FEDERAL RESERVE BANK OF ST. LOUIS

AUGUST 1978

REVIEW

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Vol. 60, No. 8

Oil Imports and the Fall of the Dollar

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> . . . the cost of foreign oil to the U.S. economy — $45 billion this year, contributing to an estimated $30 billion trade deficit — is weakening the dollar's value overseas and causing fresh concern about future U.S. economic stability.[1]

The above is one of many similar statements made during the past year reflecting the widely held belief that oil imports are *the cause* of the fall in the value of the dollar. Since imported oil in 1977 was the largest single component of total U.S. merchandise imports, the assertion is superficially plausible. However, a slightly more wide-ranging look at the facts provides substantial evidence that this contention is incorrect.

Oil Imports Abroad

How much oil do other countries import? Certainly most Western countries import less oil than does the United States, but that is not surprising, since the United States is the largest economy in the West. In comparing oil imports across countries, these imports should be related to the size of each economy. Such a comparison reveals what fraction of the income from domestic production is being used to keep the country supplied with imported oil, thereby relating oil expenditures to what is actually available to be spent.[2] The results of relating expenditures on oil to the level of national income for the United States, Germany, and Japan are shown in Table I. It is immediately clear that the United States imported *less* oil as a percentage of its Gross National Product than either Germany or Japan in each year from 1970 through 1977. And yet the currencies of both Germany and Japan have appreciated, not only against the U.S. dollar, but also against almost every other currency in the world! (In 1977, the Deutsche mark rose by 11.3 percent against the dollar and by 7.0 percent against an average of currencies, while the yen rose by 20.8 percent against the dollar, and by 19.2 percent against an average of currencies.)

The simple relationship that is often suggested between large oil imports and a weak currency plainly is hard to reconcile with these facts. To see why this is so, it is necessary to examine the composition of the balance of payments in some detail.

The Balance of Payments, the Supply and Demand for Currency, and the Exchange Rate

The balance-of-payments accounts of each country summarize its transactions with the rest of the world. These transactions can be subdivided in many ways. For present purposes it is most useful to separate them into three groups — the current account, which comprises the balance of trade and unilateral transfers, that is, gifts to foreigners; the capital account, which comprises capital movements for investment

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[1]Harry B. Ellis, "Congress Imperils Oil-Cut Plan," *Christian Science Monitor,* October 11, 1977.

[2]This is the same kind of comparison one makes, for example, when determining whether a person's debts are too large. One looks not just at the debts, but at the debts relative to assets and income; only in that way can one calculate what the person can afford.

Table 1

OIL IMPORTS: AN INTERNATIONAL COMPARISON
Total Oil Imports as a Percent of GNP

	1970	1971	1972	1973	1974	1975	1976	1977
U.S.	0.3%	0.3%	0.4%	0.6%	1.7%	1.6%	1.8%	2.2%
Germany	1.3	1.5	1.3	1.6	3.3	2.8	3.1	2.9
Japan	1.1	1.3	1.3	1.5	4.2	4.0	3.8	3.4

Source: International Monetary Fund

purposes by both the private sector and the government; and the intervention account, which comprises official movements of funds effected with the intention of influencing exchange rates.

The balance of trade includes all transactions in goods and services between a country and the rest of the world. All receipts from the sale of goods and services abroad are summed, all expenditures by a country's residents (including industry and government) on foreign goods and services are then subtracted, and the resulting total is the balance of trade. It can be positive (if receipts exceed expenditures), negative (if expenditures exceed receipts), or zero. Expenditures on imported oil appear in this part of the balance-of-payments accounts. In 1977, the United States was in deficit on its trade account with the rest of the world — that is, expenditures exceeded receipts — by some $10.5 billion.[3]

The United States must pay for this excess of expenditures over receipts in exactly the same way that an individual pays for expenditures which exceed receipts. The country can either sell its assets or borrow. These transactions are summarized in the capital account, which is subdivided between private and official capital movements. Capital movements for investment purposes are from one economy to either the private or the government sector of another economy. When someone buys securities from, or lends money to, a U.S. resident (including businesses and the U.S. Government) this transaction is called a capital inflow. The converse transaction is called a capital outflow. The former is an inflow because it provides funds which can be spent, and the latter is an outflow because it is a way of disposing of funds.

Since different countries use different currencies, a country with a deficit on its trade account (like the United States last year) has spent more foreign currency on foreign goods than it has received from foreigners. In other words, foreigners want less U.S. currency than the amount U.S. residents want to trade for *foreign* currency. The quantity of U.S. currency supplied (the amount U.S. residents want to spend) exceeds the quantity demanded (the amount foreigners want to buy) at the existing price of the currency on the foreign exchange market.[4] When the quantity supplied exceeds the quantity demanded, price falls (the currency depreciates). This has the effect of decreasing the quantity supplied and increasing the quantity which is demanded; only when the two are equal — when the amount people want to supply equals the amount that people demand at the current price — is there no further change in price.

But while a trade deficit clearly does indicate that U.S. residents want to spend more dollars on foreign goods than foreigners wish to acquire to spend on U.S. goods, that does not mean that the *total* amount of U.S. dollars supplied on exchange markets exceeds the quantity demanded. This is because, as noted above, U.S. dollars can be both demanded and supplied for reasons other than trading in goods and services.

If foreigners wish to invest in the United States, they must acquire dollars. Similarly, if U.S. residents wish to invest outside the United States, they must acquire foreign currency. These capital movements provide both a source of supply and a source of demand for U.S. dollars on the foreign exchange market. It is quite possible, therefore, for a deficit in the trade account, which would lead by itself to an excess supply of dollars, to be fully offset by such capital flows.[5] *Thus, there is no necessary connection between a trade deficit and a depreciating currency.*

[3]The figure reflects the June 22, 1978, change in the presentation of the balance-of-payments accounts. Unilateral transfers totalled $4.7 billion in 1977, resulting in a current account deficit of $15.2 billion.

[4]The foreign exchange market is where currencies are traded. It is not a single location, but a network of traders all around the world.

[5]It can also be more than offset, so that the United States would either have an appreciating currency or an increase in its international reserves.

What if, at the prevailing exchange rate, there is still an excess supply of a currency when *both* the trade account (plus unilateral transfers) and the capital account are considered? It is here that the official intervention account can become important. An excess supply of a currency can be removed by governments using other currencies to purchase the excess quantity, thus preventing its price from falling. This is what is called *official intervention* in foreign exchange markets.[6]

The important point to remember is that a deficit in the trade account does not necessarily cause a currency to depreciate. The excess supply of a currency which a trade deficit by itself implies can be offset by capital movements or official intervention to support the exchange rate, or both.

The U.S. Payments Position in 1977

The United States ran a $35.2 billion balance-of-payments deficit in 1977.[7] Even after substantial official exchange market intervention by several countries to buy dollars, the foreign exchange value of the dollar fell. This implies that the quantity of U.S. dollars supplied on foreign exchange markets exceeded the quantity demanded; consequently, the price fell, reducing quantity supplied and increasing quantity demanded.

To repeat, recognizing that foreign currency values (or, in the presence of official intervention, reserve flows) are determined by the balance of supply and demand, just as is any other price, involves in turn recognizing that the U.S. dollar's value must have fallen because the dollar was in excess supply at the original exchange rate.

Now, every component of U.S. imports contributes to the supply of dollars on the foreign exchange market; hence, if one is to look at imports, there is no particular reason to look only at oil. But, more to the point, the above analysis of the balance of payments shows that any balance-of-payments position other than exact balance (on trade and capital accounts combined) implies an excess supply of one currency relative to those of the rest of the world.[8]

If the U.S. money stock, for example, exceeds the amount people are willing to hold given the structure of interest rates and income levels — that is, there is an excess supply of money — then people will increase their spending as they attempt to reduce their holdings of money to desired levels. Spending on foreign goods, services, and securities, as well as domestic spending, will rise. As a result, the amount of dollars supplied on the foreign exchange market will increase. If the excess supply of money in the United States is greater than excess supplies of money in other countries, then the quantity of dollars supplied on the foreign exchange market will increase *relative to* quantities of other currencies supplied. Thus, the price of the dollar in terms of other currencies (its exchange rate) will come under downward pressure.

Eventually, if U.S. monetary growth does not continue to accelerate relative to any excess money growth abroad, movement toward equilibrium in both the domestic money market and the foreign exchange market will be accomplished as the U.S. price level rises and the foreign exchange value of the dollar declines. However, should the U.S. excess money supply continue increasing relative to that abroad, the foreign exchange value of the dollar will continue to fall; or, if there is intervention in the exchange market by central banks, a continuing balance-of-payments deficit will result.[9]

So far it has been shown that a balance-of-payments deficit (or depreciating currency) must imply excess monetary growth (relative to any excess money growth there may be abroad) in the country whose exchange rate is depreciating. Can oil imports cause such an excess?

Oil Imports and Excess Money

The comparison between the United States and other countries made at the beginning of this article shows that oil imports do not have to cause excess monetary expansion, and hence an excess supply of dollars on the foreign exchange market. (The

[6]It can be seen from the above description that government capital movements for some reason other than to support the exchange rate have been classified with private sector transactions.

[7]"Balance of payments" is defined here as all international transactions excluding changes in official reserves.

[8]This point was made explicitly by David Hume in 1752 ["Of the Balance of Trade," *David Hume: Writings on Economics*, ed. Eugene Rotwein (Madison: University of Wisconsin Press, 1970), pp. 60-77]. In this century, it is associated particularly with the work of Harry G. Johnson, for example, "The Monetary Approach to Balance-of-Payments Theory," in *The Monetary Approach to the Balance of Payments*, ed. Jacob A. Frenkel and Harry G. Johnson (London: George Allen and Unwin Ltd., 1976), pp. 147-67.

[9]If the excess money growth is not restrained, interest rates will rise as inflation accelerates. If, on the other hand, the excess money growth *is* held back, then the dollar will stop falling and there will be no upward trend in interest rates.

Deutsche mark and yen have certainly not been depreciating on the foreign exchange market.) But it is useful also to look at the actual data on oil imports into the United States, and how the revenue which accrued to non-U.S. residents as a result was spent.

The value of oil imports has indeed accounted for a substantial proportion of merchandise imports since the price increases of 1974. In 1977, for example, the value of oil imports totalled $45 billion, amounting to 30 percent of total U.S. merchandise imports. But the U.S. balance-of-trade deficit with oil-exporting countries was only $16.9 billion in 1977.[10] That it was substantially less than U.S. expenditures on oil shows that the oil producers spent considerable amounts on U.S. goods and services. Furthermore, oil-exporting countries' net purchases of U.S. corporate stocks and bonds and U.S. Government securities were about $7 billion during 1977.[11] Oil-exporting countries' holdings of U.S. commercial bank deposits also increased by about $400 million during the past year. These capital inflows offset about 45 percent of the 1977 U.S. balance-of-trade deficit with oil exporting countries.[12]

Reduction (or elimination) of oil imports certainly would not produce an equal reduction in (or eliminate) the current U.S. balance-of-trade deficit. To the extent that dollars earned from oil exports to the United States are used to purchase U.S. goods, services, and securities, the balance-of-payments effects of rising oil imports by the United States are offset. To reduce the U.S. balance-of-trade deficit by reducing the amount of oil imports would require oil-exporting countries to maintain both their current purchases of U.S. goods and their current rate of investment in the United States, despite a fall in their earnings. It is hard to imagine that countries would continue to both spend and invest as they now do when faced with a substantial drop in income. Reducing U.S. oil imports would therefore almost certainly reduce both U.S. exports and capital inflows into the United States.[13]

Furthermore, consider what would happen to other components of U.S. expenditures if oil imports were suddenly cut off and there were no cutback to excess money growth in the United States. U.S. residents would wish to spend the money that was previously spent on oil. Some of it would be spent on other imports. Some would be spent on goods that had previously been exported. There would be increased demand for goods which had been previously produced and consumed domestically. This would divert to the production of these goods resources previously used elsewhere, and would thereby further reduce U.S. exports and increase U.S. imports. Some of the money would be used to purchase capital assets abroad. And, of course, some of the money would be used to purchase capital assets in the United States, which would raise their price and reduce the rate of interest, thereby, in turn, reducing the inflow of capital from abroad.

A cutback on oil imports without a cutback on excess money growth in the United States (relative to any excess money growth there may be abroad) could not have a marked effect on the U.S. balance of payments or the foreign exchange value of the dollar. And, of course, if U.S. money growth *were* cut back sufficiently to eliminate the excess supply of dollars on the foreign exchange market, then the slide in the dollar's foreign exchange value would end without any misguided and welfare-reducing attacks on individual components of U.S. foreign trade.[14]

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[10]This figure does not reflect the presentational change in the balance-of-payments accounts of June 22, 1978. If it were possible to make this presentational change, the above U.S. bilateral trade deficit with the oil exporting countries would be reduced sharply.

[11]Direct foreign exchange market intervention by the members of OPEC is negligible. Thus, purchases of U.S. Government securities by OPEC governments presumably reflect investment decisions, rather than the results of exchange market intervention.

[12]A detailed account of U.S. transactions with OPEC can be found in Christopher L. Bach, "OPEC Transactions in the U.S. International Accounts," *Survey of Current Business* (April 1978), pp. 21-32. It should be noted that had prices risen as they have done in the United States without a fall in the foreign exchange value of the dollar, OPEC members would probably have spent less in the United States than they actually did, since U.S. goods and capital assets would have been more expensive, relative to those in the rest of the world, than they now are.

[13]It may perhaps be argued that the U.S. "oil deficit" has produced *expectations* of a falling U.S. dollar, and hence a flight from the dollar to other currencies, but this cannot be reconciled with the strength of the Deutsche mark and Japanese yen — Germany and Japan have *larger* "oil deficits," relative to the size of their economies, than does the United States. The argument that the "oil deficit" has produced the fall of the dollar through its effect on expectations is therefore not persuasive.

[14]The oil price increases would have had a minor effect on the value of the U.S. dollar to the extent that the price increases reduced real income in the U.S. See Robert H. Rasche and John A. Tatom, "The Effects of the New Energy Regime on Economic Capacity, Production, and Prices," this *Review* (May 1977), pp. 2-12. This fall in real income would reduce the demand for money, and thus produce an *excess* supply of dollars without any change in the quantity supplied. But there are two reasons why oil imports cannot, via that route, be blamed for the fall in the

Summary and Conclusions

The increasing value of U.S. oil imports has not "caused" the U.S. balance-of-payments deficit and the declining foreign exchange value of the dollar. Oil-exporting countries' purchases of U.S. goods and services and their investment in the United States have offset, to a large extent, the balance-of-payments effects of rising oil imports. Thus, policies directed toward reducing oil imports will have little effect on the current trend of the dollar's declining foreign exchange value. Further, the primary determinant of the 1976-77 deficits was not "an insatiable appetite" for foreign oil. Balance-of-payments deficits and weak currencies are monetary phenomena, resulting from excess money growth in the country with the deficit relative to money growth abroad.

value of the dollar. First, when that excess supply had been disposed of, the dollar would stop falling, and there would not be the sustained slide we have seen since early 1977. Second, the Federal Reserve, should it have chosen to do so, could have reduced the money stock so as to eliminate that excess.

An Explanation of Movements in the Labor Force Participation Rate, 1957-76

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As the economy has moved through recession and into the recent period of recovery, the unemployment rate, an important consideration in economic stabilization policy, has displayed a different pattern from that which had been observed in such cycles before 1973. In particular, the average level of the unemployment rate has remained uncharacteristically high for such an extended period of expansion. One reason often cited for this development is an unusual increase in the labor force participation rate since 1973. This ratio, which measures the proportion of the population of labor force age who either have a job or are looking for one, has risen markedly.

The participation rate decreased from I/1957 to IV/1964 and subsequently rose through the period ending IV/1976. Since considerable time is required to identify a change in trend, analysis of labor market conditions, for some time after 1964, did not take into consideration the reversal in the trend of the participation rate.

This study develops a theoretical model of the behavior which determines labor force participation. Parameters of the model are estimated and used to explain the observed movements in the labor force participation rate from 1957 to 1976.

A FREQUENTLY USED EXPLANATION

A prominent and widely accepted explanation of the labor market behavior of individuals is based on an analysis of the relative strengths of the "discouraged worker" and the "additional-worker" effects.[1] The discouraged worker effect involves a negative relationship between the labor force participation rate and the unemployment rate, while the additional worker effect involves a positive relationship.

Empirical evidence has been presented which indicates that the discouraged worker effect is dominant and, therefore, on balance, there is a negative relationship between the labor force participation rate and the unemployment rate. William G. Bowen and T. Aldrich Finegan, in an extensive study of the factors influencing the labor force participation rate, concluded that their cross-sectional findings ". . . raise serious doubts whether the additional-worker effect dominated the participation response of *any* demographic group, regardless of how narrowly it might be defined."[2] Several studies using time series

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[1]The discouraged worker effect is based on the postulate that decisions to enter or leave the labor market are influenced to a major extent by the "availability" of jobs. An increase in job availability, as indicated by a general decline in the unemployment rate, induces individuals to enter the labor market; a decrease in job availability causes unemployed workers to become discouraged and to leave the labor market. The additional worker effect is based on the postulate that a rise in general unemployment induces additional workers from each household to enter the labor market in an attempt to maintain household income.

[2]William G. Bowen and T. Aldrich Finegan, *The Economics of Labor Force Participation* (Princeton: Princeton University Press, 1969), p. 487. Using time series data, however, the authors reported that, ". . . we have found no convincing evidence in the postwar record that short-period changes in the overall rate of unemployment have had a large impact on the labor force participation rate of any population group other than teenagers and possibly males 65+" [p. 515]. But,

data have also found evidence supporting such a conclusion.[3]

Labor market behavior of individuals since 1973, however, has not been consistent with the implications of the above mentioned research findings. During the last recession, the labor force participation rate remained scarcely unchanged, despite a marked rise in the unemployment rate which began in late 1974. The discouraged worker hypothesis would have predicted a fall. Then, when the unemployment rate fell only moderately following the trough of the recession, the participation rate rose sharply; whereas, the results of these studies would imply a significantly smaller increase. Also, the participation rate is currently at a higher level, for the prevailing level of the unemployment rate, than would be indicated by historical relationships. Recent experience thus casts serious doubts on the validity of the discouraged worker explanation of movements in the labor force participation rate.

AN ALTERNATIVE EXPLANATION

Since the late 1960s, several studies of labor market behavior have taken into consideration the influence of such economic factors as changes in the real wage rate and nonlabor real income on the decisions of individuals to offer hours of work in the labor market.[4] The model developed in this study proceeds along similar lines.

This article consists of two parts. The first part develops a model of the overall labor force participation rate and is directed to those readers who are interested in the underlying economic theory and econometric procedures. The general reader may proceed directly to the second part which uses the model to analyze the factors influencing the participation rate from 1957 to 1976.

SUMMARY OF FINDINGS

The model relates the current period overall labor force participation rate to: current period nonlabor real income per household (income received from assets and Social Security benefits); the average real wage rate; the average effective personal income tax rate; the average effective personal Social Security tax rate; the ratio of total population to population of labor force age (16 years and over); and the previous period's participation rate. The effect of each of the first five variables is decomposed into two components. The first one, a permanent component, is the level expected to prevail in the long run. The second one, a transitory component, is the difference (in the current period) between the actual and permanent level. The lagged participation rate reflects the length of time over which perceptions regarding the permanent levels of the first four variables are formed.

Statistical estimates of the response of the current period aggregate labor force participation rate for the sample period 1957 to 1976 indicate that this rate is negatively related to the transitory components of nonlabor real income per household, the average real wage rate, and the average effective personal income tax rate. The estimates also indicate negative responses to the permanent components of nonlabor real income per household and the ratio of total population to population labor force age, and a positive response to the permanent component of the average effective personal Social Security tax rate. The response of the participation rate to the permanent component of the average real wage rate changed from negative to positive after 1964. The responses with regard to the transitory components of the average effective personal Social Security tax rate and the ratio of total population to population of labor force age and to the permanent component of the average effective personal income tax rate were found to be zero.

There are two types of movements in the aggregate labor force participation rate to be explained. One type is the long-run trend which is related to changes in the permanent component of each variable. The

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they prefaced, "In the light of the intrinsic limitations of time series regressions . . . , it is difficult to place much confidence in the precise numerical results of these regressions."

[3]Thomas Dernburg and Kenneth Strand, "Cyclical Variation in Civilian Labor Force Participation," *Review of Economics and Statistics* (November 1964), pp. 378-91; Peter S. Barth, "Unemployment and Labor Force Participation," *Southern Economic Journal* (January 1968), pp. 375-82; Alfred Tella, "The Relation of Labor Force to Employment," *Industrial and Labor Relations Review* (April 1964), pp. 454-69; George L. Perry, "Potential Output and Productivity," *Brookings Papers on Economic Activity* (1:1977), pp. 11-47.

[4]Bowen and Finegan in their cross-sectional study did include many economic factors, along with the unemployment rate and various demographic considerations. They, however, treated the discouraged worker effect as being independent of strictly economic influences. Also see the seven studies reported in Glen G. Cain and Harold W. Watts, eds., *Income Maintenance and Labor Supply: Econometric Studies* (New York: Academic Press, 1973); Michael L. Wachter, "A Labor Supply Model for Secondary Workers," *Review of Economics and Statistics* (May 1972), pp. 141-51; and Robert E. Lucas, Jr. and Leonard A. Rapping, "Real Wage Rates, Employment, and Inflation," *Journal of Political Economy* (September/October 1969), pp. 721-54.

other type is the short-run variations around the trend which are related to the transitory components and to the lag in the formation of the perceived levels of the permanent components.

Three subperiods were used to analyze movements in the aggregate labor force participation rate over the 1957-76 period. The first subperiod is 1957 to 1964, a period in which the trend of the participation rate was negative. The second one is 1965 to 1973, when the trend changed to positive. The third one is 1974 to 1976, the period cited in the introduction as providing evidence casting doubt on the validity of the commonly used discouraged worker explanation of movements in the labor force participation rate.

An analysis of the relative contribution of each factor to movements in the aggregate labor force participation rate indicates that trend influences tended to dominate in the first two subperiods. The major trend influence in the 1957-64 subperiod was the rise in the permanent average real wage rate. In the 1965-73 subperiod the major trend influence was the rise in the permanent average effective personal Social Security tax rate. In the last subperiod (1974-76), movements in the aggregate participation rate were dominated by transitory movements in the average real wage rate, nonlabor real income per household, and the average effective personal income tax rate.

PART I: MODEL OF LABOR FORCE PARTICIPATION

The model of aggregate labor force participation developed here uses time series data but incorporates many of the features found in previous studies which used cross-sectional data. The time series approach was selected to allow for an analysis of disequilibrium conditions. Such an analysis is not possible using the usual cross-sectional approach, because that approach applies only to data at a given point in time. An important feature of the cross-sectional studies, which this model incorporates, is the labor force participation behavior of individuals as members of households. Within the household context, the decisions of individual members of a household to participate or not are highly interrelated. Previous time series studies of labor force participation have generally tended to omit such interrelationships.[5]

[5]For examples of cross-sectional studies which incorporate interrelationships among household members regarding their labor force participation (or number of hours offered for work), see Bowen and Finegan, *The Economics of Labor Force Participation,* and Orley Ashenfelter and James Heckman, "The Estimation of Income and Substitution Effects in a Model of Family Labor Supply," *Econometrica* (January 1974), pp. 73-85. For examples of time series studies which do not take into consideration interrelationships among members of households see Lucas and Rapping, "Real Wage Rates, Employment, and Inflation;" Wachter, "A Labor Supply Model of Secondary Workers;" and Ray C. Fair, "Labor Force Participation, Wage Rates, and Money Illusion," *Review of Economics and Statistics* (May 1971), pp. 164-68.

Definitions

An individual of *labor force age* is one who is 16 years old or over. The term *household* is defined as a single individual or a group of individuals who share (1) the total real income (after taxes) received by the group, (2) the amount of the total time of all members of labor force age allocated to such strictly intragroup activities as housekeeping, and (3) the group's jointly formed perceptions regarding the permanent levels of such factors as the household's total real income. *Total real income* consists of real wages received by employed members of the household, and nonlabor real income, which consists of real earnings from assets and Social Security payments. *Available time* is an individual's total number of hours in the current period less a pro rata share of the total number of hours of all members of the household of labor force age which are allocated to such activities as the direct production of goods and services for household consumption. It is presumed that there are both *permanent* and *transitory* components of all factors influencing labor market participation in the current period.[6] The permanent component is the level of a factor anticipated to prevail in the long run. The transitory component is the difference between the actual experience in the current period and the permanent component.

Labor Force Participation — Individual Members of a Household

The model used in this study of the factors influencing the aggregate labor force participation rate is based on a theory of individual choice, defined in terms of goods and leisure. Or, viewed another way, the theory involves the allocation of an individual's time between hours of work offered in the labor market and hours of leisure.[7]

[6]For an exposition of these concepts, see Milton Friedman, *A Theory of the Consumption Function* (Princeton: Princeton University Press, 1957), pp. 20-37. These concepts were used in Wachter, "A Labor Supply Model for Secondary Workers," and Lucas and Rapping, "Real Wage Rates, Employment, and Inflation."

[7]Contemporary analysis of the behavior of individuals in the labor market has been influenced greatly by Gary S. Becker, "A Theory of the Allocation of Time," *Economic Journal*

It is postulated that the decision to be in the labor market in the current period depends on an individual's *reservation wage rate* relative to his *decision wage rate*.[8] The reservation wage rate reflects an individual's preferences for goods and services relative to leisure. The decision wage rate reflects the opportunity available in the market to the individual for obtaining goods and services by allocating a unit of available time from leisure to labor market work.

On a more technical level, the reservation wage rate is an individual's marginal rate of substitution of goods and services for leisure when all available time is allocated to leisure.[9] The decision wage rate is the perceived amount of goods and services the individual can purchase if a unit of time is shifted from leisure to work. If the reservation wage rate is greater than or equal to the decision wage rate, the individual allocates all available time to leisure. If the reservation wage rate is less than the decision wage rate, the individual allocates part of available time to participation in the labor market, either holding a job or seeking one.

Reservation Wage Rate — An individual's reservation wage rate in the current period is postulated to be related to the perceived permanent levels of the household's wage and nonlabor sources of total real income, tax rates on income, and the number of individuals in the household.[10] The greater the permanent nonlabor or real labor income of the household in the current period, other factors constant, the greater is each individual's reservation wage rate.[11] The higher the current period permanent marginal personal income tax rate or the permanent effective Social Security tax rate of the household, other factors constant, the lower is each individual's reservation wage rate.[12]

The influence of the permanent number of members (of all ages) of the household in the current period on an individual's reservation wage rate is ambiguous. The greater the permanent number of members, other factors constant, the smaller is each individual's pro rata share of the household's permanent real income, hence, the lower is the reservation wage rate. On the other hand, the larger the permanent size of the household the greater is the amount of household time presumed to be allocated to household activities.[13] As a result, each individual has less available time, and the greater are the reservation wage rates.[14] The net influence of the permanent size of the household on each individual's reservation wage rate is thus ambiguous, depending on which of the two influences dominates.

It is also postulated that each individual's reservation wage rate in the current period is related to transitory factors. Each individual's reservation wage rate is positively related to the transitory components of both sources of the household's real income and

(September 1965), pp. 493-517. Also see Jack Hirshleifer, *Price Theory and Application* (Englewood Cliffs, N.J.: Prentice Hall, 1976), pp. 380-85.

[8]See James Heckman, "Shadow Prices, Market Wages, and Labor Supply," *Econometrica* (July 1974), pp. 680-81, for a discussion of the arguments underlying this postulate.

[9]It is the slopes of the indifference curves representing the preferences of an individual between market goods and services (as distinct from household produced goods and services) and leisure time at the point where the indifference curves intersect the available time constraint. In constructing the indifference curves, market goods and services are on the vertical axis and hours of leisure are on the horizontal axis.

[10]The actual number of members in a household in the current period can be influenced by such unexpected events as deaths; the leaving of a member to form a new household as a result of marriage, divorce, or a desire to be independent; the military draft or a reduction in armed forces; and the admission of new members, for example, an elderly parent. Given these uncertainties, the members of the household are assumed to have a jointly formed perception regarding its permanent size in the current period. This study does not investigate the factors influencing household formation. That variable is considered to be exogenous.

[11]Leisure is assumed to be a non-inferior good. Thus, the farther an indifference curve is away from the origin, the greater is the marginal rate of substitution at its intersection with the time constraint, that is, the higher is the reservation wage rate. The greater the household's permanent real income and/or the individual's share, the farther is an individual's relevant indifference curve from the origin.

[12]The greater the permanent tax rates the smaller is the after tax permanent real income of the household and the individual's relevant indifference curve is closer to the origin. The effective Social Security tax rate is the ratio of the household's total Social Security tax payments to total wage income. The effective rate is used rather than the legislated rate so as to capture the influence of changes in the maximum wage income on which the tax is levied and in the number of workers covered.

[13]Some factors other than household size influencing the amount of household time allocated to household tasks are: the amount of time required to produce directly for the household goods and services by members of a household, the market price of goods and services similar to those produced directly by the household, and the price of education. These factors are assumed constant in this study. See Gary Becker, "A Theory of the Allocation of Time." For an empirical study of the factors influencing the allocation of time to household production of goods and services for its own consumption, see Wendy Lee Gramm, "The Demand for the Wife's Non-Market Time," *Southern Economic Journal* (July 1974), pp. 124-33.

[14]The greater the amount of time allocated to household tasks, the closer is an individual's available time constraint to the origin. Since an individual's indifference curves are presumed to slope upward to the left in an increasing manner, their slopes are steeper as the time constraint approaches the origin.

negatively related to the transitory components of the household's marginal income tax rate and effective Social Security tax rate. The influence of the transitory components of the household's size is ambiguous.

The preceding analysis of the factors influencing the current period reservation wage rate of an individual member of a given household is summarized in equation (1). The sign above each variable indicates its postulated direction of influence.

$$(1)\quad RW_{ij} = f_{ij}[\overset{(+)}{NLI^{\circ}_{j}}, \overset{(+)}{WE^{\circ}_{j}}, \overset{(-)}{ITR^{\circ}_{j}}, \overset{(-)}{SSTR^{\circ}_{j}}, \overset{(?)}{P^{\circ}_{j}}, \overset{(+)}{NLI_{j} - NLI^{\circ}_{j}}, \overset{(+)}{WE_{j} - WE^{\circ}_{j}}, \overset{(-)}{ITR_{j} - ITR^{\circ}_{j}}, \overset{(-)}{SSTR_{j} - SSTR^{\circ}_{j}}, \overset{(?)}{P_{j} - P^{\circ}_{j}}].$$

RW_{ij} = reservation wage rate of the i^{th} member of j^{th} household.

NLI°_{j} = perceived permanent nonlabor real income of the j^{th} household.

NLI_{j} = actual nonlabor real income of the j^{th} household.

WE°_{j} = perceived average permanent real wage rate of employed members of the j^{th} household.[15]

WE_{j} = actual average real wage rate of employed members of the j^{th} household.

ITR°_{j} = perceived permanent marginal income tax rate of the j^{th} household.

ITR_{j} = actual marginal income tax rate of the j^{th} household.

$SSTR^{\circ}_{j}$ = perceived permanent effective Social Security tax rate of the j^{th} household.

$SSTR_{j}$ = actual effective Social Security tax rate of the j^{th} household.

P°_{j} = perceived permanent size of the j^{th} household.

P_{j} = actual size of the j^{th} household.

Decision Wage Rate — An individual's decision wage rate in the current period is postulated to depend on the individual's perception of the permanent real wage rate available in the market, the permanent marginal income tax rate of the household, and the individual's permanent effective Social Security tax rate.[16] The greater the perceived permanent real wage rate, or the smaller the permanent tax rates, the higher is the individual's decision wage rate.

Just as in the case of the reservation wage rate, the individual's current period decision wage rate is postulated to be also related to the transitory component of each factor. It is postulated that the individual's decision wage rate in the current period is positively related to the transitory component of the individual's perception of the market real wage rate,[17] and negatively related to the transitory components of the household's marginal income tax rate and the individual's effective Social Security tax rate.

The factors influencing the individual's decision wage rate are summarized in equation (2). The sign above each variable indicates the postulated direction of influence.

$$(2)\quad DW_{ij} = s_{ij}[\overset{(+)}{W^{\circ}_{ij}}, \overset{(-)}{ITR^{\circ}_{j}}, \overset{(-)}{SSTR^{\circ}_{ij}}, \overset{(+)}{W_{ij} - W^{\circ}_{ij}}, \overset{(-)}{ITR_{j} - ITR^{\circ}_{j}}, \overset{(-)}{SSTR_{ij} - SSTR^{\circ}_{ij}}].$$

DW_{ij} = decision wage rate of the i^{th} member in the j^{th} household.

W°_{ij} = perceived permanent real wage rate of the i^{th} member in the j^{th} household.

W_{ij} = actual real wage rate of the i^{th} member in the j^{th} household.

$SSTR^{\circ}_{ij}$ = perceived permanent effective Social Security tax rate of the i^{th} member of the j^{th} household.

$SSTR_{ij}$ = actual effective Social Security tax rate of the i^{th} member of the j^{th} household.

Individual Participation in the Labor Market — The term, LF_{ij}, denotes the labor force participation status of the i^{th} individual in the j^{th} household. If the individual is in the labor force, LF_{ij} equals one, and if not in the labor force, LF_{ij} equals zero. The individual's labor force participation status is given by the following:

$$(3a)\quad LF_{ij} = 1, \text{ if } RW_{ij} < DW_{ij}.$$

$$(3b)\quad LF_{ij} = 0, \text{ if } RW_{ij} \geq DW_{ij}.$$

A change in the participation status of an individual in response to a given change in one of the arguments in either equation (1) or (2) depends on three conditions. They are: the existing magnitude of the difference between that person's reservation wage rate and decision wage rate, the magnitude of the response of either wage rate, and the magnitude of the change in the argument under consideration. For example, assume an increase in the perceived permanent real wage rate which increases an individual's decision wage rate. If the individual is already in the labor force there is no change in participation as DW_{ij}

[15]Total real income received from employed members of the household depends on the average real wage rate, the number employed, and the average number of hours worked per employed member. Attention is focused, however, on only the average real wage rate received so as not to complicate the analysis unduly.

[16]The individual's real wage rate reflects the influence of such factors specific to the individual as age, sex, education, training, and innate ability.

[17]For an individual in the labor market, either employed or seeking employment, some information regarding the wage rate is available. This does not hold, however, for an individual not in the market. In this case, it is assumed that the individual obtains some information about the real wage rate from knowledge of the rates received by the employed members of the household or by other individuals.

exceeds RW_{ij} by an even greater amount than previously. On the other hand, if previously $DW_{ij} = RW_{ij}$, the individual now enters. But, if RW_{ij} exceeded DW_{ij} by a large amount, for the individual to enter the labor force either the response of RW_{ij} to a small change in W^*_{ij} must be large or the change in W^*_{ij} must be large if the response is very small.

Household Labor Force Participation

The total number of members of labor force age in a household participating in the labor market (LF_j) in the current period is the sum of the total number of individuals whose reservation wage rates are less than their decision wage rates. Given the postulated individual behavior, the total number of individuals in a household participating in the labor market depends on the number of individuals of labor force age (PL_j) and the reservation wage rate of each, relative to the decision wage rate.

In moving the unit of analysis from one individual within a household to the household, it becomes impossible to derive, unambiguously, the response of the household's aggregate labor force participation without specific knowledge regarding the interactions of the individual members. This is because the decisions of each member with regard to participation exert an influence on the decisions of all other members (see shaded insert). This follows from equation (1) in which the reservation wage of every member depends on the perceived average permanent real wage rate received by employed members and their actual average real wage rate.

Without sufficient information regarding the interdependent behavior of each member of a household, the response of the aggregate participation of household members is ambiguous. Moreover, the response can change over time given different initial conditions in terms of the magnitude and sign of the discrepancy between each member's reservation wage rate and decision wage rate. Also, the response can change over time as the magnitude of change in each independent variable changes.

The relationship for the number of individuals of a household in the labor market is given by equation (4). It is assumed that all of the permanent variables and the related actual variables in equations (1) and (2) move in the same manner as their average values in the market. Thus, subscripts on these variables are dropped and the variables are defined as in the above assumption. All of the signs are now ambiguous, as discussed earlier, except for the positive sign associated with the household's population of labor force age.

$$(4)\quad LF_j = h_j\,[NLI^\circ,\ W^\circ,\ ITR^\circ,\ SSTR^\circ,\ P^\circ,\ NLI - NLI^\circ,\ W - W^\circ,\ ITR - ITR^\circ,\ SSTR - SSTR^\circ,\ P - P^\circ,\ PL_j].$$

Aggregate Labor Force Participation Rate

The simplifying assumption that all households are identical is made in aggregating labor force participation across households.[18] As a consequence, the total number of individuals in the labor force (LF) in the current period is given by multiplying equation (4) by the number of households (H). Assuming that equation (4) is homogeneous of degree one in PL, P^*, and P, and dividing both sides by H, yields the equation for the aggregate labor force participation rate (LF/PL).

$$(5)\quad \frac{LF}{H \cdot PL_j} = \frac{LF}{PL} = h_j\,[NLI^\circ,\ W^\circ,\ ITR^\circ,\ SSTR^\circ,\ P^\circ/PL,\ NLI - NLI^\circ,\ W - W^\circ,\ ITR - ITR^\circ,\ SSTR - SSTR^\circ,\ P/PL - P^\circ/PL].$$

EMPIRICAL MODEL

The theoretical model has been expressed in general mathematical terms in equation (5). It now becomes necessary to state that equation in a specific form in order to estimate its parameters. It is assumed that the relationship is linear in natural logarithms. There remains an additional problem to be cleared up in developing the empirical form of the model which is estimated. That problem is with regard to the formation of perceptions of the permanent components.

Formation of Perceptions of Permanent Components

The perceived permanent component of each variable in equation (5) cannot be observed. It is assumed that perceptions regarding the permanent level of each variable change in the current period in response to the discrepancy between the actual and perceived permanent levels of the variable in the previous period. An example of this adjustment process is presented in equation (6).

$$(6)\quad \ln W^*_t - \ln W^*_{t-1} = \lambda\,[\ln W_{t-1} - \ln W^*_{t-1}].$$

---

[18] This assumption implies that there are no distributional influences on overall labor force participation, such as changes in the distribution of nonlabor income among households, or that such influences are small enough to be ignored.

Sources of Uncertainty

The uncertainty regarding the response of aggregate labor force participation in the household can be illustrated by two cases. The examples are not exhaustive, but they do set forth the general considerations involved in postulating the response of aggregate labor force participation at the household level. For purpose of illustration, only the influence of a change in the average market real wage is analyzed. The analysis can readily be extended to other variables.

Case I — Suppose that there are two members (a man and a woman) of labor force age in a particular household and that at prevailing *individual* perceptions of permanent and transitory real wage rates, nonlabor real income, and tax rates, both are in the labor force and are employed. Assume further that both the perceived permanent market real wage rate and the actual real wage rate of each individual have a fixed relationship to the average market real wage rate paid in the economy. These proportions vary between individuals, say for example, because of different levels of education. Also assume that the woman's decision wage rate is only slightly greater than her reservation wage rate and that the man's decision wage rate is very large relative to his reservation wage rate. The woman is then the marginal worker in this household.

Given these assumptions, conditions can be set forth under which the response of the aggregate household labor force participation to a given increase in the average market real wage is either negative or zero. If the response of the woman's reservation wage rate with regard to an increase in the man's actual real wage rate is greater than the response of her own decision wage rate, then she, being the marginal worker, drops out of the labor force. The man's reservation wage rate falls as a result, because the woman no longer brings income to the household. But since his decision wage rate increases, the difference between his reservation and decision wage rate widens and he remains in the labor force. On the other hand, if the responses of each individual's reservation wage rate and decision wage rate are equal, both stay in the labor force.

Case II — This case illustrates conditions under which the response of aggregate household participation is either positive or zero. Assume that the man is in the labor force and is employed and that his decision wage rate greatly exceeds his reservation wage rate. Also, assume that the woman is not in the labor force but is at the margin because, for her, the two wage rates are equal. She, as the marginal individual in the household, will enter the labor force if the response of her decision wage rate to an increase in the market real wage rate is greater than the response of her reservation wage rate. If she finds employment, the man will remain in the labor market if the response of his decision wage rate is greater than the response of his reservation wage rate to the additional household income brought in by the newly employed member. On the other hand, if the response of each individual's reservation wage and decision wage rate are equal, their labor market participation remains unchanged.

Implications — The two cases indicate that changes in the aggregate participation of household members are influenced by the response of each member's reservation wage rate to a change in the average market real wage rate, relative to the response of the decision wage rate of each of them. The magnitude of the discrepancy between each member's reservation wage rate and decision wage rate, along with the magnitude of the change in the average market real wage rate, also exerts an important influence on aggregate participation. This last point can be illustrated by another example.

If, in Case II, the individual who was at the margin had instead a reservation wage rate in considerable excess of her decision wage rate, she would enter the labor force only if there were a sufficiently large increase in the average market real wage rate. Suppose, however, that she did enter and was employed. What happens to the employed individual? If he were at the margin of the labor force (instead of having a large decision wage rate relative to his reservation wage rate), he would leave the labor force due to the added income to the household contributed by the newly employed member. The net result would not be a change in aggregate participation, only a change in the individuals who are involved.

The adjustment coefficient is λ, which can take on values from zero to unity. If $\lambda = 0$, there is no adjustment; if $\lambda = 1$, there is full adjustment in the current period. For $0 < \lambda < 1$, there is partial adjustment in the current period.

Next, it is assumed that the adjustment coefficients are equal in the formation of perceptions regarding all permanent variables in order to simplify the algebra from that which is involved when the adjustments proceed at different rates. An equation similar to (6) for each of these variables is substituted into equation (5) and the lagged perceived permanent levels of the variables are eliminated by a Koyck-type transformation.[19] The resulting equation is solved for $\ln[LF/PL]_t$, which yields the following:[20]

[19]See L. M. Koyck, *Distributed Lags and Investment Analysis* (Amsterdam: North-Holland Publishing Co., 1954), pp. 22-24.

[20]The equation could also have been written in terms of current period and lagged period levels, for example, $\alpha_6 \ln NLI_t + (\lambda\alpha_1 - \alpha_6) \ln NLI_{t-1}$. The form chosen helps

$$(7)\quad \ln[LF/PL]_t = \lambda\alpha_0 + \lambda\alpha_1 \ln NLI_{t-1} + \lambda\alpha_2 \ln W_{t-1} + \lambda\alpha_3 \ln ITR_{t-1} + \lambda\alpha_4 \ln SSTR_{t-1} + \lambda\alpha_5 \ln[P/PL]_{t-1} + \alpha_6 [\ln NLI_t - \ln NLI_{t-1}] + \alpha_7 [\ln W_t - \ln W_{t-1}] + \alpha_8 [\ln ITR_t - \ln ITR_{t-1}] + \alpha_9 [\ln SSTR_t - \ln SSTR_{t-1}] + \alpha_{10} [\ln(P/PL)_t - \ln(P/PL)_{t-1}] + (1-\lambda) \ln[LF/PL]_{t-1}.$$

LF = number of individuals in the labor force.
PL = number of individuals of labor force age.
NLI = nonlabor real income per household.
W = average real wage rate.
ITR = average effective personal income tax rate.
SSTR = average effective personal Social Security tax rate.
P = total population.

Regression Equation

Next, equation (7) is expressed as a regression equation which provides the basis for estimating the parameters of the specific empirical equation used for the analysis in Part II of this article. In the regression form of equation (7), the regression coefficients reflect the following structural coefficients:

$a_0 = \lambda\alpha_0$ $\quad$ $a_6 = \alpha_6$

$a_1 = \lambda\alpha_1$ $\quad$ $a_7 = \alpha_7$

$a_2 = \lambda\alpha_2$ $\quad$ $a_8 = \alpha_8$

$a_3 = \lambda\alpha_3$ $\quad$ $a_9 = \alpha_9$

$a_4 = \lambda\alpha_4$ $\quad$ $a_{10} = \alpha_{10}$

$a_5 = \lambda\alpha_5$ $\quad$ $a_{11} = 1 - \lambda$.

The influence of the permanent and transitory components of each factor can be readily identified from the structural coefficients embodied in each regression coefficient. The lagged terms, except $\ln[LF/PL]_{t-1}$, represent the influence of the permanent components, and the first difference terms represent the influence of the transitory components. The lagged participation rate term incorporates the lag in the formation of perceptions regarding the current period permanent level of each variable.

Regression Results

The coefficients of the model are estimated by ordinary least squares regressions. Quarterly time series data for the period I/1957 to IV/1976 are used (see Appendix for data sources). All data are seasonally adjusted.

Civilian noninstitutional labor force and total population data are taken from Department of Labor sources.[21] Annual estimates of the number of households by the Bureau of the Census are interpolated to provide quarterly estimates. The average real wage rate is the average hourly compensation of employees in the private economy (adjusted for employer Social Security contributions) deflated by the consumer price index. Nonlabor real income per household is the sum of personal interest, dividends, proprietor's income, net rent and Social Security payments deflated by the consumer price index and then divided by the number of households. The average effective personal income tax rate is total personal income tax payments divided by the difference between personal income and government transfer payments to individuals. The average effective personal Social Security tax rate is worker contributions to Social Security divided by the sum of wages and salaries.

The estimated parameters of the regression equation are reported in the first column of Table I. The equation was tested for a structural change after IV/1964, when the trend in the labor force participation rate changed from a small negative to a rather large positive trend (see Chart I). The original equation was reestimated with the additions of a dummy variable, D = 1.0, for the period after IV/1964 (to allow for a change in the constant) and D times each variable (to allow for a change in each variable's regression coefficient). The results of the reestimation are reported in the second column of Table I. The F test ($F = 2.06$) rejects at the 5 percent level of significance the null hypothesis that all the estimated coefficients of D and the variables multiplied by D are zero. The test thus *rejects* the hypothesis of no change in structure.[22]

reduce the estimation problem (multicolinearity) that arises from having both contemporaneous and lagged levels of each variable. It also provides a straightforward estimation of the permanent and transitory influences.

[21]These data are adjusted by the author to eliminate discontinuities resulting from the addition of data for Alaska and Hawaii when they were granted statehood and benchmark adjustments made following the 1960 and 1970 Censuses. The adjustments made are based on overlap data reported at the time of each adjustment.

[22]The reasons for such a change in response after 1964 cannot be ascertained from the model. The specific empirical form of the model used in this study is reported in Table I, Column III. The changes in the estimated responses of the labor force participation rate with respect to the average permanent real wage rate and the transitory component of the average effective personal Social Security tax rate, however, suggest the channel through which the change occurred, but not the basic source. Both of these changes imply that, on average, the aggregate labor force partici-

Table I

ESTIMATED COEFFICIENTS

	Col. I		Col. II		Col. III	
	Coefficient	(t)	Coefficient	(t)	Coefficient	(t)
$\Delta \ln NLI_t$	–.026	1.004	–.060	.560	–.043	1.963
$\Delta \ln W_t$	–.140	2.525	–.072	.609	–.137	2.719
$\Delta \ln ITR_t$	–.002	.378	–.064	2.783	–.050	2.669
$\Delta \ln SSTR_t$	–.008	.972	.006	.337	—	—
$\Delta \ln (P/PL)_t$	.513	2.215	.469	.905	—	—
$\ln NLI_{t-1}$	.009	.644	–.038	.321	–.010	2.370
$\ln W_{t-1}$	–.004	.232	–.097	.872	–.072	3.653
$\ln ITR_{t-1}$	.010	1.700	–.029	1.483	—	—
$\ln SSTR_{t-1}$	.004	.864	.048	2.156	.022	4.090
$\ln (P/PL)_{t-1}$	–.116	3.851	–.144	.663	–.098	2.845
$\ln (LF/PL)_{t-1}$	.649	8.566	.439	2.013	.481	6.387
Constant	–.147	1.654	.260	.318	—	—
$D \cdot \Delta \ln NLI_t$			.023	.211	—	—
$D \cdot \Delta \ln W_t$			–.079	.582	—	—
$D \cdot \Delta \ln ITR_t$			.026	2.603	.044	2.250
$D \cdot \Delta \ln SSTR_t$			–.009	.458	—	—
$D \cdot \Delta \ln (P/PL)_t$			–.510	.857	—	—
$D \cdot \ln NLI_{t-1}$			.035	.296	—	—
$D \cdot \ln W_{t-1}$			.108	.955	.099	3.940
$D \cdot \ln ITR_{t-1}$			.039	1.876	—	—
$D \cdot \ln SSTR_{t-1}$			–.035	1.441	—	—
$D \cdot \ln (P/PL)_{t-1}$			–.024	.107	—	—
$D \cdot \ln (LF/PL)_{t-1}$			.031	.129	—	—
D			–.402	.483	–.110	3.804
R^2	.978		.984		.981	
S.E.	.00255		.00234		.00232	
D.W.	2.200		2.204		2.000	

A similar test for a change in structure was also performed for the period after 1973. That period was the one in which the labor force participation rate moved in a different manner from that predicted by the discouraged worker hypothesis. The regression form of equation (7) was estimated for the sample period I/1965 to IV/1976, the period found in the previous test to have a structure different from that of the I/1957 to IV/1964 period. Then the dummy variable D = 1.0 after IV/1973 was introduced, and the equation was reestimated as in the previous test. The F test (F = 1.10) does not reject at the 5 percent level of significance the null hypothesis that the estimated coefficients of all the added variables are zero. Thus, the test *does not reject* the hypothesis of no change in structure after IV/1973.

SPECIFIC EMPIRICAL FORM USED IN PART II

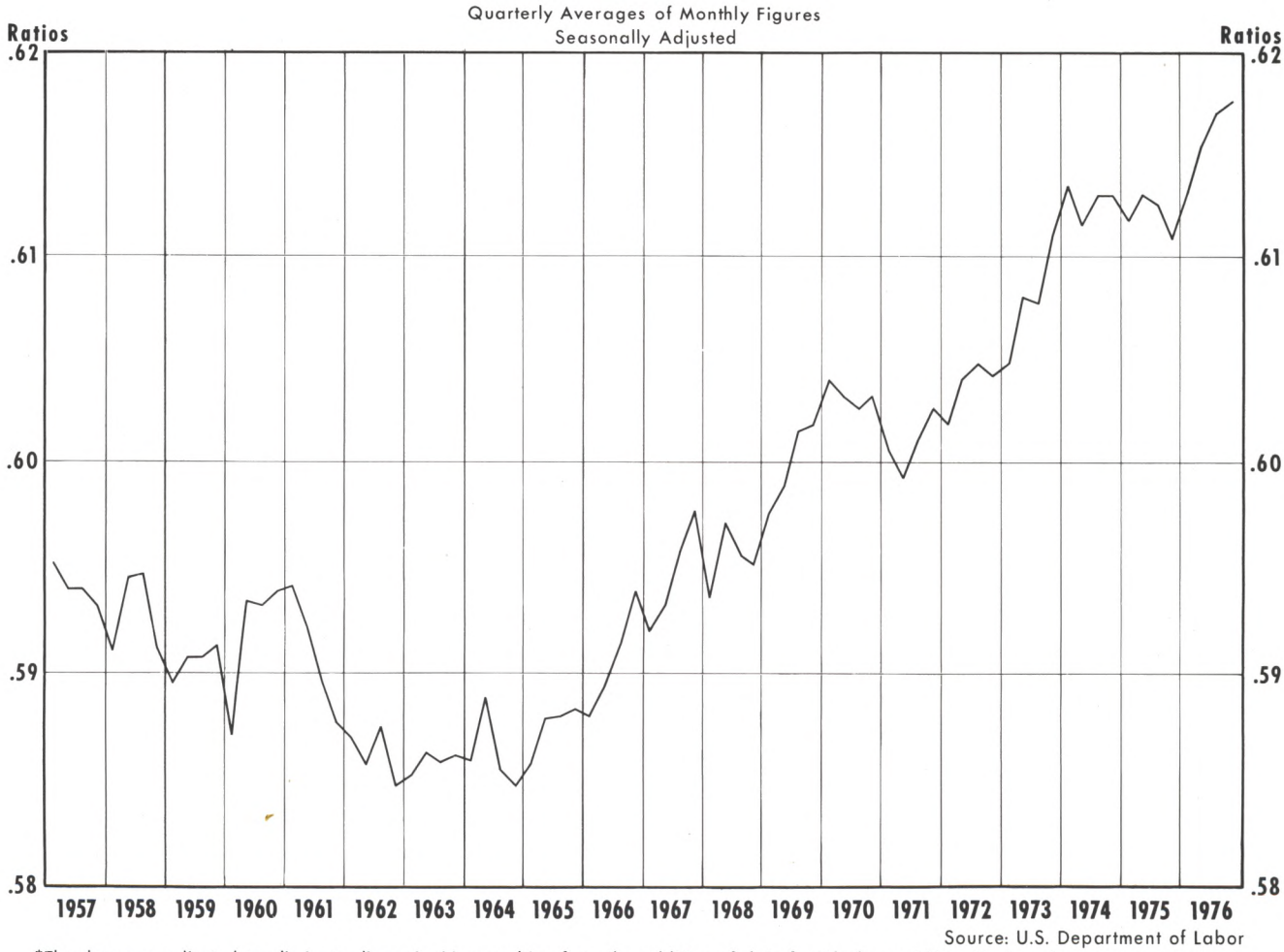
Additional tests resulted in the estimated equation reported in the third column of Table I. The F test (F = .93) did not reject at the 5 percent level of significance the null hypothesis that all the omitted coefficients from the second column are zero. The estimated equation reported in Table I, Column 3, is used in the balance of this study.

The estimated equation projects the level of the labor force participation rate with small errors within the sample period. The equation explains 98 percent of the variance in the level of the labor force partici-

pation of individuals became more responsive after 1964 to the aftertax real wage rate of individuals relative to the aftertax real income that households receive from employed members. Other studies of the participation rate have usually relied on a dummy variable to capture the change in the trend, without identifying specific channels through which the change occurred. See studies listed in footnote 3.

Chart I

Labor Force Participation Rate*



Source: U.S. Department of Labor

*The data are adjusted to eliminate discontinuities resulting from the addition of data for Alaska and Hawaii when they were granted statehood and from benchmark adjustments made following the 1960 and 1970 censuses.

pation rate. The standard error is .0023, or about one-fourth of one percent.

Such projections, however, are based on known values of the lagged participation rate. The question thus arises regarding the ability of the model to generate projections several quarters ahead when simulated levels of the lagged participation rate are used instead of known levels. The model was simulated dynamically over the sample period using the actual level of the lagged participation rate for the first quarter of 1957 and then using the simulated level thereafter.

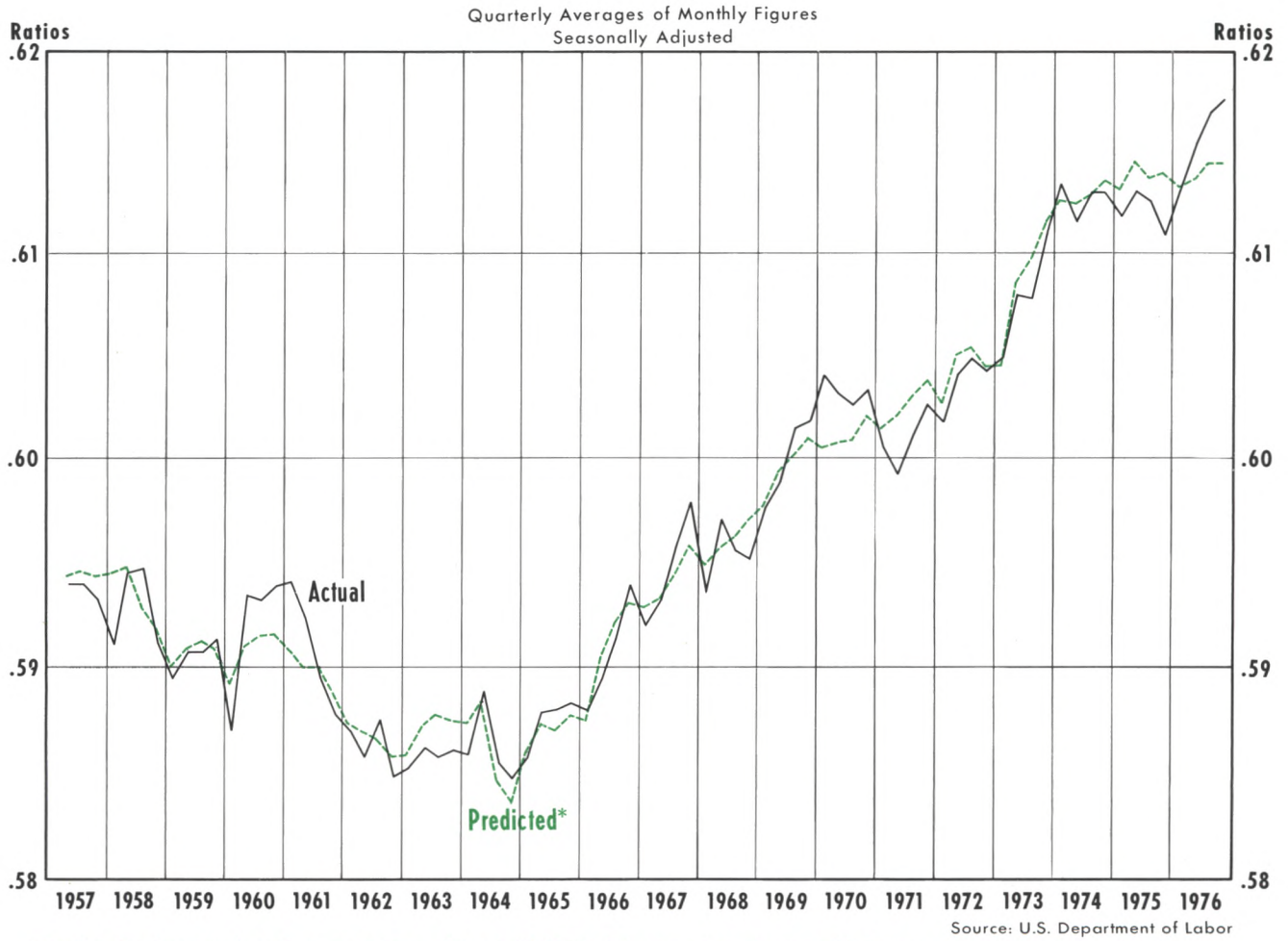
The simulation results are presented in Chart II. A comparison of the actual and simulated levels indicates that the model simulates the labor force participation rate very well. The simulation picks up the change in trend after 1964 and there are no prolonged periods of over or under projections. The correlation between the actual and simulated levels is .99. The largest absolute error is .59 percent in I/1958. The root-mean-squared error is .24 percent, only slightly larger than the standard error of the estimated equation. The error for the last quarter of the simulation is .50 percent, indicating that the errors do not accumulate significantly over time. There is virtually no systematic bias in the simulation as indicated by an average error of —.01 percent.[23]

[23] Another measure of simulation accuracy is Theil's inequality coefficient. The coefficient for the dynamic simulation results is .002, compared with a coefficient of zero for perfect forecasts. Decomposition of the total error indicates that the

Chart II

Results of Ex Post Dynamic Simulation

Labor Force Participation Rate



Source: U.S. Department of Labor

*Predicted values are based on an estimate through IV/1976 of the equation whose coefficients appear in column 3, Table 1.

PART II: ANALYSIS OF FACTORS INFLUENCING THE LABOR FORCE PARTICIPATION RATE, 1957 - 76

The empirical model developed in Part I can be used to analyze the factors influencing the overall labor force participation rate during the period from 1957 to 1976. Three subperiods are used. They are 1957 to 1964, 1965 to 1973, and 1974 to 1976.

There are two stages in the analysis for each subperiod. First, the relative contribution of each item reported in Table I, Column 3, is ascertained for each subperiod by converting the estimated response of the participation rate to a standardized statistical measure called the beta coefficient.[24] The larger a variable's beta coefficient, without regard to sign, the greater is the contribution. The beta coefficients in each of the subperiods are reported in Table II. Next,

major source (98 percent) is unsystematic influences. Theil argues that 100 percent of the total error from unsystematic influences is a desirable forecasting property. See H. Theil, *Economic Forecasts and Policy* (Amsterdam: North-Holland Publishing Co., 1958), pp. 31-38, for a discussion of the inequality coefficient, its decomposition, and interpretations.

[24]The beta coefficient for an explanatory variable is its estimated regression coefficient multiplied by the ratio of the standard deviation of that variable to the standard deviation of the dependent variable. Separate calculations of the standard deviations are made for each subperiod.

Table II

Beta Coefficients

Variable	1957-64	1965-73	1974-76
Transitory:			
Nonlabor real income	−.043	−.059	−.230
Real wage rate	−.114	−.065	−.318
Income tax rate	−.190	−.019	−.220
Permanent:			
Nonlabor real income	−.079	−.036	−.071
Real wage rate	−.701	.121	.102
Social Security tax rate	.516	.257	.096
Population/population of labor force age	−.162	−.163	−.265
Lag in formation of perceptions regarding permanent variables	.481	.481	.410

*The beta coefficient for each variable is the product of its estimated coefficient (Table I) and the ratio of its standard deviation to the standard deviation of the labor force participation rate. The standard deviations used are those calculated for each subperiod. The larger the magnitude (without regard to sign) of the beta coefficient of one factor relative to that of another factor, the greater is its contribution in explaining the labor force participation rate.

the directions of influence of the dominant forces, as indicated by the beta coefficients, are ascertained from observed movements in the underlying data within the subperiod and the sign of each coefficient.

1957-64 Subperiod

An examination of the relative magnitudes of the beta coefficients (without regard to signs) for the 1957-64 subperiod (Table II) indicates that trend influences were the most important in explaining movements in the labor force participation rate. The largest influence was the permanent component of the average real wage rate; the second largest, the permanent component of the average effective personal Social Security tax rate; and the fifth largest, the permanent component of the ratio of total population to population of labor force age. The major short-run influence was the lag in the formation of perceptions regarding the permanent level of each variable. Its beta coefficient was the third largest.

The direction of influence of each permanent component on the trend in participation is identified by examining the longer-run movements in the underlying variables that existed within at least a major portion of the 1957-64 subperiod. Nonlabor real income per household rose at a 3.8 percent average annual rate from IV/1960 to IV/1965; the average real wage rate rose at a 2.5 percent rate from IV/1957 to IV/1968; and the average effective personal Social Security tax rate rose at a 5.5 percent rate from I/1957 to I/1966. The ratio of total population to population of labor force age rose at a 0.6 percent rate from IV/1957 to IV/1961, followed by little change to IV/1966. Given the estimated signs of the coefficients of the permanent components, all the variables mentioned, except the average effective personal Social Security tax rate, moved in such a manner as to produce the negative trend in the labor force participation rate during the 1957-64 subperiod.

1965-73 Subperiod

Table II indicates that, during the 1965-73 subperiod, trend influences on the labor force participation rate were still of major importance. In terms of beta coefficients, the permanent component of the average effective personal Social Security tax rate ranked second; the permanent component of the ratio of total population to population of labor force age ranked third; and the permanent component of the average real wage rate ranked fourth. The dominant short-run influence was the lag in the formation of perceptions regarding the permanent levels of the variables, as in the previous subperiod.

Three of the variables continued to rise, but at slower rates than in the 1957-64 subperiod. Nonlabor real income per household increased at a 1.6 percent annual rate from IV/1965 to IV/1973; the average real wage rate rose at a 1.0 percent rate from IV/1968 to IV/1973; and the average effective personal Social Security tax rate increased at a 2.3 percent rate from I/1966 to IV/1972. The movement in the ratio of total population to population of labor force age changed directions from that of the previous subperiod, decreasing at a 0.8 percent rate from IV/1966 to IV/1973.

Movements in all but one of the variables mentioned contributed to the positive trend in the participation rate during the 1965-73 subperiod. The exception was the rise in nonlabor real income per household, which had a relatively unimportant influence according to Table II. Although the average real wage rate continued to rise in the subperiod, the sign of its coefficient changed from negative to positive (see the discussion of this change in footnote 22). Thus, the rise in the average real wage rate exerted a positive influence on the trend of the participation rate, whereas in the previous subperiod it had exerted a negative influence.

1974-76 Subperiod

In contrast to the previous two subperiods, movements in the labor force participation rate were dominated by short-run influences during the 1974-76 subperiod. While the lag in the formation of perceptions regarding the permanent levels of the variables was the dominant short-run influence, the transitory components also exerted a significant influence. According to Table II, the transitory component of the average real wage rate ranked second; the transitory component of nonlabor real income per household ranked fourth; and the transitory component of the average effective personal income tax rate ranked fifth. The dominant long-run influence was the permanent component of the ratio of total population to population of labor force age which ranked third.

Three of the variables fluctuated widely during the 1974-76 subperiod. Nonlabor real income per household fell at a 7.3 percent annual rate from IV/1973 to I/1975 and then rose at a 2.7 percent rate through IV/1976. The average real wage rate decreased at a 2.7 percent rate from I/1973 to I/1974, was about unchanged to the end of 1975, and then rose at a 3.9 percent rate through IV/1976. There was a great drop in the average effective personal income tax rate in II/1975 followed by a substantial rebound through the period ending IV/1976. Movements in the other two variables were less volatile over the subperiod. The average effective personal Social Security tax rate rose only slightly from I/1973 to IV/1976, while the ratio of total population to population of labor force age continued to fall steadily at a 0.9 percent annual rate.

Given such a short interval of time from 1974 to 1976, it is exceedingly difficult to relate, with any degree of precision, observed movements in the aggregate labor force participation rate to specific long-run and short-run influences. Movements in the average effective personal Social Security tax rate and the ratio of total population to population of labor force age suggest that the previous subperiod's upward trend in the participation rate continued in the last subperiod. The decreases in the first part of the subperiod in nonlabor real income per household and the average real wage rate and the sharp decrease in the average effective personal income tax rate in early 1975 suggest that the participation rate was above its underlying trend at that time. Subsequent movements in the three variables would seem to indicate that by the end of 1976 the participation rate was close to its underlying trend value.

Some Concluding Observations

The preceding analysis identified the major "proximate" influences on movements in the labor force participation rate over 1957-76. The term "proximate" is used because each of the variables cited in the analysis responds to many independent influences. For example, both the average real wage rate and elements of nonlabor real income per household are determined by the interaction of demand and supply in many markets. Thus, observed values of these two variables reflect the joint influence of many factors, such as advancements in technology, government actions, and influences from outside the United States economy. Changes in the ratio of total population to population of labor force age reflect changes in the age distribution. Changes in the two average effective tax rates reflect changes in tax laws.

It is difficult to identify and to trace out all the independent influences on the labor force participation rate during the 1957-76 period, so only some conjectures can be offered regarding the independent influences believed to be important.

The earlier analysis suggested that movements in the participation rate in the 1957-64 subperiod were dominated by trend influences. The subperiod was characterized by great advances in technology and a boom in capital formation, both of which contributed significantly to the rising average real wage rate. Legislation increasing the tax rate and expanding the number of workers covered increased the average effective personal Social Security tax rate. The rise in the ratio of total population to population of labor force age reflected the postwar "baby boom"; that is, population under 16 years of age rose faster than population of 16 years and over.

Movements in the participation rate in the 1965-73 subperiod were also trend dominated. There were two major trend influences. One was the increase in the average effective personal Social Security tax rate due to legislation which increased the basic tax rate, raised the maximum level of wage income to which the rate applied, and expanded the coverage. The other influence was the decrease in the ratio of total population to population of labor force age as the individuals born during the "baby boom" began to turn 16 and the birth rate declined.

In the 1974-76 subperiod, transitory influences dominated movements in the labor force participation rate. There was markedly greater short-run variability in the average real wage rate, nonlabor real income per household, and in the average effective personal income tax rate than earlier. One interpretation of the source of the increased variability in the first two factors attributes the variability to the great increase in the relative price of energy in 1974 which resulted in a reduction in the economy's ability to produce goods and services.[25] According to that interpretation, the reduction in productive potential decreased the average real wage rate and nonlabor real income per household in the subperiod. As a result of the temporary tax rebate adopted in response to the then on-going recession, the average effective personal income tax rate fell sharply in the first half of 1975 and then rebounded quickly.

A final observation is that the influence of the postwar "baby boom" on movements in the overall participation rate has been greatly overemphasized by some analysts. They argue that a major reason the aggregate participation rate decreased up to 1964 was that mothers stayed home to care for the children. And, then, as the children became older, the mothers entered the labor market and the participation rate began to rise. The analysis presented in this article, however, found that while the influence of the "baby boom" on the labor force participation rate was important, economic factors generally exerted a greater influence.

[25]See Robert H. Rasche and John A. Tatom, "Energy Resources and Potential GNP," this *Review* (June 1977), pp. 10-24.

APPENDIX

DATA SOURCES

From: U.S. Department of Commerce

The National Income and Product Accounts of the United States, 1929-1974, A supplement to the *Survey of Current Business*

Table 2.1, line 16
Old Age, Survivors', Disability, and Health Benefits.[1]

, line 12
Rental Income of Persons with Capital Consumption Adjustment.[1]

, line 13
Dividends.[1]

, line 14
Personal Interest Income.[1]

, line 9
Proprietor's Income with Inventory Valuation and Capital Consumption Adjustments.[1]

From: U.S. Department of Commerce, Bureau of the Census

Current Population Reports, Population Characteristics, Series P-20, nos. 140 (7/2/65), 266 (7/74), 313 (9/77)

Households, Total

Population per Household, Average of All Ages

From: U.S. Department of Labor, Bureau of Labor Statistics

Bureau *News* releases

Consumer Price Index, All Items (unrevised)[2]

Industry Analytical Ratios for the Private Business Sector

Real Hourly Compensation of All Employees[3]

Employment and Earnings

Population, Total, Non-institutional, Aged 16 and Over (quarterly averages of monthly data)

[1]Updated through IV/1976 using July 1976 and 1977 issues of the *Survey of Current Business.*

[2]Published in unadjusted form and seasonally adjusted by this Bank using Department of Labor seasonal factors. Note that this particular unadjusted series ended with June 1978 data.

[3]Data appear in nonindexed form to three decimal places (updated as of January 26, 1978).

Civilian Labor Force, All Ages 16 and Over (quarterly averages of monthly data)

The Personal Income Tax and Social Security Tax Rates were compiled by this Bank using the *Survey of Current Business* data series which appear in *The National Income and Product Accounts of the United States, 1929-1974* and in the July 1976 and 1977 issues of the *Survey*.

Personal Income (Table 2.1, line 1); Transfer Payments to Persons (Table 3.2, line 31); and Personal Tax and Nontax Receipts (Table 3.2, line 2).

Formula: TAX ÷ (INCOME — TRANSFER PAYMENTS) = Effective Personal Income Tax Rate.

Contributions for Social Security Insurance (Table 3.2, line 19) and Wage and Salary Disbursements (Table 2.1, line 2)

Formula: CONTRIBUTIONS ÷ WAGES = Effective Personal Social Security Tax Rate.

All data series are seasonally adjusted except Bureau of the Census household data.

Money-Income Relationships and the Exchange Rate Regime

TERRY C. MILLS and GEOFFREY E. WOOD

THE analysis recently elaborated in the monetary approach to the balance of payments literature demonstrates that the ability of a particular monetary authority to control its domestic monetary conditions depends crucially on two factors. The first relates to whether or not the country is the reserve currency center (the country whose money is held as international reserves by other countries); the second concerns the prevailing exchange rate regime.

As that body of analysis shows, the monetary authorities in non-reserve centers can fully control domestic monetary conditions only under a completely freely floating exchange rate regime. With pegged exchange rates, the authority's control over monetary conditions is limited by the extent to which they are willing to allow their exchange rate to change or their willingness to change their stock of international reserves. Otherwise, they can neither offset a monetary impulse from abroad nor affect nominal income by their own monetary actions.

The monetary approach to balance-of-payments analysis also indicates that, in contrast to the situation in non-reserve centers, the monetary authorities in the reserve center can influence monetary conditions both domestically and in non-reserve centers (by influencing worldwide monetary conditions) under a fixed exchange rate regime. Of course, they can influence only their own monetary conditions when exchange rates are floated.[1]

The importance of utilizing this approach to assess the relationship between money and income is highlighted by the apparently contrasting results obtained in recent studies of the money-income relationship for the United States and the United Kingdom. These studies used the Sims test, which is designed to determine the existence and direction of causality between two variables.[2] That test is based upon the assumption that if one variable leads another (temporally), it can cause movements in that other variable, while if one variable follows the other, no such possibility exists.[3]

In terms of a money stock variable (M) and an income variable (Y), if changes in M cause changes in Y, then a regression of current M on past, present, and future values of Y should show significant coefficients for future, and perhaps present, values of Y, but insignificant coefficients on past values of Y. Further, if changes in M cause changes in Y, regressing Y on past, present, and future values of M should yield significant coefficients on past, and perhaps present, values of M, and insignificant coefficients on future values of M.

Sims applied this test to the United States and found that changes in monetary growth caused changes in the growth rate of income.[4] However,

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NOTE: Terry C. Mills is a lecturer in econometrics at the University of Leeds, England. This paper was in large part written while Geoffrey E. Wood, Senior Lecturer in Banking and International Finance at the City University, London, England, was visiting the Federal Reserve Bank of St. Louis.

[1]The monetary approach to balance-of-payments analysis has a long history, dating certainly from David Hume's essay "Of the Balance of Trade," first published in 1752, which can be found in *David Hume: Writings on Economics*, ed. Eugene Rotwein (Madison, Wisc.: The University of Wisconsin Press, 1970), pp. 60-77. The modern reintegration of monetary and balance-of-payments analysis was pioneered in James Edward Meade, *The Balance of Payments* (London: Oxford University Press, 1951), and a sample of recent work is contained in Jacob A. Frenkel and Harry G. Johnson, eds., *The Monetary Approach to the Balance of Payments* (London: George Allen and Unwin Ltd., 1975).

[2]Christopher A. Sims, "Money, Income, and Causality," *American Economic Review* (September 1972), pp. 540-52.

[3]C. W. J. Granger and Paul Newbold, *Forecasting Economic Time Series* (New York: Academic Press, 1977), p. 225, suggest that in discussing tests of the types set out here, it may be preferable to replace the word "cause" with the phrase "temporally related," as these tests do not necessarily satisfy the normal philosophical criteria for establishing causality. But as H. Feigl states in, "Notes on Causality" in H. Feigl and M. Broadbeck, eds., *Readings in the Philosophy of Science* (New York: Appleton-Century-Crofts, Inc., 1953), p. 408, "The clarified (purified) concept of causality is defined in terms of predictability according to a law (or more adequately, according to a set of laws)." This suggests that the word "cause" may be permissible in the present context in view of the existence of a predictive model which underlies the analysis. An extensive discussion of these issues can be found in Arnold Zellner, "Causality and Econometrics" (Paper presented at University of Rochester-Carnegie Mellon University Conference, University of Rochester, April 1978).

[4]Sims, "Money, Income, and Causality."

when Williams, Goodhart, and Gowland applied this test to data from the U.K. economy for the I/1958 — III/1971 period, they found no clear evidence of causality in *either* direction.[5] This result conflicts not only with Sims' results for the United States, but also with other findings, which demonstrate a well determined money-income relationship for the United Kingdom, derived by estimating money demand equations.[6]

The results can, however, be reconciled by recognizing the significance of the exchange rate regime for the influence of money on income.

Alternative Interpretations of Failure to Find Causality

The failure of Williams, Goodhart, and Gowland to find a one-way relationship between money and income by means of the Sims test can bear more than one interpretation. It can mean that no causal relationship exists. Alternately, it can mean that the money-income causal relationship varied within their data period. On some occasions, when the monetary fluctuation either originated from the reserve center, was in line with a monetary fluctuation in the reserve center, or was accommodated by an exchange rate change, money influenced income in the United Kingdom. At other times, the monetary stimulus, of domestic origin, led to balance-of-payments pressure which induced the monetary authorities to reverse their previous monetary policy with sufficient rapidity that the initial monetary stimulus did not persist long enough to have a discernible effect on income. If this occurred, no causality from money to income would be observed. Further, when the U.K. monetary authorities were pegging the exchange rate and resisting interest rate movements — as they were for a substantial part of the data period used by Williams, Goodhart, and Gowland — an exogenous income fluctuation would induce an accommodating monetary response.[7]

In other words, within their data period, on some occasions money influenced income; on some occasions income influenced money; and on other occasions monetary actions were so quickly reversed that there was no time for them to influence income. The Williams, Goodhart, and Gowland result could therefore have been produced by their carrying out their test over what was a collection of subperiods, heterogeneous with respect to the causal relationship between money and income, as if the collection was actually one homogeneous data set. (It should be emphasized that the nature of the test, in combination with U.K. exchange rate policy, gave them no alternative in the data set they used.[8])

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[5]David Williams, C. A. E. Goodhart, and D. H. Gowland, "Money, Income, and Causality: the U.K. Experience," *American Economic Review* (June 1976), pp. 417-23.

[6]Well determined money demand functions for the United Kingdom have been found by, among others, L. D. D. Price, "The Demand for Money in the United Kingdom: A Further Investigation," Bank of England *Quarterly Bulletin* (March 1972), pp. 43-55, and Michael J. Hamburger, "The Demand for Money in an Open Economy: Germany and the United Kingdom," *Journal of Monetary Economics* (January 1977), pp. 25-40. In his paper, "The Demand for Money in the United Kingdom: Experience Since 1971," Bank of England *Quarterly Bulletin* (September 1974), pp. 284-305, Graham Hacche found that the fit of previously estimated M1 demand equations for the United Kingdom appeared to deteriorate towards the end of 1971. This might perhaps suggest that the money-income relationship is not particularly stable in the United Kingdom. However, a more recent study, R. T. Coghlan, "A Transactions Demand for Money," Bank of England *Quarterly Bulletin* (March 1976), p. 51, found that " . . . the evidence would now appear to support the existence of a stable demand-for-money function. . . ." It is suggested in Michael J. Hamburger and Geoffrey E. Wood, "Interest Rates and Monetary Policy in Open Economies" (Paper presented at the Allied Social Science Association's Annual Meeting, New York, December 26-30, 1977), that the deterioration in fit which Hacche found may have been due to a policy-induced change in the structure of financial markets.

[7]An analysis of how, in these conditions, monetary policy can only accommodate income fluctuations can be found in Robert A. Mundell, "The Appropriate Use of Monetary and Fiscal Policy for Internal and External Stability," *International Monetary Fund Staff Papers* (March 1962), pp. 70-79. A description by the U.K. monetary authorities themselves of their attitude towards interest rates can be found in "Key Issues in Monetary and Credit Policy," a speech by L. K. (now Lord) O'Brien, then Governor of the Bank of England, given at an international banking conference at Munich on May 28, 1971, and printed in the Bank of England *Quarterly Bulletin* (June 1971), pp. 195-98. Williams et al. do not say explicitly that they consider exchange rate policy and interest rate policy to have produced their results. Their article does, however, contain a summary of the conduct of U.K. monetary policy similar to that given above, and concludes with a sentence which can readily bear the interpretation that they believe that, as a consequence of seeking other objectives, the authorities lost control over U.K. monetary conditions. "This suggests, perhaps, a more complicated causal relationship between money and incomes in which both are determined simultaneously."

It is conceivable in principle that the results of Williams et al. were produced because the adjustment of income to money was complete within the unit of observation. But that does not seem a reasonable explanation in the present case, as it would imply a lag of about one-eighth of that found by other studies. These studies are surveyed in David Laidler, "Inflation in Britain: A Monetarist Perspective," *American Economic Review* (September 1976), pp. 485-500.

[8]A most useful analysis of economic policy in the United Kingdom, highlighting the relationship between the conduct of monetary policy and the state of the balance of payments, can be found in Dietrich K. Fausten, *The Consistency of British Balance of Payments Policies* (London: Macmillan, 1975).

Therefore, the conflict between the results of Williams, Goodhart, and Gowland and the finding of a stable money demand function in the United Kingdom can be reconciled by the argument that the causal relationship between money and income in their data period should be, as indeed they found it, not clear cut in either direction. The relationship would vary with both the origin of the monetary impulse (whether or not it came from abroad), and the effect it was allowed to have on the exchange rate or the United Kingdom's stock of international reserves.

Furthermore, the analysis also suggests why Sims encountered no such interpretation problems. He applied the test to the United States, which was the reserve center in his data period, and therefore produced results consistent with both United States money demand studies and more general studies such as Milton Friedman and Anna Jacobson Schwartz, *A Monetary History of the United States, 1867-1960* (Princeton: Princeton University Press, 1963).[9]

The empirical findings of Sims and of Williams, Goodhart, and Gowland are consistent with the above analysis of the importance of both the exchange rate regime and how it influenced the behavior of policymakers in the interpretation of the money-income relationship. They do not, however, yield very strong support for this proposition, since the implication from the monetary approach to balance of payments was that when applying the Sims test, the exchange rate regime should not affect the result for the United States and that the test should reveal no clear cut relationship for the United Kingdom. It is strongly desirable that the analysis be tested on some other data set, for which it yields a different and more clear-cut prediction.[10]

The Choice of Period for Testing

It might appear that data from any country, except the United States, would be suitable so long as it was from the period of floating exchange rates since the breakdown of the Bretton Woods system in 1971-72. There are, however, two difficulties with such a choice. First, the period is rather short for the testing of a money-income relationship by the Sims method. Second, the float has not been free from official exchange market intervention, so the results of a causality test would be predicted to remain ambiguous. Nor can any suitable data be obtained prior to the breakdown of the Bretton Woods agreement, for virtually no country pursued an unvarying exchange rate policy throughout that period.

There is, however, one set of data, although certainly not recent, which is suitable for the present test. It consists of U.K. data for the period 1870 to 1914, the heyday of the gold standard and fixed exchange rates. This episode is long enough for the testing of a money-income relationship, the exchange rate was pegged throughout the period, and the focus of monetary policy was the condition of the balance of payments.[11] Hence, the situation corresponds exactly to the fixed exchange rate model analyzed by, for example, R. A. Mundell, in which monetary policy cannot affect income, but rather income fluctuations produce accommodating monetary flows.[12]

Accordingly, an application of the Sims causality test to this period, if it found that income led money, would support the proposition that the exchange rate regime is crucial to the interpretation of the results of a two variable test for the causal relationship between money and income.

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[9]Questions have been raised about Sims' findings, but his findings seem to be fairly generally accepted; see, for example, Yash P. Mehra, "An Empirical Note on Some Monetarist Propositions," *Southern Economic Journal* (July 1978), pp. 154-67. A discussion and assessment of the reasons underlying the questioning of Sims' findings can be found in G. William Schwert, "Tests of Causality: The Message in the Innovations" (Working Paper Series No. GPB77-4, Graduate School of Management, University of Rochester, 1977).

[10]Bluford H. Putnam and D. Sykes Wilford, "Money, Income, and Causality in the United States and the United Kingdom: A Theoretical Explanation of Different Findings," *American Economic Review* (June 1978), pp. 423-27, use a simple formal model, based upon the monetary approach to balance-of-payments analysis, to develop a reconciliation of the Sims and Williams et al. results which is similar to that suggested above. However, their reconciliation depends on the assumption of very rapid arbitrage of prices internationally. Without that assumption, which is inconsistent with findings in John Williamson and Geoffrey E. Wood, "The British Inflation, Indigenous or Imported?" *American Economic Review* [September 1976], pp. 520-31, one must take account of the interaction of the attitudes of the monetary authorities with the exchange rate regime, in the manner done above, before the findings of Sims and Williams et al. can be reconciled. Further, Putnam and Wilford's paper includes no empirical work.

[11]Some countries had their exchange rates pegged to sterling, so the system was not the pure gold standard of theory. The Bank of England did, however, act by gold standard rules and adjusted monetary policy as indicated by the U.K. balance of payments. A brief and vivid description of the conduct of U.K. monetary policy in this period can be found in Norman Macrae, "Towards a Keynesian Friedmanism," *The Economist*, June 17-23, 1978, pp. 37-41, and a detailed analysis is given in Alec G. Ford, *The Gold Standard, 1880-1914: Britain and Argentina* (Oxford: Clarendon Press, 1962).

[12]See R. A. Mundell, "The Appropriate Use of Monetary and Fiscal Policy." That would also be the prediction of Putnam and Wilford's model, "Money, Income, and Causality," if one relaxed their assumption of very rapid price arbitrage.

Details of the Test

The relationship between nominal income and nominal money was assumed to be linear in levels of the variables; identical results were found when the estimation procedure was repeated with the variables in logarithmic form.[13]

The number of future and past lags included in the regressions was determined by the form of the data. The M series relates to year-end stock whereas the Y series relates to a flow throughout the year. Thus the income observation associated with year t, Y_t, must be regarded as leading the corresponding money observation, M_t, by approximately six months. Therefore, when regressing M on Y, the contemporaneous variable Y_t must be regarded as a past lag, whereas when regressing Y on M, the contemporaneous variable M_t must be considered as a future lag.

Incorporating that point and considering the degrees of freedom available led to the specification of the following regression models.

$$(1a)\quad M_t = \alpha_{10} + \alpha_{11}t + \sum_{i=1}^{3} \beta_{1i} Y_{t+i} + \sum_{j=0}^{5} \gamma_{1j} Y_{t-j} + u_{1t}.$$

$$(2a)\quad Y_t = \alpha_{20} + \alpha_{21}t + \sum_{i=0}^{3} \beta_{2i} M_{t+i} + \sum_{j=1}^{5} \gamma_{2j} M_{t-j} + u_{2t}.$$

In terms of the coefficients of these models, unidirectional causality from Y to M requires that

$$\beta_1 = [\beta_{11}, \beta_{12}, \beta_{13}] = 0$$

$$\gamma_1 = [\gamma_{11}, \ldots, \gamma_{15}] \neq 0$$

$$\beta_2 = [\beta_{20}, \ldots, \beta_{23}] \neq 0$$

and $$\gamma_2 = [\gamma_{21}, \ldots, \gamma_{25}] = 0.$$

Unidirectional causality from M to Y, on the other hand, requires that

$$\beta_1 \neq 0$$

$$\gamma_1 = 0.$$

$$\beta_2 = 0$$

and $$\gamma_2 \neq 0$$

The first set of conditions would show Y temporally leading M and the second would show M temporally leading Y.

[13] As nominal income from 1870 to 1914 we used GNP, and as money for that period we used a series calculated by Shizuya Nishimura, *The Decline of Inland Bills of Exchange in the London Money Market, 1855-1913* (London: Cambridge University Press, 1971). This latter series is the closest approximation to current M1 which is available for our data period; we are indebted to Professor Nishimura for his extensive discussion of the series with us.

The actual estimation and testing procedures are outlined in the Appendix, while the resulting estimates and test statistics, accompanied by related summary statistics, are given in Table I. Columns (1b) and (2b) show the results obtained by estimating the two equations under the assumption that the errors were generated by a first order autoregressive process, with ρ denoting the estimate of the coefficient of that process. Columns (1c) and (2c) show the results obtained from estimating the equations under the restrictions $\beta_1 = 0$ and $\beta_2 = 0$ respectively, while columns (1d) and (2d) show the results obtained under the restrictions $\gamma_1 = 0$ and $\gamma_2 = 0$. The variable L denotes the log likelihood of each estimated equation and T denotes the number of observations. The χ^2 statistics derived from these log likelihoods test the above restrictions as follows: χ^2_{1c} tests the null hypothesis $\beta_i = 0$, and χ^2_{1d} tests the null hypothesis $\gamma_i = 0$. (See Appendix for further details.)

From the values of χ^2_{1c} and χ^2_{2d}, we cannot reject the null hypotheses $\beta_1 = 0$ and $\gamma_2 = 0$ at any conventional significance level, whereas from the values of χ^2_{2c} and χ^2_{1d}, the null hypotheses $\beta_2 = 0$ and $\gamma_1 = 0$ can be rejected at the .005 and .05 levels of significance respectively. In view of the conditions required for the existence of unidirectional causality, these results imply that there is unidirectional causality between Y and M, the direction of causality being from Y to M. In other words, fluctuations in Y induce fluctuations in M. There is no evidence to suggest that there is any causality running from M to Y.

Although the estimated regression coefficients show that the lag distributions are rather loosely determined — no doubt a consequence of the lack of any prior restrictions on their shape — one important feature emerges. The largest and most significant coefficients appear on the contemporaneous independent variables in all regressions, on the one period past lag variable in the M on Y regressions and on the one period future lag variable in the Y on M regressions. In view of the data considerations discussed previously, this suggests that income led money by 6 to 18 months.

Summary and Conclusions

It has been argued that, when interpreting the results of the Sims test for causality, it is essential to consider the expected effects of exchange rate policy if the test is being used to examine the relationship between money and income. The results of both the

Table I

Statistical Results for the Money-Income Relationships

Coeff.	(1b) Est.	(1b) S.E.	(1c) Est.	(1c) S.E.	(1d) Est.	(1d) S.E.
β_3	.045	.064	—	—	.003	.059
β_2	.039	.088	—	—	.067	.070
β_1	.077	.086	—	—	.103	.068
γ_0	.144	.085	.164*	.069	—	—
γ_1	.122	.091	.094	.078	—	—
γ_2	.023	.091	–.007	.080	—	—
γ_3	.012	.098	.039	.093	—	—
γ_4	–.002	.123	–.014	.107	—	—
γ_5	–.051	.090	–.018	.079	—	—
α_0	62.640	63.483	140.856*	57.369	245.414*	55.579
α_1	1.241	3.470	6.398*	2.739	13.883*	3.409
ρ_1	.513*	.145	.597*	.136	.716*	.118
R^2	.9925	—	.9917	—	.9893	—
L	–87.08	—	–89.03	—	–93.58	—
T = 35			$X^2_{1c}(3) = 3.90$		$X^2_{1d}(6) = 12.99$	

	(2b)		(2c)		(2d)	
β_3	–.621	.391	—	—	–.597	.379
β_2	.226	.450	—	—	.147	.432
β_1	.807	.430	—	—	.928*	.419
β_0	1.119*	.426	—	—	1.293*	.389
γ_1	.514	.418	.835	.473	—	—
γ_2	.009	.415	.073	.490	—	—
γ_3	–.076	.428	–.212	.492	—	—
γ_4	–.446	.421	–.341	.484	—	—
γ_5	.582	.858	.678	.423	—	—
α_0	–45.657	172.472	249.015	157.43	60.444	161.828
α_1	1.644	8.479	17.414*	6.563	5.672	8.359
ρ_2	.526*	.144	.565*	.139	.547*	.142
R^2	.9907	—	.9842	—	.9887	—
L	–188.17	—	–127.40	—	–121.48	—
			$X^2_{2c}(4) = 18.45$		$X^2_{2d}(5) = 6.60$	

S.E. = Standard errors.

*Denotes coefficient significantly different from zero at 5 percent level.

Sims study of the United States and the Williams, Goodhart, and Gowland study of the United Kingdom are consistent with this approach, but neither study was well suited to testing this proposition. Accordingly, the Sims test was used to analyze the money-income relationship for the United Kingdom during a period when a different relationship from that found by either Sims or Williams, Goodhart, and Gowland was predicted. The results were found to confirm the importance of assessing the impact of exchange rate policy.

Further, these results seem to resolve the apparent inconsistency between the results of Sims-type studies of the United Kingdom in the Bretton Woods era, and those of money demand studies. It appears that the exchange rate regime masked the underlying money-income relationship from tests of the Sims type. Therefore, the results from money demand studies are more useful in revealing the money-income relationship for the United Kingdom (and presumably other such countries) in the Bretton Woods period than are Sims-type results.

APPENDIX

The basic equations to be estimated are

$$(1a)\quad M_t = \alpha_{10} + \alpha_{11}t + \sum_{i=1}^{3}\beta_{1i}Y_{t+i} + \sum_{j=0}^{5}\gamma_{1j}Y_{t-j} + u_{1t}$$

$$(2a)\quad Y_t = \alpha_{20} + \alpha_{21}t + \sum_{i=0}^{3}\beta_{2i}M_{t+i} + \sum_{j=1}^{5}\gamma_{2j}M_{t-j} + u_{2t}$$

$$t = 1, 2, \ldots, T.$$

However, as the precise use of significance tests on groups of coefficients is required, it is important that the errors in the regressions be serially uncorrelated. Although the inclusion of a linear time trend in the equations will partially account for serial correlation, the error terms were assumed to be generated by first order autoregressive processes, that is:

$$(3)\quad u_{1t} = \rho_1 u_{1,\,t-1} + \epsilon_{1t},$$

$$(4)\quad u_{2t} = \rho_2 u_{2,\,t-1} + \epsilon_{2t},$$

with ϵ_{1t} and ϵ_{2t} assumed to be independently normally distributed random variables with zero means and constant variances. This assumption led to the use of maximum likelihood estimation methods rather than conventional regression techniques. Equations (1a) and (2a) were transformed using (3) and (4) to obtain

$$(1b)\quad M_t^{\circ} = \alpha_{10}(1-\rho_1) + \alpha_{11}t^{\circ} + \sum_{i=1}^{3}\beta_{1i}Y^{\circ}_{t+i} + \sum_{j=0}^{5}\gamma_{1j}Y^{\circ}_{t-j} + \epsilon_{1t}$$

$$(2b)\quad Y_t^{\circ\circ} = \alpha_{20}(1-\rho_2) + \alpha_{21}t^{\circ\circ} + \sum_{i=0}^{3}\beta_{2i}M^{\circ\circ}_{t+i} + \sum_{j=1}^{5}\gamma_{2j}M^{\circ\circ}_{t-j} + \epsilon_{2t}$$

where $M_t^{\circ} = M_t - \rho_1 M_{t-1}$, $M_t^{\circ\circ} = M_t - \rho_2 M_{t-1}$, etc.

The maximum likelihood (ML) estimate of ρ_i, i = 1 or 2, was obtained by minimizing

$$\hat{\sigma}^2_{ib}(\rho_i)/(1-\rho_i^2)^{1/T}$$

where $\hat{\sigma}^2_{ib}(\rho_i) = S_{ib}(\rho_i)/T$, $S_{ib}(\rho_i)$ being the residual sum of squares from the regression of equation (ib), i = 1 or 2, associated with a given value of ρ_i.[1] This minimization was actually accomplished by searching over the admissible range of ρ_i, (−1, 1). ML estimates of the other parameters of (ib) were obtained as the coefficients of the regression associated with the ML estimate $\hat{\rho}_{ib}$.

Under the hypotheses $\beta_1 = 0$ and $\beta_2 = 0$, the following restricted models were obtained:

$$(1c)\quad M_t^{\circ} = \alpha_{10}(1-\rho_1) + \alpha_{11}t^{\circ} + \sum_{j=0}^{5}\gamma_{1j}Y^{\circ}_{t-j} + \epsilon_{1t}$$

$$(2c)\quad Y_t^{\circ\circ} = \alpha_{20}(1-\rho_2) + \alpha_{21}t^{\circ\circ} + \sum_{j=1}^{5}\gamma_{2j}Y^{\circ\circ}_{t-j} + \epsilon_{2t}.$$

Again, ML estimates of the parameters of these models were obtained by minimizing

$$\hat{\sigma}^2_{ic}(\rho_i)/(1-\rho_i^2)^{1/T}$$

and estimating the coefficients if the regression associated with $\hat{\rho}_{ic}$.

The above hypotheses were tested by constructing the appropriate likelihood ratio test. Since the maximum log likelihood of equations (ib) and (ic), denoted L_{ib} and L_{ic}, are

$$L_{ib} = \text{Constant} - \frac{T}{2}\ln\left[\frac{\hat{\sigma}^2(\rho_{ib})}{(1-\hat{\rho}_{ib}^2)^{1/T}}\right]$$

and

$$L_{ic} = \text{Constant} - \frac{T}{2}\ln\left[\frac{\hat{\sigma}^2(\rho_{ic})}{(1-\hat{\rho}_{ic}^2)^{1/T}}\right]$$

respectively, then the statistic

$$\chi^2_{ic} = 2(L_{ib} - L_{ic})$$

is asymptotically distributed as chi square with k_i degress of freedom, k_i being the number of coefficients in β_i.[2] Values of this statistic greater than $\chi^2_{\alpha}(k_i)$ will reject the null hypothesis $\beta_i = 0$ at the $(1-\alpha)$ level of significance.

A similar approach was taken in testing the hypotheses $\gamma_1 = 0$ and $\gamma_2 = 0$. Here the restricted models were given by

$$(1d)\quad M_t^{\circ} = \alpha_{10}(1-\rho_1) + \alpha_{11}t^{\circ} + \sum_{i=1}^{3}\beta_{1i}Y^{\circ}_{t+i} + \epsilon_{1t}$$

$$(2d)\quad Y_t^{\circ\circ} = \alpha_{20}(1-\rho_2) + \alpha_{21}t^{\circ\circ} + \sum_{i=0}^{3}\beta_{2i}M^{\circ\circ}_{t+i} + \epsilon_{2t}.$$

ML estimation of these models leads to the test statistic

$$\chi^2_{id} = 2(L_{ib} - L_{id}),$$

values of which greater than $\chi^2_{\alpha}(h_i)$, where h_i is the number of coefficients in γ_i, lead to the rejection of the null hypothesis $\gamma_i = 0$ at the $(1-\alpha)$ level of significance.

[1] See Phoebus J. Dhrymes, *Distributed Lags: Problems of Estimation and Formulation* (San Francisco: Holden-Day, 1971), pp. 64-70.

[2] See Dhrymes, "Distributed Lags," pp. 83-84.