MONEY AND FINANCE IN THE MACRO-ECONOMIC PROCESS

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by

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1. INTRODUCTION: ANALYTICAL FRAMEWORKS IN MACRO-ECONOMICS AND MONETARY THEORY

The historic terrain of macro-economic theory is the explanation of the levels and fluctuations of overall economic activity. Macro-economists have been especially interested in the effects of alternative fiscal, financial, and monetary policies. With the publication of J. M. Keynes's *General Theory* in 1936 and the mathematical formalizations of his theory by J. R. Hicks (1937) and others, the language of macro-economic theory became systems of simultaneous equations. These are *general equilibrium* systems of interdependence in the sense that the relationships describe an entire national economy, not just a particular industry or sector. The systems are usually not completely closed; they depend on exogenous parameters including instruments controlled by policy-makers. Seeking definite relationships of economic outcomes to policies and other exogenous variables, qualitative and quantitative, these models sacrifice detail and generality, limiting the number of variables and equations by aggregations over agents, commodities, assets, and time.

Theoretical macro-economic models of one brand or another are very influential. They guide the architects of econometric forecasting models. They shape the thinking of policy-makers and their advisers about "the way the world works." They color the views of journalists, managers, teachers, housewives, politicians, and voters. Almost everyone thinks about the economy, tries to understand it, and has opinions how to improve its performance. Anyone who does so uses a model, even if it is vague and informal.

1.1 *The Keynes-Hicks Model and an Alternative Framework*

Hicks's (1937) "IS-LM" version of Keynesian and classical theories has been especially influential, reaching not just professional economists but, as the standard macro-model of textbooks, also generations of college students. Its

I am indebted to Kenneth Warwick for compiling Tables 1 and 2, and to Laura Harrison and Glena Ames for efficiently preparing the manuscript of the Lecture under great pressure of time. Research reported here was supported by 'the National Science Foundation and the Cowles Foundation. Among my many intellectual debts, I mention here only my long partnership with William Brainard. Although his influence pervades the paper, he is not responsible for errors of commission and omission, except that there would be fewer if time had permitted him to read and comment.

simple apparatus is the trained intuition of many of us when we confront questions of policy and analysis, whatever more elaborate methods we may employ in further study. But the framework has a number of defects that have limited its usefulness and subjected it to attack. In this lecture I wish to describe an alternative framework, which tries to repair some of those defects. At the same time, I shall argue, the major conclusions of the Keynes-Hicks apparatus remain intact. The reconstruction I shall summarize has engaged me for a long time, and I will of necessity draw on previous work.

The principal features that differentiate the proposed framework from the standard macro-model are these:

Precision regarding time. A model of short-run determination of macro-economic activity necessarily refers to a slice of time. It is one step of a dynamic sequence, not a repetitive equilibrium into which the economy settles.

Tracking of stocks. An essential part of the process is the dynamics of flows and stocks, investment and capital, saving and wealth, specific forms of saving and asset stocks. It is not generally defensible to ignore these relations on the excuse that the analysis refers to so short a time that stocks cannot change significantly.

Several assets and rates of return. The traditional aggregation of all non-monetary assets into a single asset with a common interest rate does not permit analysis of some important policies, institutional structures, and events. My alternative framework can in principle accommodate as many distinct asset categories as appropriate for the purpose at hand, though the illustrative application set forth below distinguishes only four. Asset disaggregation is essential for analyzing, among other phenomena, financing of capital accumulation and government deficits, details of monetary and debt management policies, international capital movements and foreign exchange markets, and financial intermediation.

Modeling of financial and monetary policy operations. Too often macro-economic models describe monetary policy as a stock M whose time path is chosen autonomously by a central authority, without clearly describing the operations that implement the policy. In fact money supplies are changed by government transactions with the public in which goods or non-monetary financial assets are exchanged for money, or by similar transactions between banks and the non-bank public. What transactions are the sources of variation of money stocks makes a difference, depending on how they alter the wealth and portfolio positions of economic agents.

Walras's Law and adding-up constraints. "Walras's Law" says that the excess demand functions of an economic agent must sum to zero for every vector of the variables that are arguments in any of the functions. The “law” imposes the consistency of meeting the budget constraint on the schedules of demand or supply which the agent communicates to all the markets in which she participates. For the asset markets modeled below, for example, the implication is that household demands for end-of-period holdings of the several assets sum to household demand for end-of-period wealth, for every set of values of the determinants of asset and wealth demands. This implies that the partial derivatives of asset demands with respect to, say, any interest rate must add up to the partial derivative of wealth demand with respect to the same variable.

As my collaborator William Brainard and I observed (1968), this consistency requirement is not always explicitly observed in theoretical and statistical models of financial markets. If demand functions are not explicitly specified for the whole range of assets, the function for the omitted category implied by the wealth demand function and the explicit asset functions may be strange in ways unintended by the model-builders. For example, if money demand is related negatively to an interest rate and total wealth demand is not, the implication is that non-money asset functions carry the mirror image of the interest effect on money. The best practice is to write down all the functions explicitly, even though one is redundant, and to put the same arguments in all the functions.

1.2 *Microfoundations, Aggregation, and Expectations*

J. R. Hicks' 1935 article has been an inspiration and challenge to me and many other monetary economists. It stimulated us to look for the properties and functions of money, and of promises to pay money in future, that underlie poeple's willingness to hold these assets. Understanding these foundations, we could seek the observable determinants of demands for money and money substitutes. This quest for the microfoundations of monetary theory has motivated inventory-theoretic models of the demand for transactions media (Baumol, 1952; Tobin, 1956; Miller and Orr, 1966) and models of portfolio choice (Tobin, 1958). It is still unfinished. The reason, I think, is the difficulty of explaining within the basic paradigms of economic theory why paper that makes no intrinsic contribution to utility or technology is held at all and has positive value in exchange for goods and services. I certainly have no solution to that deep question,[1] nor do I regard one as prerequisite to pragmatic monetary theory.

For this and other reasons, macro-economic models of the type I am advocating are, I admit, only loosely linked to optimizing behavior of individual agents. Following an older tradition, economy-wide structural equations are an amalgam of individual behavior and aggregation across a multitude of diverse individuals. This is the pragmatic alternative to two other procedures, both with serious disadvantages. One is to preserve the diversity of agents' preferences and endowments allowed in fully general equilibrium models; the weak restrictions that optimization places on individual excess demands imply no restrictions at all on market-wide schedules. The other is to assume that all agents are alike or fall into two or three classes (old and young, for example) internally homogeneous but differing from each other in arbitrarily specified ways. Although set-ups of this kind (the Samuelson 1958 overlapping generation model, for example) are promising and already generate instructive parables, they are still so abstract and arbitrary as to be useless for policy analysis and econometric model-building.

[1] Hahn (1965, 1971, 1973a, 1973 b) has been an insightful contributor to the literature of this subject. The proceedings of a recent conference on it are reported in Kareken and Wallace (1980).

Another influential methodological wave in current macro-economics is the emphasis on information and expectations, and on the desirability of building models in which agents' behavior is grounded on the information about the present and future which, according to the model itself, would be revealed to the agents (Lucas, 1976). This is a good principle, but my own efforts to construct an improved framework have had a different purpose and emphasis. The system I shall display in this lecture involves expectations, recognizing as any analysis of financial behavior must that the attractiveness of various assets to savers and portfolio managers depends on their estimates of the joint probability distributions of the assets' earnings and capital gains. The consequences of variation of these expectations can be traced, for example if moods, confidence, and "animal spirits" change exogenously, as Keynes thought they frequently do. In dynamic applications and simulations, Lucas's principles of rational expectations could be respected, but I have not done so in the work I will report here.

1.3. Macro-Economics and Full General Equilibrium

Kenneth Arrow's Nobel lecture of 1972 is an elegant exposition of general equilibrium theory, recognizing both its power and its limitations. Were there a full set of simultaneously cleared markets for all commodities, including commodities for future and contingent delivery, there would be no macro-economic problems, no need for money, and no room for fiscal and monetary policies of stabilization. Theorists who take full general equilibrium as their reference point naturally seek to explain alien phenomena as "market failures". Arrow discussed the inability of decentralized competitive markets to supply collective or public goods in optimal amounts. The public-good nature of common monetary units of account and universally acceptable media of exchange is, I believe, one reason why the general equilibrium paradigm has trouble incorporating money. But the departure from that paradigm that I would emphasize, the departure that sets the stage for macro-economic theory and policy, is one emphasized by Keynes. It is the virtual absence of futures markets and of course contingent markets in any commodities other than money itself. As Keynes said (1936, pp. 210-212),

> An act of individual saving means - so to speak - a decision not to have dinner today. But it does not necessitate a decision to have dinner or to buy a pair of boots a week hence or a year hence or to consume any specified thing at any specified date. Thus it depresses the business of preparing today's dinner without stimulating the business of making ready for some future act of consumption. It is not a substitution of future consumption-demand for present consumption-demand, - it is a net diminution of such demand ... If saving consisted not merely in abstaining from present consumption but in placing simultaneously a specific order for future consumption, the effect might indeed be different. For in that case the expectation of some future yield from investment would be improved, and the resources released from preparing for present consumption would be turned over to preparing for the future consumption..
>
> The trouble arises, therefore, because the act of saving implies, not a substitution for present consumption of some specific additional consumption which requires for its preparation just as much immediate economic activity as would have been required by

present consumption equal in value to the sum saved, but a desire for "wealth" as such, that is for a potentiality of consuming an unspecified article at an unspecified time.

In short, the financial and capital markets, are at their best highly imperfect coordinators of saving and investment, an inadequacy which I suspect cannot be remedied by rational expectations. This failure of coordination is a fundamental source of macro-economic instability and of the opportunity for macro-economic policies of stabilization. Current macro-economic theory perhaps pays too exclusive attention to labor markets, where Keynes also detected failures of competition to coordinate demand and supply.

1.4 Statistics of Flows and Stocks of Funds

National income accounts, developed in the inter-war period, provided the data for testing and estimating the models of Keynes and subsequent macro-economists. Both theory and data dealt mainly with flows and their interrelations. Flow-of-funds accounts, notably those compiled by the United States Federal Reserve System since 1949, provide stock and flow data relevant to theoretical models of financial markets, the observations we seek to understand and explain.

In Tables 1 and 2 I show data for 1979, condensed into smaller numbers of sectors (columns) and asset categories (rows) than the Federal Reserve actually reports. In Table 1 there are 9 sectors and 11 assets, the level of aggregation of a model that our group at Yale has been trying to estimate (Backus *et al.,* 1980). In Table 2 the data are further aggregated, into four sectors and four assets, conforming as closely as possible to the theoretical model I shall be discussing here.

In the format of these tables, a column represents a sector's balance sheet (stocks) or sources and uses of funds (flows). A row distributes the stock or flow of an asset over the supplying and demanding sectors. The task of theory and estimation is to bring the columns to life by functions relating sectoral portfolio and saving decisions to relevant variables, and to bring the rows to life as a set of simultaneous market-clearing equations.[2]

[2] See Backus *et al.* (1980), Brainard and Smith (1979), Smith and Brainard (1974, 1976), Backus and Purvis (1980), and Friedman (1977, 1980).

Table I. Flow of Funds Matrix for Eleven Assets and Nine Sectors, 1979
Flows at Annual rates, End-of-Year Stocks in Parentheses (billions of dollars)

	I	Households	Commercial Banking	Savings Institutions	Insurance & Pension Funds	Miscellaneous Intermediaries	Businesses	Federal Government	State & Local Government	Rest of the World	Discrepancy
(1)	Currency & Reserves	7.9 (107.1)	1.3 (46.8)					-9.2 (- 153.9)			*0* *(0)*
(2)	Demand Deposits	15.1 (145.4)	-25.8 (-330.2)	-0.7 (0.6)	1.9 (11.4)	0.7 (6.9)	5.5 (87.4)	0.4 (14.3)	-1.5 (9.6)	4.4 (23.4)	(31.2)
(3)	Small Time Deposits	61.4 (1049.2)	-31.0 (-421.1)	-29.9 (-632.9)	—			0.1 (1.0)	-0.6 (3.8)		0 (0)
(4)	Shorts	85. I (295.6)	-30.7 (-276 4)	-13.5 (-4.4)	-0.7 (25.9)	-12.3 (-53.0)	2.8 (61.5)	-10.5 (-216.2)	2.0 (90.9)	-27.1 (35.1)	+4.9 (+41.0)
	Longs	39.6 (246.3)	15.2 (226.8)	0.2 (76.9)	46.9 (492.4)	-2.6 (-39.0)	-26.3 (-353.2)	-68.4 (-464.5)	-6.4 (<232.7)	1.7 (47.0)	0.1 (0)
(6a)	Nonfinancial Business Equity: Purchases	-206.	0. I	-0.1	54.8	-3.4	-36.9			6.3	-0.2
(6b)	Nonfinancial Equity: Capital Gains	151.8 (748.2)	-0. I (0.1)	(4.2)	-28.0 (200.3)	6.3 (34.1)	-129.4 (- 1029.5)			-0.8 (42.7)	0.2 (- 0 . 1)
(7)	Financial Business Equity	21.0 (148.3)	-7.5 (-72.3)	(0.5)	-7.4 (-41.4)	-6.8 (-40.7)				0.6 (5.5)	0.1 (-0.1)
(8)	Nonmarketables	79.2 (889.5)	-	-	-71.8 (-732.9)			-7.4 (- 156.6)		–	*0* *(0)*
(9)	Mortgages	- 104.9 (-771.6)	31.1 (245.2)	48.5 (569.1)	14.2 (132.1)	0.1 (14.4)	-41.3 (-428.1)	46. I (215.7)	6.3 (23.2)	–	-0.1 (0)
(10)	**Loans**	-54.8 (-486.1))	66.3 1610.0)	3.9 (60. I)	8.0 (60. 1)	27.6 (134.7)	-52.4 (-295.5)	13.7 (101.9)	- 1.6 (-22.7)	-3.6 (-88.1)	-7.1 (-74.4)
(11)	Foreign Assets	3.6 (14.8)	-0.8’ (1.0)	-			23.8 (175.6)	1.2 (28.4)		-25.4 (-229.4))	-2.4 (9.6)
(12)	Miscellaneous (Domestic)	7.2 (66.7)	-18.1 (-29.9)	-4.0 (-24.4)	- 17.8 (- 147.9)	-9.4 (-57.5)	-7.2 (3.1)	9.0 (64.9)	1.3 (13.1)	23.5 (66.9)	15.5 (+45.0)
											11.0
(13)	Financial Net Worth	291.6 (2453.4)	0.0 (0.0)	4.4 (49.7)	0.1 (0.0)	0.2 (-0.1)	-261.4 (-I 778.7)	-25.0 (-565.0)	-0.5 (-114.8)	-20.4 (-96.9)	(52.4) 11.0 (52.4)
(6b)	-Capital Gains Net	151.8	-0. I		-28.0	6.3	-129.4			-0.8	
(14)	= Financial Saving	139.8	0.1	4.4	28. I	-6.1	-132.0	-25.0	-0.5	- 19.6	

Notes to table 1

Source: Flow of Funds Accounts, Federal Reserve, 1981.

Notes & Definitions

(1) Base money. Currency held by the nonbank public has been allocated entirely to households.

(2) Demand deposits include checkable deposits at both commercial banks and savings institutions.

(3) Small time deposits include all time and savings deposits of less than $100,000 at commercial banks and thrift institutions.

(4) 'Shorts' include short-term government securities, federal funds and security repurchase agreements, time deposits in excess of $100,000, money market fund shares, eurodollar deposits, commercial paper and bankers' acceptances.

(5) 'Longs' include longer-term government and agency securities, state and local government obligations and corporate bonds.

(6) 'Equity' includes only the equity liability of nonfinancial corporate business (NFC). Equity of financial business is shown separately in row 7.

(8) 'Nonmarketables' include U.S. savings bonds and insurance and pension reserves.

(10) 'Loans' consist mainly of consumer credit, trade credit, security credit, bank loans not elsewhere classified and U.S. government and agency loans. The discrepancy in this row is due to trade credit.

(11) Foreign assets are claims held by the U.S. on foreigners, denominated in foreign currencies. Included are foreign deposits, foreign equity, direct investment abroad and U.S. foreign exchange and net IMF position.

(6), (7) The following procedures and assumptions were used in order to separate out equity of nonfinancial corporations NFCs from equity of financial institutions (FI).

(i) Equity issued by rest of world (ROW) and Open-end investment companies (OEICs) (mutual funds) was allocated to households.

(ii) The division of remaining equity liability between NFC and FI was made by taking the equity liability of FIs to be equal to their reported net worth, the residual being allocated to business.

(iii) Business equity was then allocated to holders in proportion to their total holdings of equity (excluding equity issued by OEICs and ROW).

(iv) Purchases of equity were treated similarly (although in this case data on equity issue of business are directly available).

(v) In addition, retained earnings of business were treated as an issue of equity and allocated to holders in proportion to their holdings of business equity.

(vi) Capital gains are derived as the difference between the change in business equity holdings/liability and purchases (including retained earnings).

(14) 'Net financial saving' as shown in the table will differ from National Income and Product, Account figures for several reasons-conceptual differences between NIPA and the Flow of Funds Accounts; unallocated discrepancies in the FFA; capital gains in assets other than business equity; and the treatment here of business retained earnings as an issue of equity by business and saving by other sectors.

Table 2. Flow of Funds Matrix for Four-Asset Model, 1979
Flows at Annual Rates, End-of-Year Stocks in Parentheses (billions of Dollars)

	"Households"	Business	Government	Rest of the World	Discrepancy
Equity: Purchases	50.9	-58.1		7.3	-0.1
Equity: Capital Gains	130.0 (1 314.0)	-129.4 (-1369.0)		-0.8 (54.9)	0.2 (0.1)
Bonds	103.1 (616.9)	-2.3 (47.7)	-83.3 (-822.4)	-22.5 (116.9)	5.0 (40.9)
Foreign Assets	6.7 (62.8)	23.8 (175.6)	1.2 (28.4)	-29.3 (-276.4)	-2.4 (9.6)
Base Money	9.2 (153.9)		-9.2 (- 153.9)		0 (0)
Miscellaneous	-3.8 (355.6)	-95.4 (-633.0)	65.9 (268.2)	25.0 (7.8)	8.3 (1.4)
Financial Net Worth	296.1 (2503.2)	-261.4 (1778.7)	-25.4 (*-679.7*)	-20.3 (*-96.8*)	11.0 (52.0) *11.0* (52.0)
-Capital Gains	130.0	-129.4	-	-0.8	
= Net Financial Saving	166.1	-132.0	-25.4	- 19.5	

Source: Flow of Funds Accounts, Federal Reserve, 1981.
Notes:
(1) "Households" includes the household sector and the financial sector.
(2) Differences may arise between this and the previous table due to rounding.
(3) Corporate bonds are included in the equity row. Corporate bonds issued by financial institutions are assumed to be entirely held by households, i.e., foreigners are assumed not to hold any. All foreign corporate bond issues are assumed to be held by "households" and are classified as foreign assets in this table.
(4) It is not possible to identify capital gains for corporate bonds from the Flow of Funds Accounts.
(5) "Miscellaneous" includes demand deposits, small time deposits, mortgages, loans, nonmarketables, equity liability of financial business, and other miscellaneous assets.

2. A MULTI-ASSET MODEL OF THE DETERMINATION OF OUTPUT AND PRICES IN THE SHORT RUN

2.1 *Sources of New Supplies of Private Wealth*

There are three sources of supply of new financial wealth to private households in a modern capitalist economy: (I) net accumulation of goods in inventories or productive capital, (D) government budget deficits, and (CAS) surpluses in current account transactions with other nations. (All symbols and equations are listed at the end of the paper.) By financial wealth I refer to negotiable assets, whether real properties or paper claims (of which negative holdings are liabilities). I exclude illiquid assets such as future labor earnings (human capital) and entitlements to future government transfers, and prospective tax liabilities. During any period of time (t) household saving is the sum of the three items:

$$S = I + D + CAS \qquad (1) \qquad \text{National income identity}$$

Since in any period of time saving is also the excess of net national income Y over consumption C plus taxes T, and the deficit D is the difference between government purchases of goods and services G and taxes T, the *accounting* identity (1) can also be written as:

$$Y = C + I + G + CAS \qquad (2) \qquad \text{National income identity}$$

In either form the identity becomes an equation if any or all of its constituents are expressed as functions of economic variables. Then the equation will be satisfied only for certain sets of values of those variables. On this interpretation (1) or (2) is the familiar "IS" locus introduced by Hicks (1937).

Let me be more precise about the three sources of asset supply on the right hand side of (1). The illustrative model I wish to describe contains, I believe, the highest degree of asset aggregation compatible with analyzing the central issues of macroeconomics, in particular the workings of fiscal and monetary policies. Later in the paper I shall discuss several directions of disaggregation. I distinguish just four assets: *equities,* titles to physical capital and its earnings, generated by investment I; *government bonds* and *base money,* issued to finance deficits D; and *foreign currency assets,* earned by the current account surplus CAS, consisting of the trade surplus X and earnings on the foreign assets themselves.

In reality of course, none of these categories is internally homogeneous. Physical capital takes many different forms, and so do the claims to them - direct titles, debts, and shares. Government securities vary in maturities and other terms. International claims and debts are even more heterogeneous. Moreover, banks and other financial intermediaries transform the liabilities of business, governments, and foreigners into a variety of obligations to suit the tastes and circumstances of household savers. Representing these complex realities by four assets is a great abstraction, comparable to many others in macro-economics. In its defense, I remind you that the common textbook macro-model limits itself to two asset categories, money and everything else. That is, all nonmonetary assets and debts are, in the Hicksian "IS-LM" formalization of Keyne's *General Theory,* taken to be perfect substitutes at a common interest rate plus or minus exogenous interest differentials.

2.2 Claims to Productive Capital

Private capital investment is the source of new claims to physical capital, modeled as equity shares, one share for each unit of capital. The aggregate stock of capital at any time consists of all surviving durable or storable goods, previously produced or imported but not consumed. These stocks are valued continuously in markets for the goods themselves (realistic examples are used vehicles and machinery, and existing residences and other buildings) and in markets for corporate securities or for entire businesses. These market valuations of old capital goods typically differ, up or down, from their replacement costs, i.e., from the costs of producing, and installing at a normal pace, new capital goods of the same type. These deviations are, in turn, the incentives for rates of investment faster or slower than normal. When equity markets place high values on capital goods, the margin above replacement cost induces investors to speed up capital accumulation. This inducement is essentially what the great Swedish economist Knut Wicksell ascribed to a natural rate of interest higher than the market interest rate.

However, there is a limit to the acceleration of capital formation generated by arbitrage of such margins. Abnormally rapid accumulations of capital, exceptionally high rates of investment, impose extra costs on investing firms individually and on the economy collectively. These adjustment costs are a principal reason that positive differences of market valuations from normal replacement costs of capital can and do arise and persist, without triggering virtually instantaneous jumps in capital stock accomplished at virtually infinite rates of investment. Likewise low market valuations of existing capital slow down capital formation, but rarely shut gross investment off completely while stocks are consumed at maximum speed.

The account I have just sketched refers to replacement costs as current costs of production and installation at a normal rate of investment. By normal rate I mean investment that keeps the capital stock growing at the trend of the economy, in Harrod's terminology the "natural" growth rate of its exogenous resources as augmented by technological progress. The upshot, for purposes of a simple macroeconomic model, is an equation for net investment as follows:

(3) $I_t = q_t^K \Delta K_t = q_t^K K_{t-1} f(q_t^K)$ **Investment function**

$$\text{where } \Delta K_t + \delta K_{t-1} \geqslant 0$$
$$f(1) = g$$
$$f'(q_t^K) \geqslant 0$$
$$0 < f^{-1}(-\delta) < 1$$

where:

q_t^K is the ratio of market valuation of capital goods to normal replacement cost at time period t. Its normal value is 1, and the value that induces zero gross investment is $q = f^{-1}(-\delta)$.

K_{t-1} is the stock, valued at normal replacement cost, at the beginning of period t. The supply of productive services of capital available in period t is proportional to K_{t-1}.

ΔK_t is the addition of K_{t-1} occurring in period t.

δ is the rate of depreciation of capital.

g is the natural rate of growth of the economy.

(When no confusion can arise, I suppress the subscripts t and denote values of a variable in the preceeding, current, and next periods as x_{-1}, x, x_{+1}.) Note that investment is valued at asset market prices rather than normal replacement costs both in (3) and in the national income accounting identities (1) and (2). The reason is that the deviations of q^k from 1 represent real costs of adjustment, including positive or negative rents, incurred by investing firms in changing the size of their installed capital.[3]

2.3 The Financing of Government Deficits

Fiscal policy concerns the size of government expenditures and tax receipts, and the stocks and flows of assets issued by the government to finance budget deficits. Monetary policy concerns the composition of privately owned assets of government issue, in particular the relative amounts of monetary issue and non-monetary public debt. Governmental monetary actions, whether taken by Treasury Departments or Finance Ministries or by central banks, determine the proportions in which a current deficit is financed by monetary and non-monetary issues. Open market operations also change the composition of the existing debt.

Clearly it is not possible to model monetary policies, distinct from fiscal policies, without explicit allowance for at least one non-monetary government obligation. (The theoretical literature contains many models in which government deficits can be met only by printing money. Though the consequences of greater or lesser budget deficits in these models are sometimes attributed to "monetary" policies and money growth rates, the primitive asset structure assumed confounds monetary and fiscal policy and excludes operations describable as "monetary" in the usual understanding of the word.) In the four-asset model I am now describing, I take the non-monetary government debt to consist of perpetual bonds or "consols" - promises to pay one dollar each period forever. The government's aggregate obligation to pay these coupons in period t is the number of bonds outstanding at the end of the previous period, B_{-1}. The market price of a consol in dollars is q^B.

The government's monetary issue corresponds to the usual concept of high-powered or base money, currency or its equivalent in central bank deposit liabilities. Base money bears a zero own-rate of interest. I have in mind a fiat issue, not one convertible on demand into gold or any other commodity. However, in a fixed-rate foreign exchange regime, the local currency is in effect convertible into foreign currency. The counterpart of the market price of bonds would be q^H, but it is identically equal to 1. The size and market value of the outstanding stock of high-powered money are both H_{-1}.

In reminding you at the outset of the national income accounting identity, I defined the deficit as G, government purchases, less tax revenues T. In this reckoning taxes are net of the government's transfer payments, which are negative taxes in the sense that the recipients have no contemporaneous reciprocal obligation to render goods and services to the government. Public debt interest might be regarded either as the purchase of a service or as a

[3] The so-called "q" theory of investment was introduced as such in Tobin and Brainard (1968) and has been further discussed and applied in Tobin (1969), Tobin and Brainard (1977), Tobin (1978), Ciccolo (1975), Ciccolo and Fromm (1979), Malkiel, von Furstenberg, and Watson (1979), von Furstenberg (1977), Summers (1981), Abel (1980), and by many other writers. Since it is a straightforward application of the neoclassical theory of the firm, it has many precursors.

transfer payment. For my purpose, it is best to treat it as a transfer but to keep track of it separately.

A government may own marketable assets and earn income from them. I assume in this simplest model that the government does not buy or sell or own physical capital or privately issued equities or debts. But to model fiscal and monetary policy in an open economy it is necessary to allow for government transactions in foreign-currency assets and for its holdings of such assets as international reserves. These are represented as the fourth asset of the model. The government's holdings at the beginning of period t are ${}_GF_{-1}$ in units of foreign currency, valued in period t at $e \cdot {}_GF_{-1}$ where e is the domestic - currency price of a unit of foreign currency. Conceivably ${}_GF_{-1}$ is negative, i.e., the government is a net debtor to foreigners. In any case, if ϱ^F is the foreign-currency yield, the government's income on its reserves is $e\varrho^F \cdot {}_GF_{-1}$

Thus the budget deficit in dollars is, for commodity price level p:

$$pD = pG(\cdot) - pT(\cdot) + B_{-1} - e\varrho^F \cdot {}_GF_{-1} \quad \text{Government deficit} \tag{4}$$

Here the parameters of fiscal policy are the relationships established by legislation defining purchases and taxes-less-transfers as functions $(\cdot)$ of economic variables. For example, $G(\cdot)$ may be each period an *ad hoc* constant G, while $T(\cdot)$ may be a function of contemporaneous real income, and of other current and past variables (including p for nominal tax and transfer systems neither indexed nor rapidly adjusted).

The deficit must be financed by transactions at current asset prices in the three assets high-powered money, consols, and foreign currency:

$$pD = \Delta H + q^B \Delta B - e\Delta_G F \quad \text{Government deficit} \tag{5}$$

$$\left.\begin{aligned} &(6)\quad \Delta H = \gamma^H pD + z^H \\ &(7)\quad q^B \Delta B = \gamma^B pD + z^B \\ &(8)\quad -e\Delta_G F = z^F \end{aligned}\right\} \quad \begin{aligned} 0 \leq \gamma^H, \gamma^B \leq 1 \\ \gamma^H + \gamma^B = 1 \\ z^H + z^B + z^F = 0 \end{aligned} \quad \begin{aligned} &\text{Supply of base money} \\ &\text{Supply of bonds} \\ &\text{Supply of foreign currency assets by government} \end{aligned}$$

Here there are three independent parameters of monetary policy. One of them, say γ^H, which also fixes γ^B, determines the share of the current deficit financed by monetary issue. It is assumed that there is no systematic policy of financing budget deficits by selling foreign currency assets or borrowing in foreign currency. The other two policy parameters, say z^H and z^F, which together fix z^B, describe open market operations. A domestic open market purchase of government bonds is a positive z^H offset by a negative z^B of equal size. Intervention in the foreign exchange market to sell domestic currency for foreign currency assets is a positive z^H offset by a negative z^F of equal size. A "sterilized" acquisition of foreign currency assets is a positive z^B offset by a negative z^F of equal size.

2.4. Supply of Foreign Currency Assets to the Public

At this stage I assume that all capital transactions between the economy described by the model and the rest of the world occur in foreign currency assets. The new supply of foreign currency to the economy as a whole, including both government and private agents, is its surplus on current account. This in turn consists of its surplus in commodity trade plus its earnings on existing foreign-currency holdings. Expressed in current domestic prices, the current account surplus is:

$$e\Delta F + e\Delta_G F = pX(\cdot) + e\varrho^F F_{-1} + e\varrho^F \cdot {}_G F_{-1} \qquad \text{(9)} \qquad \text{Balance of payments}$$

Here F without the prefix subscript G refers to foreign-currency asset holdings of domestic private individuals. $X(\cdot)$ is the real trade surplus in domestic currency, a function of local economic activity, specifically of real national income Y, and of the real exchange rate ep^F/p (where p^F is the foreign-currency price of foreign tradable goods), as well as of other variables, lagged and contemporary, foreign and domestic. The sign of the relationship of X to the real exchange rate depends, as is well-known, on various elasticities; it is positive if excess-demand elasticities are high enough so that real devaluation improves the trade balance.

Using the relationships in the previous subsection, I derive from (8) and (9) the supply of foreign assets to the public:

$$e\Delta F = pX(\ ) + e\rho^F(F_{-1} + {}_G F_{-1}) + z^F = pCAS + z^F \qquad \text{(10)} \qquad \text{Supply of foreign currency assets to public}$$

2.5. Total Saving

Equations (3), (6), (7) and (10) give the additional supplies in period t of the four assets, equities, base money, consol bonds, and foreign currency. In constant dollars they add to $I_t + D_t + CAS_t$, as in the national income identity (1).

2.6. Demands for Asset Accumulations

The next step is to specify the demands for added holdings of the four assets, to match the added supplies described in 2.1-2.5. Since the sum of the four supply flows is total saving, specifying the four demands also implies a total saving function. Of course saving, specific or general, is not identical to increment in wealth. Asset holders also make capital gains or losses, some anticipated and others unexpected.

I assume that households seek for each asset J (= K, B, F, H) a desired end-of period holding $p_t A^J_t$, in market value at current-period asset prices in dollars. The A^J_t are functions; they jointly express fundamental portfolio management and wealth accumulation behavior. Households enter period t with certain holdings of the various assets, J_{t-1}. These will turn out to be worth $q^J_t J_{t-1}$ where q^J_t is the dollar price of asset J determined in period t. Thus the net demand for new assets, $q^J_t \Delta J_t$ in dollar value, is $P_t A^J_t - q^J_t J_{t-1}$. It is this vector which must be equated to the supplies described in the previous section.

The four-equation system for a period t is given in detail below, now in real terms rather than in dollars

Demand = supply equations:

$$(11) \quad A^K(\cdot) - q^K K_{-1} = q^K K_{-1} f(q^K)$$ Equities market

$$(12) \quad A^B(\cdot) - q^B B_{-1}/p = \gamma^B D + z^B/p$$ Bond market

$$(13) \quad A^F(\cdot) - eF_{-1}/p = X(Y, ep^F/p) + e\rho^F(F_{-1} + {}_G F_{-1})/p + z^F/p$$ Foreign-currency assets market

$$(14) \quad A^H(\cdot) - H_{-1}/p = \gamma^H D + z^H/p$$ Base money market

Their summation is the IS relation:

$$(15) \quad A^W(\cdot) - W^*_{-1} = q^K K_{-1} f(q^K) + D + X(Y, ep^F/p) + e\rho^F(F_{-1} + {}_G F_{-1})/p$$ Total wealth

Here W^*_{-1} is the sum of the second left-hand-side terms of the four preceding equations, i.e., the value at period t prices of the assets inherited from the past.

Recall also the expression for the deficit D:

$$(16) \quad D = G - T(Y) + B_{-1}/p - e\rho^F \cdot {}_G F_{-1}/p$$ Deficit defined

2.7. Gross Substitutability among Assets: Effects of Expected Returns

What are the arguments in the A^J functions? In principle, the same vector appears in all the functions. The vector will include four kinds of variables: those that are within-period endogenous, i.e., those whose values are determined by solving a set of simultaneous equations including the four equations (11) to (14); lagged values of within-period endogenous variables; expected future values ofwithin-period endogenous variables; exogenous variables, past, contemporaneous, or future. The fact that A^W is the sum of the A^J means that (15) could be substituted for any of the previous four equations. It also means that the partial derivative of wealth demand with respect to any determining variable is the sum of the partial derivatives of specific asset demands with respect to the same variable. For example, the four specific marginal propensities to save from income sum to the overall marginal propensity to save.

Among the arguments in each asset demand function will be the several real yields expected from holding an asset one period, the vector (r^K, r^B, r^F, r^H). These involve expectations of commodity and asset prices in period t+1, as follows:

$$(17)\quad q_t^K(1+r_t^K) = R_t(Y_t, K_{t-1}) + Eq_{t+1}^K$$ Equities, price and rate of return

Holding of capital equity costing q_t^K from t to t+ 1 entitles the owner to receive the earnings R,, which depend on the output Y produced in period t by use of the capital stock K_{t-1}, and to sell the shares at a real price expected to be Eq_{t+1}^K.

$$(18)\quad q_t^B(1+r_t^B) = (1+Eq_{t+1}^B)/(p_t/Ep_{t+1})$$ Bonds, price and rate of return

$$(19)\quad e_t(1+r_t^F) = (1+p_t^F)Ee_{t+1}(p_t/Ep_{t+1})$$ Foreign currency assets, price and rate of return

$$(20)\quad 1+r_t^H = p_t/Ep_{t+1}$$ Base money, rate of return

With these relationships the asset prices (q^K, q^B, e) in (11)-(14) can be expressed in terms of the r^J vector, or vice versa. Clearly for given price expectations, there is an inverse relation between the current price and the real one-period expected yield on each asset. This remains true so long as the elasticity of expected asset price with respect to current price is less than 1. For equities and bonds it is true even if the elasticity equals or somewhat exceeds 1.

The assumption that the assets are gross substitutes means that the partial derivative of A^J is positive with respect to its own yield r^J but non-positive with respect to other yields r^L $(L \neq J)$. In the present context this is a stronger assumption than it is for asset stock demands that are constrained to add to a constant independent of the vector of determining variables. Here the partial derivatives, own and cross, with respect to any expected yield sum to the total effect of that yield on desired end-of-period wealth. The gross substitutes assumption implies that the total effect is non-negative, and further that any effect of a single interest rate on wealth demand takes the form of demand for the asset whose interest yield has increased without spillover into the other assets, whose yields have not. These are plausible assumptions, and they are consistent with but not required by rational portfolio and saving behavior.

Portfolio theory provides a loose rationale for modeling distinct assets as imperfect substitutes, held jointly in positive amounts even though their expected yields differ (Markowitz, 1952 and 1959; Tobin, 1958). It also provides a rationale for dependence of portfolio demands on the structure of expected yields. But it does not dictate that assets be gross substitutes. Assets with strong negative covariance of yields could be complements, with a rise in the expected return on one inducing an increase in a hedged package which includes both. Even in the absence of covariance complementarity, the income effects of an increase in the expected yield of one asset might cause the gross substitutes assumption to fail. For these reasons gross substitutability is, for asset demands as for consumption goods demands, a more restrictive assumption than utility maximization.

2.8. Other Determinants of Asset Demands

The asset demand functions A^j are not necessarily the permanent portofolios households would choose at the prevailing values of expected yields and other determining variables. In any short period of time, they will adjust only partially to new information about the financial environment. Lags in response are rational in view of the costs of transactions and decisions. For example, when capital gains and losses alter portfolio shares, portfolio managers may be slow to make corrective transactions. For these reasons the A^j will be multivariate stock adjustment functions and involve the vector of initial holdings J_{-1}. One would generally expect the own effect of an initial stock to be negative and the cross effects positive, with the own effects dominating in the summary wealth demand function A^w.

Current and recent real disposable incomes were major determinants of consumption in Keynesian models, but post-war theory has downplayed their role in favor of forward-looking calculations of long-run disposable resources.[4] The issue is the length of the household horizons within which earnings, taxes and transfers are pooled and over which this pool of current and future resources is consumed at a fairly steady rate. The longer the horizon, the larger the share of an increase in current income that will be saved rather than consumed. No doubt households vary greatly in these horizons, from extremely liquidity-constrained consumers who live hand-to-mouth and spend quickly any cash receipts, to lords of dynasties who save all extra income for their descendants. Liquidity constraints, e. g., limitations on the intertemporal fungibility of future wages and pensions, are sufficiently binding for many households that current disposable income remains an important determinant of consumption.

Current income is also a measure of transactions volume, and as such affects particularly the demand for transactions money. In the four-asset model the transactions effect will show up in a relatively high income-elasticity of demand, direct or indirect, for base money.

As the previous discussion makes clear, "human capital," expected future wages, taxes, and transfers, is a determinant of current consumption and saving. Current disposable income may be an indicator of such wealth, but it is an incomplete and imperfect one. Good news about future disposable incomes within households' horizons will reduce current saving, bad news will increase it. Effects on the composition of saving are more difficult to analyze. The time and age profiles of disposable income no doubt influence portfolios, especially if assets differ in liquidity. But these effects average out for the economy as a whole. A more important consideration arises from the uncertainties of both asset returns and earnings from human capital. Their covariances are very relevant to portfolio choice. Risk-averse savers will favor assets with returns negatively correlated with their own wages. Wage-earners who expect a highly

[4] Friedman (1957) and Modigliani and Brumberg (1952, 1954) are seminal. My own work on consumption began with my doctoral thesis in 1947 and encompasses ten papers published over the years and reprinted in Tobin (1975, Ch. 29-38).

cyclical macro-economic future will be wary of equities, whose returns and values are likely to be low precisely when they are most likely to be unemployed. Those who expect stable employment, real wages, and profits will be skeptical of nominally denominated assets, bonds and money. Belief that inflationary periods will be stagflationary because of counter-inflationary monetary policies would lead households seeking hedges against unemployment and lowered real wages to short-term dollar-denominated assets bearing market interest rates (not included in my illustrative model) rather than to equities or long-term bonds.

The lesson of the previous discussion is that asset demand functions cannot be expected to be stable in the face of significant variations in the economic environment. The variances and covariances of returns on the several assets reflect probability distributions of more fundamental shocks to the economy. These are exogenous shocks in technology, tastes, and foreign economies as well as in government policies. Their impacts depend, moreover, on the responses to them by both private agents and government policy-makers. The perceived joint probability distributions of those impacts, as reflected in the estimated risks of various asset portfolios in combination with human capital, are undoubtedly different in the 1980s from the 1960s. Asset demand functions are different too. But the perceptions, conventions, and habits that underlie asset demand functions do not change suddenly. It is sufficient for our immediate purpose that the functions are stable over the medium-term horizons of economic fluctuations and stabilization policies.

Taxes and transfers have been mentioned as elements in current and future disposable incomes. Taxes on capital incomes also affect the after-tax returns to asset holdings. The obvious point that taxation lowers expected yields is not the whole story, because it changes the entire distribution of uncertain returns. If the government shares symmetrically in losses and gains, its tax reduces the risk as well as the average return on risky portfolios, while increasing the risk and return to payers of other taxes, e.g. those on wages and consumption. The effect of a given tax system on saving, portfolio choice, and asset values is a large and complex topic, beyond the scope of this lecture.

2.9. Macro-Economic Modeling Strategy: Stocks, Flows, and Specific Saving Functions

The innovation of the approach thus far described is the integration of saving and portfolio decisions. Functions for accumulation of particular assets are specified, and they add up to total wealth accumulation for the period. The markets which determine asset prices and interest rates coordinate these demand flows with the supply flows arising from real investment, the government deficit, and the external current account. The markets handle simultaneously flows arising from saving and accumulation and those arising from reshuffling of portfolios, both by private agents on the demand side and by the monetary authorities on the supply side. By the end of the period, simultaneously with the determination of the asset prices for the period, these market participants have the stocks of assets and of total wealth they desire at this time at the prevailing prices.

This is not the conventional strategy of short-run macro-economic models. The conventional strategy is to model the determination of asset prices and interest rates as a temporary stock equilibrium independent of flows of new saving. This is done in the "LM" sector of the model, where wealth-owners, constrained by the net worth inherited from their past savings but revalued at current market prices of assets, choose the stocks of money and alternative assets they wish to hold at these prices. The stocks supplied to them are also predetermined by history, except for instantaneous discrete modifications engineered by the monetary authorities by open market operations at current asset prices. Although households are simultaneously saving to accumulate wealth, the IS-LM model contains no specific saving functions describing in what forms they wish to accumulate it. Their absence means that the composition of household portfolios at the end of the period is re-shaped solely by the issues of new asset supplies to finance investment, government deficit, and current account surplus. This composition may not be what households want, but the correction is deferred until the asset-stock markets reopen at the beginning of the next period. The unwelcome implication is that wealth-owners and savers, in formulating their portfolio demands, ignore the fact that they are at the same time saving to augment their wealth. In contrast to the “LM” markets in stocks, the simultaneous “IS” equations are grinding out flows of goods and services.

In my 1969 article describing a multi-asset framework for monetary analysis, I perpetuated the implausible bifurcation to which I now object.[5] I tried to generalize the stock equilibrium of asset prices and quantities to a larger collection of assets while winding up nonetheless with a single “LM” locus to be juxtaposed with an “IS” locus. This condensation, I now recognize, is not in general attainable. The major points of the 1969 paper did not depend on this feature, but the blending of stock adjustments and saving flows advocated in this lecture seems to me a preferable approach.

The interpretation of the solution to a Keynesian short-run macroeconomic system has always been ambiguous. This is especially true when the variables are not explicitly dated by points or periods of time. Is the solution an equilibrium in the sense of a position of rest? This can hardly be the case for a model whose very solution implies changes in stocks of capital, wealth, government debt, and other assets. Since the structural equations of the model depend on those stocks, they will not replicate the solution when the stocks are moving. Keynes himself recognized the problem but excused himself for ignoring the dynamics of accumulation by defining the horizon of analysis as short enough so that flows make insignificant difference to the size of stocks. The excuse makes tolerable sense for the stocks of physical capital and total wealth, but unbalanced government budgets, monetary operations, and external imbalances can alter the corresponding asset stocks quite rapidly. A model whose solution generates flows but completely ignores their consequences may be

[5] However, my 1968 paper with William C. Brainard is not subject to this objection. Explicitly modeling time in discrete periods, we followed in that paper the procedure here recommended.

suspected of missing phenomena important even in a relatively short run, and therefore giving incomplete or even misleading analyses of the effects of fiscal and monetary policies.

A specific complaint in this spirit was the allegation that the standard macro model "ignored the government budget constraint", i.e., the identity that requires the deficit to be financed by issue of one or another government liability.[6] This is true in the standard model unless it is dynamically extended by tracking over time the growth in asset stocks and its effects on asset prices and other variables. The formulation I presented above makes explicit the government's financing requirements and allows its issues of money and bonds to affect financial markets right away.

But neither the problem nor its solution is confined to government finance. Another example concerns international capital movements and the determination of the exchange rate (Branson, 1976, 1977). The recently popular aphorism "the exchange rate is an asset price" is a truth, but a half- or quarter-truth. It is a natural result of divorcing flows from stocks and of viewing asset markets simply as reconciling wealth-constrained portfolio demands with existing stocks. The application of this model to international financial markets was, to be sure, an advance over older analyses of payments imbalances and exchange rates, which either neglected capital transactions altogether or assumed that flows induced by interest rate differentials or other factors would continue indefinitely regardless of their effects on composition of portfolios. But it is more natural to recognize that exchange rates are determined - or held at parities by official interventions - in markets in which demands and supplies for current and capital accounts are mingled (Tobin and de Macedo, 1980; Tobin, 1981).

Here, as in other financial markets, practical participants and observers are acutely conscious of the flows of new issues and new demands, while economists focus on stocks. Each group is puzzled by the other's emphasis. The chances are that both are right.

2.10. Macro-economic Modeling Strategy: Continuous or Discrete Time

The issues just discussed are related to the modeling of time. The equations introduced above count time in discrete periods of equal finite length. Within any period, each variable assumes one and only one value. In particular, clearing of asset markets determines one set of asset prices per period. From one period to the next asset stocks jump by finite amounts. Therefore the demands and supplies for these jumps affect asset prices and other variables within the period, the more so the greater the length of the period. They will also, of course, influence the solutions in subsequent periods.

The same modeling strategy can be used with continuous time. The specific saving functions, as well as the total saving function, then tell the rate at which savers want to be increasing their stocks of particular assets and of total wealth.

[6] An early example of the complaint is Christ (1966, 1968). The issue is discussed in Blinder and Solow (1973, 1974) and by Tobin and Buiter (1976, 1980), and Tobin (1979).

They will reflect both the continuous execution of long run saving and portfolio plans and the speeds of adjustment of stocks to deviations from these plans that arise because of surprises, news, and altered circumstances or preferences.

Either representation of time in economic dynamics is an unrealistic abstraction. We know by common observation that some variables, notably prices in organized markets, move virtually continuously. Others remain fixed for periods of varying length. Some decisions by economic agents are reconsidered daily or hourly, while others are reviewed at intervals of a year or longer except when extraordinary events compel revisions. It would be desirable in principle to allow for differences among variables in frequencies of change and even to make those frequencies endogenous. But at present models of such realism seem beyond the power of our analytic tools. Moreover, many statistical data are available only for arbitrary finite periods.

Representation of economies as systems of simultaneous equations always strains credibility. But it takes extraordinary suspension of disbelief to imagine that the economy solves and re-solves such systems every micro-second. Even with modern computers the task of the Walrasian Auctioneer, and of the market participants who provide her with their demand and supply schedules, would be impossible. Economic interdependence is the feature of economic life that it is our business as professional economists to understand and explain. Simultaneous equations systems are a convenient representation of interdependence, but it is more persuasive to think of the economic processes that solve them as taking time rather than as working instantaneously.

In any event, a model of short-run determination of macro-economic activity must be regarded as referring to a slice of time, whether thick or paper-thin, and as embedded in a dynamic process in which flows alter stocks, which in turn condition subsequent flows.

2.11. Solution of the One-period Model

The four asset-market equations (11)-(14) are the core of the model, augmented by the definition (16) of the deficit D and by the relationships (17)-(20) between current and expected prices and the four one-period rates of return r^j. The solution and interpretation of this structure depend on which variables are regarded as within-period endogenous and which as exogenous or predetermined. If more than four variables are to be taken as endogenous, then one or more equations must be added.

Here I provide, both for illustration of method and for substantive interest, three variants: (1) a "Keynesian" version in which current real income Y is endogenous but commodity price p is predetermined; (2) a "classical" version in which price p is endogenous but Y is supply-determined by the capital stock K_{-1} and an exogenous labor force; (3) a "mixed" version with both p and Y endogenous and connected by a within-period Phillips curve, a fifth equation. In all variants, the asset price expectations figuring in (17)-(19) are assumed to be less than unit-elastic with respect to the corresponding current prices, so that the current prices are inversely related to the rates of return r^j. However, in the "Keynesian" and "classical" variants, the commodity price expectation

Ep_{+1} is assumed to be proportional to the current price p. This assumption fixes the expected inflation rate and thus r^H. In a variant of the "mixed" case, the expected inflation rate is taken to be the same as the current inflation rate, $Ep_{+1}/p = p/p_{-1}$, so that r^H is determined by the short run Phillips curve.

The exogenous variables representing fiscal policy are government purchases G and a constant or shift parameter in the tax-transfer function T (to be interpreted, for simplicity, as not changing marginal tax rates on capital incomes). The parameters of monetary policy are γ^H, the share of the deficit financed by printing base money, and z^H and z^F, open market "sales" of money and foreign currency. In a regime of clean float of the exchange rate z^F is zero; in a regime with discretionary intervention, sale of foreign exchange, either for money or for bonds, is a policy variable. In a regime of fixed exchange rates, which will not be analyzed here, z^F becomes an endogenous variable while e and r^F become exogenous.

The Keynesian variant. With p and r^H predetermined, the model can be solved for (r^K, r^B, r^F, Y). Equations (17) - (19) implicitly substituted to eliminate (q^K, q^B, e) from the core equations, can then be used to obtain these three asset prices.

Differentiation of the core equations (11)-(14) gives a set of equations in the differentials, with sign structures shown in (21). The fifth row, added for reference, refers to the IS equation (1.5).

$$(21)\quad \begin{array}{c}\begin{bmatrix} + & - & - & +(?) \\ - & + & - & + \\ - & - & + & + \\ - & - & - & + \end{bmatrix} \\ \begin{matrix} + & + & + & + \end{matrix}\end{array} \begin{bmatrix} dr^K \\ dr^B \\ dr^F \\ dY \end{bmatrix} = \begin{array}{c}\begin{bmatrix} 0 & -A_T^K & 0 & 0 & 0 & + \\ +\gamma^B & -A_T^B-\gamma^B & +D & 1/p & 0 & + \\ 0 & -A_T^F & 0 & 0 & 1/p & + \\ +\gamma^H & -A_T^H-\gamma^H & -D & -1/p & -1/p & - \end{bmatrix} \\ \begin{matrix} +1 & -A_T^W-1 & 0 & 0 & 0 & - \end{matrix}\end{array} \begin{bmatrix} dG \\ dT \\ d\gamma^B \\ dz^B \\ dz^F \\ dr^H \end{bmatrix}$$

Comparative statics

The sign structure of the Jacobian, except for the last column, follows from the gross substitutability assumption for the A^J functions, reinforced by the signs of partial derivatives of the other terms in the core equations, specifically the negative relations of asset prices to rates of return and the standard Marshall-Lerner elasticity conditions for the trade balance. The final column embodies the presumption that the marginal propensity to save from current income in every asset is positive. Given this presumption, the only ambiguity, indicated by (?), is the possibility that an increase in Y, by raising current earnings of capital R, raises q^K, investment, and the valuation of K_{-1} enough to exceed the new demand for equity wealth it induces. The marginal propensity to invest may exceed the marginal propensity to save in equities.

Assuming the sign structure shown, the determinant of the Jacobian is positive.[7] Even if the questionable sign is reversed, it may be positive and will

[7] A dominant-diagonal matrix has positive diagonal elements, non-positive off-diagonal elements, and positive column sums. Its determinant is positive. It remains positive if any column is replaced by a non-negative vector with no negative elements and at least one positive element.

definitely be so if the sum of the first and last entries in the column is positive. Given a positive Jacobian determinant, the structure of multipliers is shown in Table 3.

These are conventional macroeconomic results, qualitatively the same as comparable conclusions of IS-LM apparatus. Note, however, that - contrary to the classical Mundell (1963) conclusion that monetary policies work and fiscal policies do not in a regime of floating exchange rates - expansionary policies of both kinds are here effective. In the Mundell model, fiscal expansion alone cannot increase aggregate demand because it appreciates the exchange rate and lowers the current account surplus; the foreign interest rate ties down domestic rates so that the velocity of money cannot be raised. In the present model, fiscal expansion does not completely "crowd out" net exports. Exchange appreciation lowers the demand for money both because the return on foreign assets is higher, given sticky exchange rate expectations, and because the value of foreign-currency wealth holdings is lower. This wealth effect requires, of course, that the holdings be positive. The asset substitution effects also imply that the floating rate does not insulate the economy from external demand shocks.

The ambiguities of sign of the multipliers for rates of return reflect the variety of possible substitution patterns in a multi-asset model. For example, with bond financing of deficits, the equity return r^K may actually decline if bonds are a good substitute for money but a poor substitute for equities.

The classical variant. Formally, the classical model has qualitatively the same structure as (21), with the roles of p and Y interchanged. The multipliers for both are those in Table 3. The positive price effects on excess asset demands explicit in equations (11) - (14) may be reinforced by Pigou effects in the A^J functions themselves. Without them the top entry in the last column of the Jacobian, now the dp column, is zero. In any case the possible ambiguity of that sign is removed.

Table 3. Multipliers for Keynesian and Classical Cases

Endogenous Variables:		dr^K $(-dq^K)$	dr^B $(-dq^e)$	dr^F $(-de)$	dY (Keynesian) dp (Classical)
Expansionary fiscal policy					
dG	Purchases ($\gamma^H = 1, \gamma^H < 1$)	(−, ?)	(−, ?)	(−, ?)	(+, +)
- d T	Tax reduction, transfers	?	?	?	+
d G + d T	Balanced increase of budget	?	?	?	?
Expansionary monetary policy					
$-d\gamma^B$	More monetary finance of deficit	-	-	-	+
$-dz^B$	Open market purchases of bonds	-	-	-	+
$-dz^F$	Open market purchases of foreign currency assets	-	-	-	+
$dz^B - dz^F$	Sterilized purchases of foreign currency assets	?	+	-	?
$-dr^H$	Expectation of inflation	-	-	-	+

Monetary expansion is not neutral but lowers real interest rates and shifts the composition of output from consumption to investment. Fiscal expansion raises the price level, and if this does not induce enough saving and current account deficit to finance the increased budget deficit, it raises r^K and crowds out investment. Monetarist conclusions about fiscal policy require, as often argued in the past, that interest-elasticities of money demand be zero (the first three items in the fourth row of the Jacobian).

The mixed model. Clearly an "aggregate supply" function, a positive within-period relation between p and Y can be appended to the model without changing its essential features. The effects of various policies and of other exogenous variables will then be split between price and real income, but will be in the same directions as shown in Table 3. These results depend on the assumption that expected inflation, and thus r^H, are independent of the current price p.

In the final column of (21) are given the signs of differentials for exogenous variation of r^H. In the middle two rows these reflect, in addition to the negative effects of r^H on A^B and A^F, its negative effects on q^B and e. The resulting multiplier signs appear in the final row of Table 3; not surprisingly, expectation of inflation is expansionary and inflationary.

Now suppose that r^H is endogenous, equal to r^H_{-1} plus an expectation revision related negatively to Y. This will add a fifth column to the Jacobian of (21), namely the r^H column with signs reversed as it becomes the fourth column of the Jacobian. The relation of r^H to Y will add a row, [0 0 0 + +], and possibly reverse the sign of the Jacobian determinant and of the multipliers for p and Y. In an IS-LM diagram in r-Y space the equivalent reversal would arise if the LM locus, after subtracting from it the inflation generated at each level of Y by a Phillips curve, crossed IS from above to below rather than in the normal way.

In models of this kind we are not free to dismiss such intuitively perverse solutions as unstable equilibria. There are no dynamics within the period or the slice of continuous time. The one-period model, simultaneous equations and all, is meant to say what actually happens. Dynamics and stability questions arise over a sequence of one-period solutions. In the example of the previous paragraph, the resolution probably lies elsewhere, e.g. in slowing down the translation of actual inflation into expected inflation.

3. POSSIBLE EXTENSIONS AND ELABORATIONS OF THE MODEL

3.1 Financial Intermediation, Loans, and Inside Money

As Table 1 shows, banks and other financial institutions mediate between borrowers and lenders, making loans to businesses, governments, households, and others, and incurring liabilities to households and other creditors. The traditional business of commercial banks is to accept deposits and other obligations payable on demand or at specified times and to acquire assets of less liquidity and longer maturity. Almost all their assets and liabilities, except their owners' equity, are promises to pay currency. Other intermediaries likewise transform their assets into forms better tailored - in convenience of denomination, liquidity, maturity, and risk - to the preferences and circumstances of their creditors. Banks and other intermediaries, together with capital and credit markets, thus create "inside" assets, claims of agents on each other that wash out in aggregations of privately owned national wealth. In particular, banks create inside money, i. e., deposits that serve on a par with government currency as generally acceptable transactions media or as close substitutes therefor, "backed" on the other side of their ledgers not by base money or government debt but by private loans and securities. In the United States the equivalence of bank deposits to currency is sustained by government deposit insurance, which in effect extends to deposits the government's fiat.

With banks and inside money, the nature of the demand for base ("outside") money is altered. In the United States, there are essentially two uses of base money: currency in public circulation and bank reserves. Banks are legally required to hold reserves, either in currency or on deposit in the central bank, in fractions of checkable deposits and certain other liquid liabilities. They may hold reserves in excess of requirements, or by borrowing from the central bank they can make their "net free reserve" positions negative. Thus the demand function for base money consists of three parts: the nonbank public's holdings of currency; required bank reserves, the required fraction of the public's demand for deposits; and net free reserves, a choice made by the banks in the light of the Federal Reserve discount rate and the rates available on loans and securities. The arguments in the three functions are the interest rates and other variables relevant for household or bank portfolio decisions.

The addition of bank deposits, of one or more varieties, to the asset list adds rows to matrices like Table 1. Whether it also adds to the list of endogenous interest rates depends on whether the nominal rate on deposits is, like the zero rate on currency, fixed by law or convention. Deposits with controlled interest rates are an example of an asset market not cleared by price. Banks are not on their deposit supply schedules. They would be ready to accept more deposits than the public wants at the controlled rate, but the smaller side of the market controls the quantity. Thus the banks' disposable deposits, i. e. deposits net of required reserves, are available for allocation among free reserves, loans, and securities.

Banks and other intermediaries can bid for deposits and other liabilities carrying market-determined assets. These in principle add to the list of endogenous interest rates, although in practice certificates of time deposit may be nearly perfect substitutes for Treasury bills and other short open market paper. Similarly commercial loans, mortgages, and other assets characteristic of intermediaries may call for distinct rows and interest rates. Some loans may be rationed at administratively set interest rates, like the "prime", with excess supply from borrowers chronic or frequent. A way to model a privately administered non-competitive price is to imagine it to be reset for each period in relation to the excess supply observed in the preceding period. Then it is not a with-in period endogenous price, and the endogenous variable corresponding to its row equation is a quantity.

The existence of monetary assets with fixed nominal interest rates - base money, deposits, and for short periods central bank loans - gives leverage to central bank monetary operations affecting their supplies. The reason is that other asset prices, interest rates, commodity prices, and real incomes must adjust to induce the public to absorb in their portfolios changes in these supplies. For the same reason and for good or ill, non-policy shocks to the supply of or demand for fixed-rate assets have leverage. In contrast, exogenous increases in the net supply of an asset bearing a flexible market-determined rate can in great part be accommodated by increases in the own-rate itself.

In an n-asset model, if there are less than n endogenous interest rates the asset-market equations can determine, as shown above, at least one other variable, e.g. Y or p or some combination of them. If all assets had market-determined rates, this degree of freedom would be lost. The trend of the financial system is to enlarge the range of assets that have variable market-determined rates, increasing the leverage of base money supplies and equivalent shocks on market interest rates. This trend makes the Hicksian "LM" curve more nearly vertical, rendering fiscal policies and other “IS” shocks less consequential. Whether it contributes to stability or instability of output and prices depends on the nature and strength of unpredictable and uncontrollable shocks to the demands for and supplies of the small remaining core of fixed-rate assets, and to the patterns of demands and supply among the variable-rate assets, especially between nominally denominated securities and equities. It is possible that q^K and Y will be more rather than less variable in the *new* regime.

3.2 Substitutabilily, Aggregation, and Estimation

In principle, the model should distinguish imperfectly substitutable asset categories and determine a separate rate of return for each. If two assets are perfect substitutes, their interest rates move together and can be represented as one variable. Then the two rows must be consolidated. In econometric practice this is also expedient for close though imperfect substitutes. The strong collinearities of time series of interest rates present difficult econometric problems. It is often not clear whether observed co-variation is due to close substitutability or to pervasive common exogenous shocks. History has frequently not performed those experiments in variation of relative asset supplies that would test substitutability hypotheses and allow estimations of cross elasticities. For this reason, estimations and simulations of models or partial models have relied heavily on priors about coefficients and their error distributions. In some cases these Bayesian methods, though inferior to standard procedures in fitting sample observations, have done better in out-of-sample forecasts (Smith and Brainard, 1976).

3.3 International Asset Transactions

In Section 2 international capital movement was modeled in the most primitive fashion, by specifying a single foreign-currency asset in which domestic residents could borrow or lend at an exogenous foreign currency interest rate. Foreigners were assumed not to demand domestic assets. Because of these simplifications, the supply-equals-demand equation for the foreign-currency asset was also the balance-of-payments equation. One step toward realism is to add foreign demands, with the same formats and properties *mutatis mutandum* as the domestic asset demand functions, to the equations for all local assets. Foreign portfolio managers are presumably concerned with returns in their own currencies. This amendment can be kept within the bounds of the "small country" assumption by continuing to assume that foreign interest rates, foreign incomes, and other relevant foreign variables are exogenous. The balance-of-payments equation is the previous foreign-currency asset balance equation, but with net demands now augmented by the sum of net foreign demands for domestic assets. This amendment leaves intact, with only minor qualifications, the conclusions of the simpler model.

The second step, however, introduces considerable complexity and ambiguity. This is to model two economies jointly and symmetrically, with residents of each country demanding asset holdings in both currencies and with macroeconomic variables endogenous in both countries. The "gross substitutes" assumption, the source of determinate qualitative results in Section 2, no longer applies, because the same movement of the exchange rate has opposite meanings to investors in the two countries. Own-currency preferences arise from the facts that each country's residents expect to buy consumer goods in its currency and that the two countries' products are imperfectly substitutable. Obviously, succeeding steps, with n currencies and economies, would be still more difficult.[8]

4. DYNAMICS AND LONG-RUN STEADY STATES

Each within-period solution generates new values of predetermined variables for the following period. These include of course stocks of portfolio assets and capital, which follow obvious transitional equations. Likewise transitional equations could pre-set other variables by the solutions in the immediately preceding and other past periods. The inertia of commodity prices, and their relation to economic activity, could be modeled in this way, as could be adaptive expectations. Rational expectations dynamic solutions are also possible. However, dynamic solutions of a non-linear system, even one of such small dimensionality as the one described in Section 2, cannot be obtained analytically but require simulations.

With some special assumptions, the model has a steady state solution like that of a monetary growth model (Tobin, 1955, 1965, 1968). The most important assumptions, in addition to the familiar restrictions on production functions, technological progress, and exogenous resources, concern asset preferences and saving. The existence of steady states requires that any constant set

[8] On the topic of this subsection, see Tobin and de Macedo (1980), which describes more fully the simple model and takes the first and second steps of amendment. In a subsequent paper, Tobin (1981), I have discussed the internationalization of portfolios and its relation to the theory of exchange rates.

of rates of return all asset demands grow in proportion to the size of the economy. The same homogeneity is required of government purchases and tax revenues.

Which of the various feasible steady states paths, all with the natural rate of growth of the economy g, is the long run equilibrium depends on policy parameters. These are two parameters setting budget purchases and tax revenues as fractions s and τ of total output, and one parameter determining how deficits are financed, γ^B or γ^H. Open market operations have no place or purpose along an equilibrium path.

A steady state solution determines the three rates of return (r^K, r^B, r^H). Capital accumulation occurs steadily at the natural rate of growth, and q^K is therefore equal to 1. Thus r^K is the net (after-tax) marginal product of capital, inversely related to the capital-labor and capital-output ratios, and to output and real wages per effective worker. The rate of return to base money, the negative of the inflation rate, is endogenous in the long run though not in the short-run one-period model. This is because rational expectations apply, as they always have, to steady state solutions; expected and actual inflation must be the same.

I turn now to a brief discussion of the nature of a long-run equilibrium and of the accompanying issues of analysis, interpretation, and policy. Here I refer to a closed economy with three assets; the whole concept of steady long run growth fails for open economies unless their several natural rates of growth happen to be identical. For convenience, I use continuous time. Let b and h be the stocks of bonds (consols) and high-powered (base) money at nominal market value, each as a fraction of nominal income. These will be constants over time in a steady state. The nominal interest rates on the two assets, also constant over time, are ($r^B+\pi$, 0) and the real rates (r^B, r^H), where $r^H=-\pi$. The nominal price of bonds q^B, again constant, is $1/(r^B+\pi)$. The nominal stock of each asset, in dollars, is growing at rate $g+\pi$, along with nominal income. The following two equations describe the financing of the deficit:

$$(22)\quad \begin{cases} \gamma^B(s-\tau+(r^B+\pi)b)Yp = bYp(g+\pi) \\ \gamma^H(s-\tau+(r^B+\pi)b)Yp = hYp(g+\pi) \end{cases}$$

Steady state supplies of bonds and base money

Eliminating Yp from these equations and solving them for b and h gives:

$$(23)\quad b=\frac{\gamma^B(s-\tau)}{g-\gamma^Br^B-\gamma^Hr^H},\qquad h=\frac{\gamma^H(s-\tau)}{g-\gamma^Br^B-\gamma^Hr^H}$$

Solution of (22)

Note that the denominator could be written as $g-r^D$ where r^D is the appropriately weighted average real interest rate on the public debt, monetary and non-monetary. I confine myself to non-negative values of s-t, $g-r^D$, b, and h. Long-run asset demand functions are $a^K(\cdot)$, $a^B(\cdot)$, and $a^H(\cdot)$, each expressed as fractions of real income Y and containing as arguments the three r^J and the tax rate τ. As before, these add up to wealth demand a^W. Let k be the capital-output ratio, which with a normal constant-returns-to-scale production function in capital (endogenous) and effective labor (exogenous) will be inversely related to r^K.[9] The three equations determining the steady state are:

Steady state equations:

$$(24)\quad a^K(r^K, r^B, r^H, \tau) = k(r^K) = k \qquad \text{Capital, Equities}$$

$$(25)\quad a^B(r^K, r^B, r^H, \tau) = \frac{\gamma^B(s-\tau)}{g-\gamma^B r^B-\gamma^H r^H} = b \qquad \text{Bonds}$$

$$(26)\quad a^H(r^K, r^B, r^H, \tau) = \frac{\gamma^H(s-\tau)}{g-\gamma^B r^B-\gamma^H r^H} = h \qquad \text{Base Money}$$

Their sum, a long-run "IS" relation, is

$$(27)\quad a^W(r^K, r^B, r^H, \tau) = k(r^K)+\frac{s-\tau}{g-\gamma^B r^B-\gamma^H r^H} \qquad \text{Wealth}$$

Simple as system (24) - (26) looks, it leaves open a variety of possible relations between endogenous variables and policy parameters. Particular interest, of course, attaches to r^K because of its link to capital intensity, labor productivity, consumption per capita, and real wages. In the comparative statics of steady states, "expansionary" policies - high s, low τ, and high γ^H — may be associated with lower r^H (more inflation) and with lower r^K and higher capital intensity k. Or the steady state association ofpolicies and results may be quite the opposite.

The formal reason for these ambiguities is that the "gross substitutes" property, though assumed for the a^J functions, does not guarantee a dominant-diagonal Jacobian matrix. For example, in the H equation of (24) an increase of r^H raises the demand for base money on the left hand side. But it also raises the supply, by diminishing the denominator on the right hand side - and perhaps by more than the demand. For a similar reason the diagonal entry in the Jacobian might be negative in the B row.

The major possibilities can be illustrated graphically, though with some loss of generality, by aggregating b+h and plotting their sum d against r^D, the weighted average defined above. This is done in Figures 1 and 2, where the rectangular hyperbola d_s is the "supply" of d, equal to $(s-\tau)/g-r^D)$. Now imagine that r^B and r^H affect a^K only as they affect r^D; this special assumption is necessary for the graphical illustration. For any r^D, the K equation can then be solved for r^K, which will be positively associated with r^H. The corresponding k can be added to ds to obtain w. Now r^k, together with the r^B and r^H that make up r^D, determines a^B and a" in the second and third equations. Their sum is the demand for public debt, a^D. In an equilibrium a^D and d_s must be equal, as at a point labelled E. In the bottom panels of the figures r^K is plotted against r^D. The r^K associated with k equal to w-d_s is r^K_S, and the r^K associated with w-a^D is r^K_a.

[9] Pre-tax. I do not discuss here the taxation of capital income, but it could be analyzed by putting after-tax rates of return in the a^J functions and taking account also of the effects of taxation on risk, mentioned above.

They are equal in the equilibrium E. Expansionary policies raise r_S^K, but what that does to equilibrium r^k differs in the two cases.

Figure 1 is the analog of what I called in the short-run analysis the standard case, associated with a dominant-diagonal Jacobian. The demand effects of own-rates exceed the supply effects. Clearly an increase in s-t, raising the d_s hyperbola as indicated by the arrows raises r^D and r^K. Greater deficit spending "crowds out" capital, and part of the mechanism is *lowering* the inflation rate. It is quite possible that an increase in γ^H, greater monetization of deficits, works in the same directions; assuming r^H is less than r^D, one of its effects too is to shift d_s to the left.

The stability of the equilibrium in Figure 1 is another question, which I must leave open. Skepticism of its stability arises not only from intuition but from the same model's short-run conclusion that the same policies are inflationary and may increase capital investment. Resolution of the apparent paradox would presumably require a rational expectations explanation of the price level, with economic agents foreseeing the steady state and internalizing the transversality conditions.

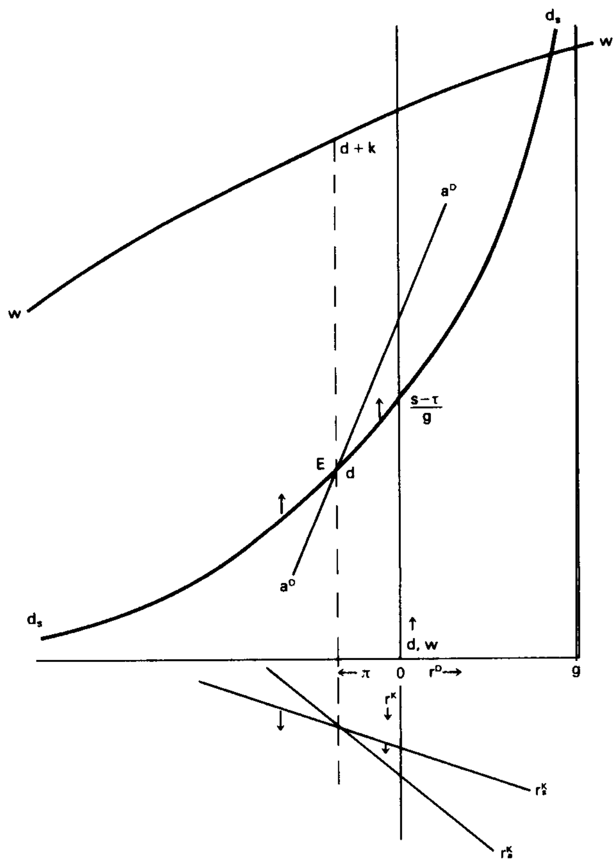

Figure 1. Steady State Equilibrium of Government Debt and Capital And Their Rates of Return (Standard Case)

The alternative, Figure 2, shows a^D flatter than d_s. Here the same "expansionary" policies raise the inflation rate and "crowd in" capital, which replaces less attractive public debt. Here the demands for money and bonds are less responsive to rates of return; perhaps paradoxically, Figure 2 pictures the more monetarist world. Still another possibility, shown by the dashed a^D curve in Figure 2, is that there is no steady state equilibrium at all. The deficit S-T is so high that there is no r^D at which the supply of debt will be held in competition with capital. This is a recipe for hyper-inflation.

In the United States total federal debt is about 24% of GNP, 6% base money plus 18% non-monetary debt, implying $\gamma^H = 1/4$ and $\gamma^B = 3/4$. With inflation of 10% per year and nominal interest rates on debt instruments around 14%, r^D is 0.5%. Assuming a natural growth rate of 2.5%, g-r^D is 2%. Implicit in these numbers is a steady-state budget deficit (exclusive of debt interest) of 0.48% of GNP. Thus d_s would double to 48% by a 100 basis point rise in r^D. Since it seems unlikely that demand a^D would rise as much, Figure 2 applies.

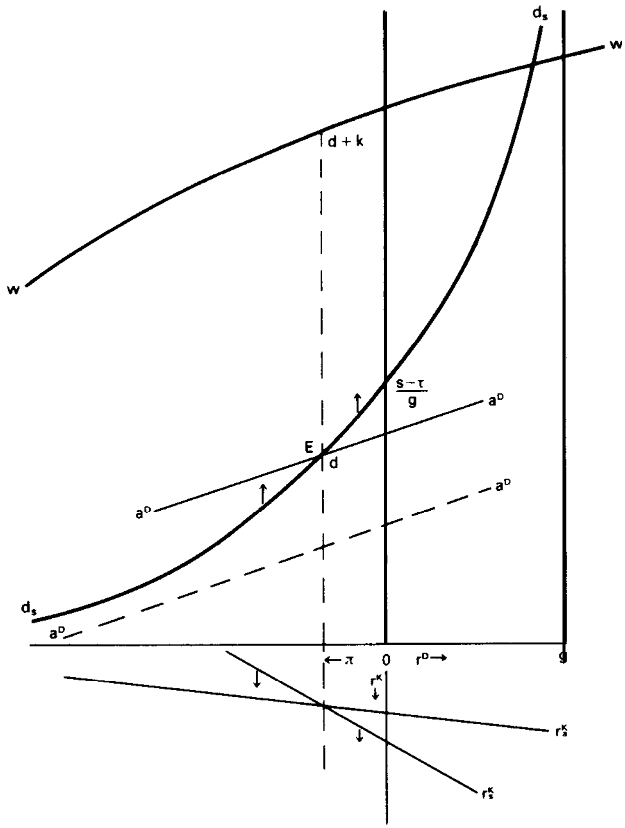

Figure 2. Steady State Equilibrium of Government Debt and Capital And Their Rates of Return (Non-standard Case).

In any case, financial policies are not neutral in the long run any more than in the short run. The variation of r^K and capital intensity across steady states violates "super-neutrality," i.e., invariance of real outcomes to the rate of inflation. Since inflation is the inverse of a real interest rate, this is scarcely surprising. In the background is the competition between capital and public debt for allocation of limited wealth. Such competition might not occur for consumers with infinite horizons, who would accumulate capital and every other asset until each of their yields equals a constant time preference rate. In contrast, savers with horizons of lifetimes or other finite periods will have finite demands for wealth and for every asset at any given rates of return (Tobin and Buiter, 1980, pp. 98-103).

Paul Samuelson showed in his 1958 parable of overlapping generations that unassisted competitive markets do not necessarily attain socially optimal or even Pareto-optimal equilibria when mortal households cannot trade with each other across time. The insight reinforces Keynes's observation of the difficulties of market coordination without futures markets and helps to explain their absence.

Macro-economic market failures make it possible that government financial interventions can improve welfare, but they by no means guarantee that actual policies will do so. The focus of my lecture has been on the ways fiscal and monetary policies alter macro-economic outcomes in the short and the long run. I have not considered the optimal design of policies, or the optimal rules of government intervention in response to shocks that disturb the economy's path. Those are important items of unfinished business on the agenda of monetary theory and macro-economics.

EQUATIONS

(1) $S = I+D+CAS$ — National income identity

(2) $Y = C+I+G+CAS$ — National income identity

(3) $I_t = q_t^K \Delta K_t = q_t^K K_{t-1} f(q_t^K)$ — Investment function

$$\text{where } \Delta K_t + \delta K_{t-1} \geqslant 0$$
$$f(1) = g$$
$$f'(q_t^K) \geqslant 0$$
$$0 < f^{-1}(-\delta) < 1$$

(4) $pD = pG(\cdot) - pT(\cdot) + B_{-1} - e\rho^F \cdot {}_G F_{-1}$ — Government deficit

(5) $pD = \Delta H + q^B \Delta B - e\Delta_G F$ — Government deficit

$$\left.\begin{array}{ll} (6) & \Delta H = \gamma^H pD + z^H \\ (7) & q^B \Delta B = \gamma^B pD + z^B \\ (8) & -e\Delta_G F = z^F \end{array}\right\} \begin{array}{r} 0 \leqslant \gamma^H, \gamma^B \leqslant 1 \\ \gamma^H + \gamma^B = 1 \\ z^H + z^B + z^F = 0 \end{array}$$

(6) Supply of base money

(7) Supply of bonds

(8) Supply of foreign currency assets by government

$$(9)\quad e\Delta F + e\Delta_G F = pX(\cdot) + e\rho^F F_{-1} + e\rho^F \cdot {}_G F_{-1}$$

Balance of payments

$$(10)\quad e\Delta F = pX(\cdot) + e\rho^F(F_{-1} + {}_G F_{-1}) + z^F = pCAS + z^F$$

Supply of foreign currency assets to public

Demand = supply equations:

$$(11)\quad A^K(\cdot) - q^K K_{-1} = q^K K_{-1} f(q^K)$$

Equities market

$$(12)\quad A^B(\cdot) - q^B B_{-1}/p = \gamma^B D + z^B/p$$

Bond market

$$(13)\quad A^F(\cdot) - eF_{-1}/p = X(Y, ep^F/p) + e\rho^F(F_{-1} + {}_G F_{-1})/p + z^F/p$$

Foreign-currency assets market

$$(14)\quad A^H(\cdot) - H_{-1}/p = \gamma^H D + z^H/p$$

Base money market

$$(15)\quad A^W(\cdot) - W^{\bullet}_{-1} = q^K K_{-1} f(q^K) + D + X(Y, ep^F/p) + e\rho^F(F_{-1} + {}_G F_{-1})/p$$

Total wealth

$$(16)\quad D = G - T(Y) + B_{-1}/p - e\rho^F \cdot {}_G F_{-1}/p$$

Deficit defined

$$(17)\quad q_t^K(1 + r_t^K) = R_t(Y_t, K_{t-1}) + Eq_{t+1}^K$$

Equities, price and rate of return

$$(18)\quad q_t^B(1 + r_t^B) = (1 + Eq_{t+1}^B)(p_t/Ep_{t+1})$$

Bonds, price and rate of return

$$(19)\quad e_t(1 + r_t^F) = (1 + p_t^F)Ee_{t+1}(p_t/Ep_{t+1})$$

Foreign currency assets, price and rate of return

$$(20)\quad 1 + r_t^H = p_t/Ep_{t+1}$$

Base money, rate of return

$$(21)\quad \begin{array}{c} \begin{bmatrix} + & - & - & +(?) \\ - & + & - & + \\ - & - & + & + \\ - & - & - & + \end{bmatrix} \\ \begin{matrix} + & + & + & + \end{matrix} \end{array} \begin{bmatrix} dr^K \\ dr^B \\ dr^F \\ dY \end{bmatrix} = \begin{array}{c} \begin{bmatrix} 0 & -A_T^K & 0 & 0 & 0 & + \\ +\gamma^B & -A_T^B - \gamma^B & +D & 1/p & 0 & + \\ 0 & -A_T^F & 0 & 0 & 1/p & + \\ +\gamma^H & -A_T^H - \gamma^H & -D & -1/p & -1/p & - \end{bmatrix} \\ \begin{matrix} +1 & -A_T^W - 1 & 0 & 0 & 0 & - \end{matrix} \end{array} \begin{bmatrix} dG \\ dT \\ d\gamma^B \\ dz^B \\ dz^F \\ dr^H \end{bmatrix}$$

Comparative statics

$$(22)\quad \begin{cases} \gamma^B(s - \tau + (r^B + \pi)b)Yp = bYp(g + \pi) \\ \gamma^H(s - \tau + (r^B + \pi)b)Yp = hYp(g + \pi) \end{cases}$$

Steady state supplies of bond and base money

$$(23)\quad b = \frac{\gamma^B(s - \tau)}{g - \gamma^B r^B - \gamma^H r^H}, \qquad h = \frac{\gamma^H(s - \tau)}{g - \gamma^B r^B - \gamma^H r^H}$$

Solution of (22)

Steady state equations: Capital, Equities

$$(24)\quad a^K(r^K, r^B, r^H, \tau) = k(r^K) = k$$

(25) $a^B(r^K, r^B, r^H, \tau) = \dfrac{\gamma^B(s-\tau)}{g-\gamma^B r^B - \gamma^H r^H}$ Bonds

(26) $a^H(r^K, r^B, r^H, \tau) = \dfrac{\gamma^H(s-\tau)}{g-\gamma^B r^B - \gamma^H r^H}$ Base Money

(27) $a^W(r^K, r^B, r^H, \tau) = k(r^K) + \dfrac{s-\tau}{g-\gamma^B r^B - \gamma^H r^H}$ Wealth

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SYMBOLS

Y	real net national product
S	real private saving
I	real net capital investment (including adjustment costs)
D	real government deficit
C	real private consumption
G	real government purchases of goods and services
T	tax revenues net of transfers, real
CAS	real current account surplus
K	capital stock, real
B	stock of bonds, nominal, measured by coupon payments per period
H	stock of high-powered (base) money, nominal
F	stock of foreign currency assets, privately owned, nominal in foreign currency
G^F	stock of foreign currency assets publicly owned, nominal in foreign currency
W	private net worth, real
p	commodity price
$p\,G^F$	foreign commodity price, in foreign currency
e	exchange rate: domestic currency price of a unit of foreign currency
q^k	ratio of market price of equities to standard replacement cost of a unit of capital
q^B	nominal price of a bond paying $1 per period in perpetuity
γ^B	fraction of deficit financed by selling bonds
γ^H	fraction of deficit financed by issuing base money
z^J	(J = B, F, H) additional government sale or issue of asset J, nominal
ϱ^F	interest rate on foreign-currency assets, in foreign currency
r^J	(J = B, F, H) real one period expected return on asset J
X	trade surplus
g	natural growth rate
δ	capital depreciation rate
A^J	(J = K, B, F, H) demand for asset J at end of period, real
R	earnings per unit of capital, real
x or x_t	value of a variable x in period t
x_{-1} or x_{t-1}	value of x in period t- 1
Ex_{+1} or Ex_{t+1}	expected value of x in period t + 1
Δx or Δx_t	$x_t - x_{t-1}$
s	steady state G/Y
τ	steady state T/Y
k	steady state K/Y $\quad a^k$ steady state demand for k
b	steady state $q^B B/pY$ $\quad a^b$ steady state demand for b
h	steady state H/pY $\quad a^h$ steady state demand for h
w	steady state W/Y $\quad a^w$ steady state demand for w
r^D	average real interest rate on government debt, $\gamma^B r^B + \gamma^H r^H$
d	$b+h$
π	inflation rate $\quad \frac{dp}{dt}\cdot\frac{1}{p} = -r^H$