 II	19,020	17,479	89,090	132.181
1951 III	19,391	17,697	90,502	133.681
1951 IV	20,056	18,499	93,790	139,154
1952 I	19,733	17,878	91,821	137.046
1952 II	19,381	17,723	89,891	136.198
1952 III	20,066	18,178	93,108	141.502
1952 IV	19,950	18,140	92,859	140.059
1953 II	19,561	17.780	91,514	138.030
1953 IV	20,160	13,356	99,985	151.953
1954 I	19,194	17,224	95,610	144.864
1954 II	19,011	17,128	97,116	146.039
1954 III	18,676	16,721	100,209	150.464
1954 IV	18,876	16,963	102,151	153.842
1955 I	18,283	15,719	96,043	143.777
1955 II	18,066	16,010	96,909	143.357
1955 III	18,423	15,587	94,130	139.246
1955 IV	19,005	16,910	101,054	151.278
1956 I	18,799	15,627	95,168	142.254
1956 II	18,443	16,132	97,421	144.756
1956 III	18,831	15,275	92,735	138.410
1956 IV	19,059	16,966	102,034	153.204
1957 I	18,629	15,682	94,500	141.467
1957 II	18,376	15,190	92,051	141.777
1957 III	18,399	15,075	90,390	133.516
1957 IV	19,034	16,712	100,439	150.809
1958 I	18,532	15,300	97,920	146.807
1958 II	18,784	15,211	99,450	148.655
1958 III	18,147	14,090	94,065	140.605
1958 IV	18,504	15,893	104,846	157.426

Table 3: Calculation of M^*, 1922-1960 (Continued)

Year and Quarter	Total Reserves of Member Banks	R^s	kR^s	$M^* = \frac{kR^s}{1-c-h}$
1959 I	$18,192	$13,650	$ 91,892	$137.976
1959 II	17,640	12,376	82,597	124.206
1959 III	17,760	13,608	92,072	137.832
1959 IV	18,484	15,262	101,263	151.819
1960 I	17,991	12,135	82,676	125.267
1960 II	18,182	13,413	89,250	131.318
1960 III	18,779	14,003	93,806	140.218
1960 IV	19,682	16,688	108,505	164.153

Table 3

Definitions and Discussion of Variables

Total reserves of member banks. This seasonally-unadjusted series is taken as of the quarterly call dates given in Table 1. It consists of legal reserves behind both demand and time deposits. Source: Banking and Monetary Statistics, pp. 72-73, for prewar data, and the Federal Reserve Bulletin for postwar figures.

Supplied reserves (R^S). This seasonally-unadjusted series, taken as of quarterly call dates, is derived by subtracting reserves required for time deposits and member-bank borrowing from total reserves of member banks.

TABLE 4: DATA USED FOR SINGLE-EQUATION TESTS ON $\frac{M}{M^*}$

Year and Quarter[a]	$\frac{M}{M^*}$	4-6 Month Commercial Paper Rate r (percent)	Federal Reserve Discount Rate r_d (percent)	$r-r_d$	$\frac{r}{r_d}$	Federal Funds Rate f (percent)
1922 II	1.292	4.38	4.31	.07	1.016	n.a.
1923 II	2.070	5.00	4.50	.50	1.111	
1923 IV	1.631	4.88	4.50	.38	1.084	
1924 II	1.139	4.00	3.82	.18	1.047	
1924 IV	.994	3.63	3.47	.16	1.046	
1925 II	1.184	3.88	3.67	.21	1.057	
1925 IV	1.389	4.38	3.81	.57	1.150	
1926 II	1.242	4.00	3.81	.19	1.050	
1926 IV	1.500	4.50	4.00	.50	1.125	
1927 II	1.217	4.25	4.00	.25	1.063	
1927 IV	1.197	4.00	3.50	.50	1.143	
1928 II	2.362	4.88	4.50	.38	1.084	
1928 IV	2.432	5.38	4.92	.46	1.094	
1929 II	2.519	6.00	5.00	1.00	1.200	
1929 IV	1.795	5.00	4.62	.38	1.082	
1930 II	1.087	3.38	3.44	-.06	.983	
1930 IV	1.055	2.88	2.79	.09	1.032	
1931 II	.901	2.00	2.14	-.14	.935	
1931 IV	2.042	3.88	3.53	.35	1.099	
1932 II	1.652	2.63	2.95	-.32	.892	
1932 IV	.838	1.38	2.84	-1.46	.486	
1933 II	.720	1.63	2.80	-1.17	.582	
1933 IV	.590	1.50	2.49	-.99	.602	
1934 II	.387	.88	2.10	-1.22	.419	
1934 IV	.434	.88	2.02	-1.14	.436	
1935 II	.399	.75	1.75	-1.00	.429	
1935 IV	.393	.75	1.72	-.97	.436	
1936 II	.414	.75	1.72	-.97	.436	
1936 IV	.577	.75	1.74	-.99	.431	
1937 II	.746	1.00	1.74	-.74	.575	
1937 IV	.701	1.00	1.28	-.28	.781	
1938 II	.532	.75	1.28	-.53	.586	
1938 IV	.521	.63	1.25	-.62	.504	
1939 II	.481	.56	1.25	-.69	.448	
1939 IV	.448	.56	1.20	-.64	.467	
1940 II	.408	.56	1.20	-.64	.467	
1940 IV	.438	.56	1.20	-.64	.467	
1941 II	.508	.50	1.20	-.70	.417	
1941 IV	.636	.63	1.25	-.62	.504	

[a]All values are taken as of the call dates given in Table 1.

Table 4: Data Used for Single-Equation Tests on $\frac{M}{M^*}$ (Continued)

Year and Quarter	$\frac{M}{M^*}$	r	r_d	$r-r_d$	$\frac{r}{r_d}$	f
1946 II	.835	.75	1.00	-.25	.750	
1946 IV	.872	1.00	1.00	0	1.000	
1947 II	.872	1.00	1.00	0	1.000	
1947 III	.863	1.00	1.00	0	1.000	
1947 IV	.821	1.06	1.00	.06	1.060	
1948 I	.881	1.25	1.25	0	1.000	1.19
1948 II	.868	1.38	1.25	.13	1.104	1.04
1948 IV	.842	1.56	1.50	.06	1.040	.83
1949 I	.868	1.56	1.50	.06	1.040	1.40
1949 II	.857	1.56	1.50	.06	1.040	1.24
1949 III	.849	1.38	1.50	-.12	.920	1.11
1949 IV	.831	1.31	1.50	-.19	.873	1.19
1950 I	.867	1.31	1.50	-.19	.873	1.35
1950 II	.871	1.31	1.50	-.19	.873	.34
1950 III	.847	1.63	1.75	-.12	.931	1.25
1950 IV	.836	1.75	1.75	0	1.000	1.50
1951 I	.851	2.06	1.75	.31	1.177	1.32
1951 II	.868	2.31	1.75	.56	1.320	1.47
1951 III	.878	2.19	1.75	.44	1.251	1.35
1951 IV	.895	2.38	1.75	.63	1.360	1.66
1952 I	.879	2.38	1.75	.63	1.360	.28
1952 II	.890	2.31	1.75	.56	1.320	1.61
1952 III	.869	2.31	1.75	.56	1.320	.48
1952 IV	.921	2.31	1.75	.56	1.320	1.71
1953 II	.900	2.75	2.00	.75	1.375	1.16
1953 IV	.859	2.25	2.00	.85	1.125	1.10
1954 I	.853	2.00	1.75	.25	1.143	1.20
1954 II	.858	1.56	1.60	.06	1.040	1.39
1954 III	.851	1.31	1.50	-.19	.873	.88
1954 IV	.874	1.31	1.50	-.19	.873	1.44
1955 I	.891	1.69	1.50	.19	1.127	1.30
1955 II	.911	2.00	1.75	.25	1.143	1.66
1955 III	.949	2.56	2.25	.31	1.138	2.23
1955 IV	.914	3.00	2.50	.50	1.200	2.46
1956 I	.925	3.00	2.50	.50	1.200	2.50
1956 II	.919	3.38	2.79	.59	1,212	2.55
1956 III	.959	3.50	3.00	.50	1.167	2.90
1956 IV	.912	3.63	3.00	.63	1.210	2.99
1957 I	.937	3.63	3.00	.63	1.210	2.95
1957 II	.978	3.85	3.00	.85	1.283	3.00
1957 III	.998	4.00	3.50	.50	1.143	3.50
1957 IV	.919	3.75	3.00	.75	1.250	3.00

Table 4: Data Used for Single-Equation Tests on $\frac{M}{M^*}$ (Continued)

Year and Quarter	$\frac{M}{M^*}$	r	r_d	$r-r_d$	$\frac{r}{r_d}$	f
1958 I	.899	2.38	2.25	.13	1.058	1.10
1958 II	.901	1.50	1.75	-.25	.857	.98
1958 III	.927	2.90	2.00	.90	1.40	1.65
1958 IV	.916	3.38	2.50	.88	1.352	2.53
1959 I	1.002	3.38	3.00	.38	1.127	2.98
1959 II	1.119	3.88	3.50	.38	1.109	3.50
1959 III	1.015	4.75	4.00	.75	1.188	4.00
1959 IV	.954	4.88	4.00	.88	1.220	4.00
1960 I	1.093	4.25	4.00	.25	1.063	3.35
1960 II	1.036	3.63	3.50	.13	1.037	3.00
1960 III	.981	3.50	3.00	.50	1.167	2.40
1960 IV	.880	3.13	3.00	.13	1.043	2.10

Definitions and Discussion of Variables

The short-term interest rate (r). The 4-6 month commercial paper rate is used as a measure of the short-term interest rate. In order to make this measure conform as closely as possible to the "call date" concept used for the measurement of stock variables, the value recorded for each quarter is the average of daily rates for the last full week preceding the call date. Source: Banking and Monetary Statistics, pp. 453-459, for prewar data, and the Federal Reserve Bulletin for the postwar period.

The Federal Reserve discount rate (r_d). The discount rate series is a weighted average of the discount rates set by each district Federal Reserve Bank as of each call date. Member-bank deposits at each bank on such dates are used as weights. Source: Banking and Monetary Statistics, pp. 440-442, for rates in effect during 1922-1941; the Federal Reserve Bulletin for postwar rates.

The Federal funds rate (f). The Federal funds rate series used was obtained by averaging the daily effective rates for the five days prior to each call date. This was done in order to smooth the series somewhat, since the daily rate tends to be quite volatile. The series is available only from 1948 to the present. Source: These data were supplied by Mr. Parker B. Willis of the Federal Reserve Bank of Boston and were collected by Garvin, Bantel and Co.

TABLE 5: ADDITIONAL DATA USED FOR STRUCTURAL ESTIMATES

Year and Quarter*	Net Worth** NW	Exogenous Expenditures** E	Gross National Product** Y
1924 II	$ 328.0	$ 26.9	$ 85.94
1924 II	343.0	28.4	90.35
1926 II	361.0	29.6	96.93
1927 II	389.0	29.1	95.38
1928 II	428.0	26.9	97.19
1929 II	467.0	31.7	103.83
1930 II	444.0	24.9	90.86
1931 II	384.0	17.1	75.93
1932 II	319.0	11.5	58.34
1933 II	306.0	11.8	55.76
1934 II	324.0	15.7	64.87
1935 II	337.0	19.6	72.19
1936 II	363.0	23.7	82.48
1937 II	377.0	28.0	90.21
1938 II	357.0	23.8	84.68
1939 II	368.0	27.0	91.34
1940 II	378.0	32.7	101.44
1941 II	403.0	48.9	126.42
1946 IV	790.0	72.0	232.8
1947 II	825.0	72.4	226.0
1947 III	850.8	77.6	232.0
1947 IV	871.8	84.0	260.8
1948 I	878.7	86.0	241.2
1948 II	900.9	88.0	252.4
1948 IV	914.2	97.2	282.4
1949 I	930.4	92.4	250.0
1949 II	925.4	82.0	252.4
1949 III	937.9	90.4	257.2
1949 IV	946.7	83.6	272.4
1950 I	962.2	91.2	255.6
1950 II	991.3	92.4	270.0
1950 III	1,013.7	106.4	292.4
1950 IV	1,046.4	118.8	320.4
1951 I	1,086.3	123.6	308.0
1951 II	1,103.1	134.4	322.4
1951 III	1,126.9	141.6	330.8
1951 IV	1,144.7	138.4	354.8

*All values are taken as of the call dates given in Table 1.

**Billion dollars.

Table 5: Additional Data Used for Structural Estimates (Continued)

Year and Quarter	NW	E	Y
1952 I	$1,163.5	$144.0	$331.6
1952 II	1,172.0	136.8	338.0
1952 III	1,187.6	144.8	342.4
1952 IV	1,202.4	146.8	376.4
1953 II	1,224.4	152.8	367.6
1953 IV	1,247.0	144.0	377.6
1954 I	1,267.4	348.4	348.4
1954 II	1,295.8	138.8	358.0
1954 III	1,321.5	142.4	358.4
1954 IV	1,347.7	142.0	388.0
1955 I	1,378.4	151.2	370.8
1955 II	1,407.2	156.0	390.8
1955 III	1,454.2	164.0	400.0
1955 IV	1,479.9	163.6	428.4
1956 I	1,507.7	162.4	395.6
1956 II	1,537.5	182.0	410.0
1956 III	1,568.6	173.6	417.6
1956 IV	1,580.8	175.6	453.6
1957 I	1,594.8	176.4	420.8
1957 II	1,629.7	180.4	440.0
1957 III	1,641.6	182.4	443.6
1957 IV	1,625.6	176.4	466.8
1958 I	1,649.8	163.2	416.8
1958 II	1,688.4	167.6	433.6
1958 III	1,730.6	176.8	443.2
1958 IV	1,781.0	183.6	484.8
1959 I	1,817.3	183.2	454.0
1959 II	1,837.8	199.2	484.8
1959 III	1,856.0	192.8	477.2
1959 IV	1,862.0	194.4	515.2

Definitions and Discussion of Variables

Net worth (NW). The net worth data are based upon figures reported in Raymond W. Goldsmith, Dorothy S. Brady, and Horst Mendershausen, A Study of Saving in the United States, Vol. III (Princeton, N.J.: Princeton University Press, 1956). The figures used are derived from the national balance sheet data reported in this volume, and were supplied by Professor Albert Ando. The precise content of this series can be found by reference to Goldsmith et. al. (See Table W-16, for example). The adjustments which have been made to this series reflect price changes in some of the component variables. The data refer to the beginning of each quarter and are in current dollars.

Exogenous expenditure (E). For purposes of this model, exogenous expenditure is defined as the sum of gross private domestic investment, total exports, and government expenditure at all levels. The quarterly data are seasonally unadjusted annual rates. For the period 1929-1960, the source is U. S. Income and Output, 1958, Table I-1 and the Survey of Current Business. Data for 1924-1929 are derived from the figures reported as autonomous expenditure by Milton Friedman and David Meiselman in their study for the Commission on Money and Credit entitled "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958," Table B-1. These figures were derived from savings data, since investment information was not available; therefore, they do not precisely match the series derived from Department of Commerce investment data. In order to link the two series, the Friedman-Meiselman figures for 1924-1928 were multiplied by the ratio of ~~the ratio of~~ the Department of Commerce-based figure for exogenous expenditure for 1929 to that of Friedman-Meiselman.

Gross national product (Y). For the prewar period, the data on gross national product are obtained from Goldsmith et. al., A Study of Saving in the United States (Princeton, N.J., Princeton University Press, 1956), Table N-1. The figures are in current dollars. Department of Commerce data were used for the postwar period; the source was U.S. Income and Output, 1958 edition, Table I-4, and the Survey of Current Business. The figures are seasonally unadjusted annual rates.

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BIOGRAPHICAL NOTE

The author, Ronald Leslie Teigen, was born in Kenyon, Minnesota, on April 12, 1931. He attended the University of Minnesota from 1948 to 1952 and received the degree of Bachelor of Business Administration with High Distinction in June, 1952. In 1951 he was elected to membership in Beta Gamma Sigma, the national commerce honorary society.

In June, 1952, he was commissioned a second lieutenant in the United States Air Force and spent the following two years on active duty. He entered the Graduate School at the University of Minnesota in September, 1954, and was awarded the degree of Master of Arts by that institution in December, 1955. He was employed by the General Electric Company as a marketing research analyst until September, 1958, when he joined the faculty of Saint Olaf College, Northfield, Minnesota, as an interim instructor in economics. He began doctoral study in economics at the University of Minnesota in January, 1959, and became a doctoral candidate at the Massachusetts Institute of Technology in September, 1959 as a Ford Foundation Fellow. The doctoral thesis was completed at MIT during the tenure of a Ford Foundation Dissertation Fellowship in 1961-62.

In addition to one semester of full-time teaching and approximately three and one-half years of experience in industry, his professional experience includes appointments as a teaching assistant in the Departments of Economics and

Business Administration at the University of Minnesota, designation as a Lecturer in Business Administration at Indiana University-Fort Wayne Center during 1957-1958, and appointment as a research assistant in the Department of Sponsored Research at MIT.

In September of 1962 he will become an Assistant Professor of Economics at the University of Michigan, Ann Arbor, Michigan.