

Review

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In This Issue . . .

The articles in this *Review* focus on three different areas of monetary policy that are frequently subject to misunderstanding and misperceptions: the determination of foreign exchange rates, seasonal adjustment procedures and the issue of lagged vs. contemporaneous reserve accounting.

Media and policy discussions frequently place the blame for many economic ills, both domestic and international, on the system of floating (market-determined) exchange rates that has existed for the past decade. In the first article of this issue, "Five Common Myths About Floating Exchange Rates," Dallas S. Batten and Mack Ott point out that, when these criticisms are considered more carefully, they reflect a shared misinterpretation of the data and, at times, a misunderstanding of exchange rate determination itself. In investigating the merits of these complaints against floating exchange rates, the authors provide a simple analytic description of the process through which exchange rates are determined and identify the important influences that affect exchange rate movements. They then apply this framework to the analysis of five commonly held views about exchange rates and demonstrate how these are inconsistent with both the data and generally accepted economic theory. The authors conclude that, contrary to the beliefs of many, floating exchange rates merely reflect international economic conditions; they do not create them.

In the second article, "Seasonally Adjusting Money: Procedures, Problems, Proposals," Scott E. Hein and Mack Ott note that economic activity typically varies systematically over the year—in response to the seasons, holidays and a variety of other annually recurring activities. For many analytical and policymaking purposes, it is useful to remove this seasonal variability in economic data so that longer-term influences and trends are more clearly revealed. For this reason, the most widely cited economic data, such as figures about GNP, employment or monetary growth, typically are reported in a seasonally adjusted form.

Since 1982, the seasonal adjustment procedure applied to U.S. monetary data has been the X-11 ARIMA procedure, which is a variant of the X-11 seasonal adjustment procedure developed by the Census Bureau of the U.S. Department of Commerce. While this procedure is well understood and widely used on economic data by governments around the world, its performance in seasonally adjusting money is subject to two important criticisms: bias and smoothing. These shortcomings present crucial problems both for the setting of monetary policy and its subsequent evaluation. Hein and Ott discuss these problems and assess recent proposals to deal with them.

In a third article, "Lagged and Contemporaneous Reserve Accounting: An Alternative View," Daniel L. Thornton reassesses the primary argument that influenced the Federal Reserve's decision to return to contemporaneous reserve accounting. In particular, Thornton questions whether the return to contemporaneous will actually result in a significant reduction in the variability of money by restoring the contemporaneous link between depository institutions' reserves and their transaction deposits. Thornton shows that depository institutions can manage their assets and liabilities in such a way as to weaken this contemporaneous link even under a system of contemporaneous reserve accounting.

In This Issue . . .

Thornton points out the difficulties in isolating the effects of the change in the reserve accounting system on the variability of money and interest rates. Finally, using weekly data from 1966 to 1982, he finds little evidence that the move to lagged reserve accounting in 1968 had any significant effect on the variability of money.

Five Common Myths About Floating Exchange Rates

DALLAS S. BATTEN and MACK OTT

MORE than a decade has passed since the demise of the Bretton Woods system of fixed exchange rates.¹ Because of its demonstrated inability to provide for the institutional adjustment of exchange rates necessary to incorporate change, there is general agreement that the Bretton Woods system, under which world trade was organized from 1945 to 1971, could not have been maintained.² Moreover, the viability of the system of floating exchange rates is buttressed by both a massive

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¹Since 1973–74 every country has faced the choice of whether to allow its currency to float; most countries have chosen not to float freely:

Of the 146 countries comprising the membership of the International Monetary Fund, 37 peg their currency to the U.S. Dollar, 13 to the exchange rate of the French Franc, 14 to SDRs, 24 to some other composite unit, and 5 to some other currency. Eight countries, the members of the European Monetary System, peg their currencies to the European Currency Unit and to each other while floating freely against other currencies. Thirty-seven countries have miscellaneous arrangements. Only eight countries, (including the United States) permit their individual currencies to float freely.

International Letter, Federal Reserve Bank of Chicago (May 20, 1983), p. 1. This result neither refutes the advantages of floating rates nor surprises floating-rate advocates. Both Milton Friedman, in Milton Friedman and Robert V. Roosa, *The Balance of Payments: Free Versus Fixed Exchange Rates* (American Enterprise Institute for Public Policy Research, 1967), p. 121, and Harry G. Johnson, "The Case for Flexible Exchange Rates, 1969," this *Review* (June 1969), pp. 12–24, have noted that a fixed rate has advantages for small open economies and that closely knit trading partners would find a joint float preferable. Moreover, they argued that only the most important currencies (the dollar, the mark and the yen) have to be market determined for the advantages of floating rates to accrue.

²For examples, see Leif H. Olsen, "The Nostalgia for Bretton Woods," *Wall Street Journal*, May 25, 1983; Irwin L. Kellner, *The Manufacturers Hanover Economic Report* (May 1983); and David R. Francis, "Why World Bankers Look Askance at Returning to Fixed Exchange Rates," *Christian Science Monitor*, May 24, 1983.

body of theoretical support and a continuing emergence of institutions that facilitate international trade under such a system.³

Despite the theoretical arguments and historical evidence supporting the benefits of floating exchange rates, there have been many calls for a return to fixed exchange rates.⁴ The criticisms of floating exchange rates have emanated from a variety of spokesmen — businessmen, politicians and columnists — and have led to media discussions that blame floating exchange rates for a wide variety of economic ills, both domestic and international. When carefully considered, however, most criticisms of floating exchange rates share some common misinterpretations of international data or misunderstandings of exchange rate determination.

Rather than confronting the broad issue of whether floating or fixed exchange rates are preferable, we choose to examine five common myths about floating exchange rates that have received considerable support in the financial and general press. Since these

³For examples, see Milton Friedman, "The Case for Flexible Exchange Rates," in his *Essays in Positive Economics* (University of Chicago Press, 1953), pp. 157–203; Johnson, "The Case for Flexible Exchange Rates, 1969"; Johan Myhrman, "Experiences of Flexible Exchange Rates in Earlier Periods: Theories, Evidence, and a New View," *Scandinavian Journal of Economics* V. 78, No. 2 (1976), pp. 169–96; and Roy A. Batchelor and Geoffrey E. Wood, "Floating Exchange Rates: The Lessons of Experience," in Batchelor and Wood, eds., *Exchange Rate Policy* (St. Martin's Press, 1982), pp. 12–34.

⁴The best known among these is President Francois Mitterrand of France who, addressing a recent meeting of the Organization of Economic Cooperation and Development in New York City, said: "The time has come to think of a new Bretton Woods . . . Outside this proposition, there will be no salvation." "Mitterrand Seeks Parley to Revamp Monetary System," *New York Times*, May 10, 1983.

misconceptions frequently are based on a faulty understanding of exchange rate determination, we first outline the elements of the modern asset market view of exchange rates.

ELEMENTS OF EXCHANGE RATE DETERMINATION⁵

An exchange rate is simply the relative price of two assets — one country's currency in terms of another's — which is determined in relatively efficient markets in the same manner as are the prices of other assets, such as stocks, bonds or real estate. Unlike the prices of services or nondurable goods, asset prices are influenced comparatively little by current events. Thus, for example, daily fluctuations in the flow of buyers to a farmers' market have a great impact on the prices of vegetables sold there but almost no impact on the price of the farms producing those vegetables; instead, longer-term expectations of demands and supplies of vegetables govern the farms' values. Similarly, the values of national currencies do not rise or fall with contemporaneous exports or imports of goods and services but rather with the long-term expectations of their countries' economic prospects.

Given the dominance of this long-term perspective in exchange rate determination, several characteristics of the modern theory of asset price determination are of both theoretical and empirical relevance. First, asset price movements are irregular and unpredictable; that is, they behave as a random walk in the short run. Since the current price already reflects the expected future value of assets, this observed unpredictability can reflect only unexpected events or "news."⁶

⁵The asset market view of exchange rate determination sketched in this section follows that of Michael Mussa, "Empirical Regularities in the Behavior of Exchange Rates and Theories of Foreign Exchange Markets," in Karl Brunner and Allan H. Meltzer, eds., *Policies for Employment, Prices, and Exchange Rates*, Carnegie-Rochester Conference Series on Public Policy (supplement to the *Journal of Monetary Economics*, Volume 11, 1979), pp. 9–57. It is the predominant view of most international economists due to its ability to explain many of the empirical regularities in the behavior of exchange rates that have been exhibited throughout our experience with floating exchange rates. See also Jacob Frenkel, "Flexible Exchange Rates, Prices, and the Role of 'News': Lessons from the 1970s," *Journal of Political Economy* (August 1981), pp. 665–705. It should be noted, at the outset, that we do not intend to present a complete theory of exchange rate determination, nor even extend the state of the current theory. Instead, we will follow up this sketch of accepted theory with what we consider to be widely held misconceptions concerning both the determination of exchange rates and the consequences of exchange rate changes, and then demonstrate how these misconceptions are inconsistent with both the data and generally accepted economic theory.

⁶See Frenkel, "Flexible Exchange Rates, Prices, and the Role of 'News'."

Second, exchange rates reflect anticipated relative inflation rates that are generated by both past and expected future monetary and fiscal policies of the countries whose currencies are valued in the exchange rate. Therefore, currencies of countries with relatively lower expected inflation rates are cheaper to hold over time and are in greater demand at the same price than those with higher expected inflation rates. Consequently, higher-inflation currencies will tend to depreciate relative to lower-inflation currencies.

Third, in the long run, exchange rates move to maintain purchasing power parity (PPP) among the various countries; PPP means that a dollar's worth of the foreign currency (at the current exchange rate) will buy the same amount of goods in the foreign country as a dollar will buy in the United States. If so, the ratio of the U.S. price level to that of the foreign country will equal the exchange rate. Nonetheless, due to interest rate movements, among other things, short-run departures from this condition are observed frequently. Also, over long periods, relative scarcities and labor productivities in different countries may change at different rates, altering the equilibrium absolute PPP. Therefore, a somewhat weaker form of this condition, relative purchasing power parity (RPPP), which asserts that changes in the exchange rate will equal *changes* in the ratio of U.S. to foreign price levels, is a more reliable, but not infallible, short-run guide.

Fourth, paralleling PPP is a condition called interest rate parity (IRP). IRP means that the real yield — net of expected inflation and expected exchange rate changes — obtained by investing in securities in any given currency will be roughly equal to the yield obtained from securities in any other currency. For example, IRP implies that a German investor would expect to obtain the same return from buying a short-term Bundesbank security and then selling it three months later as he could alternatively obtain from selling deutsche marks (DMs) to get dollars, using the dollars to buy a U.S. Treasury bill, selling it three months later and then using the dollar proceeds to buy DMs. Other things equal, if the real yield in Germany rises relative to that in the United States, the dollar would depreciate.

Each of these four elements of exchange rate determination operates simultaneously so that exchange rate movements can seldom, if ever, be attributed to a single cause. Conversely, all of these elements can be understood to result from the aggressive interactions of well-informed, profit-seeking traders transacting in well-organized, international currency markets. Any trader who by his possession of some new information

sees an opportunity for profit will make transactions which will tend to move exchange rates both to reflect that new information and to foreclose the opportunity for further profit. This tendency for market prices of assets, such as exchange rates, to reflect quickly all relevant new information is the primary characteristic of an "efficient market." This efficient market property will be useful in examining the five common myths about floating exchange rates.

MYTH 1: FLOATING EXCHANGE RATES HINDER INTERNATIONAL TRADE.

Proponents of a return to fixed exchange rates argue that since exchange rate fluctuations are obviously larger in a floating rate system, there is more uncertainty associated with international trade in such a system. Consequently, they contend that floating exchange rates raise more impediments to international trade than would exist if exchange rates were fixed.⁷

A *floating* exchange rate is one whose equilibrium value is determined by market forces, not by the intervention of monetary authorities in foreign exchange markets.⁸ As previously outlined, the factors that influence exchange rates are not only those factors that reflect current conditions of demand and supply in foreign exchange markets, but also market participants' *expectations* about those conditions in the future. Increases (or decreases) in exchange rates, therefore, are responses to changes in both current market forces and expectations of future market conditions — changes that will occur regardless of the type of exchange rate system.

⁷For example: "There is broad agreement that exchange rates play an important role in the international adjustment process. . . . However, in the judgment of some countries, exchange rates have deviated at times strongly in the short- and medium-term from the rates that appeared to be warranted by fundamental determinants such as price or current-account developments. In addition, it is widely felt that excessive short- and medium-term exchange rate variability has adverse consequences for domestic economic developments and the working of the international adjustment process," excerpted from the introduction to the *Report of the Working Group on Exchange Market Intervention*, established at the Versailles Summit of the Heads of State and Government (March 1983). See also, Otmar Emminger, "All Nations Need An Exchange Rate Policy," *New York Journal of Commerce*, October 5, 1981; Jack Kemp, "A Floating Dollar Costs Us Jobs," *Washington Post*, May 15, 1983; and Richard W. Rahn, "It Is Time for a New International Monetary Conference," *Economic Outlook*, Chamber of Commerce of the United States, June 28, 1983.

⁸For a discussion of how official intervention may affect the exchange rate, see Dallas S. Batten and James E. Kamphoefner, "The Strong U.S. Dollar: A Dilemma for Foreign Monetary Authorities," this *Review* (August/September 1982), pp. 3–12.

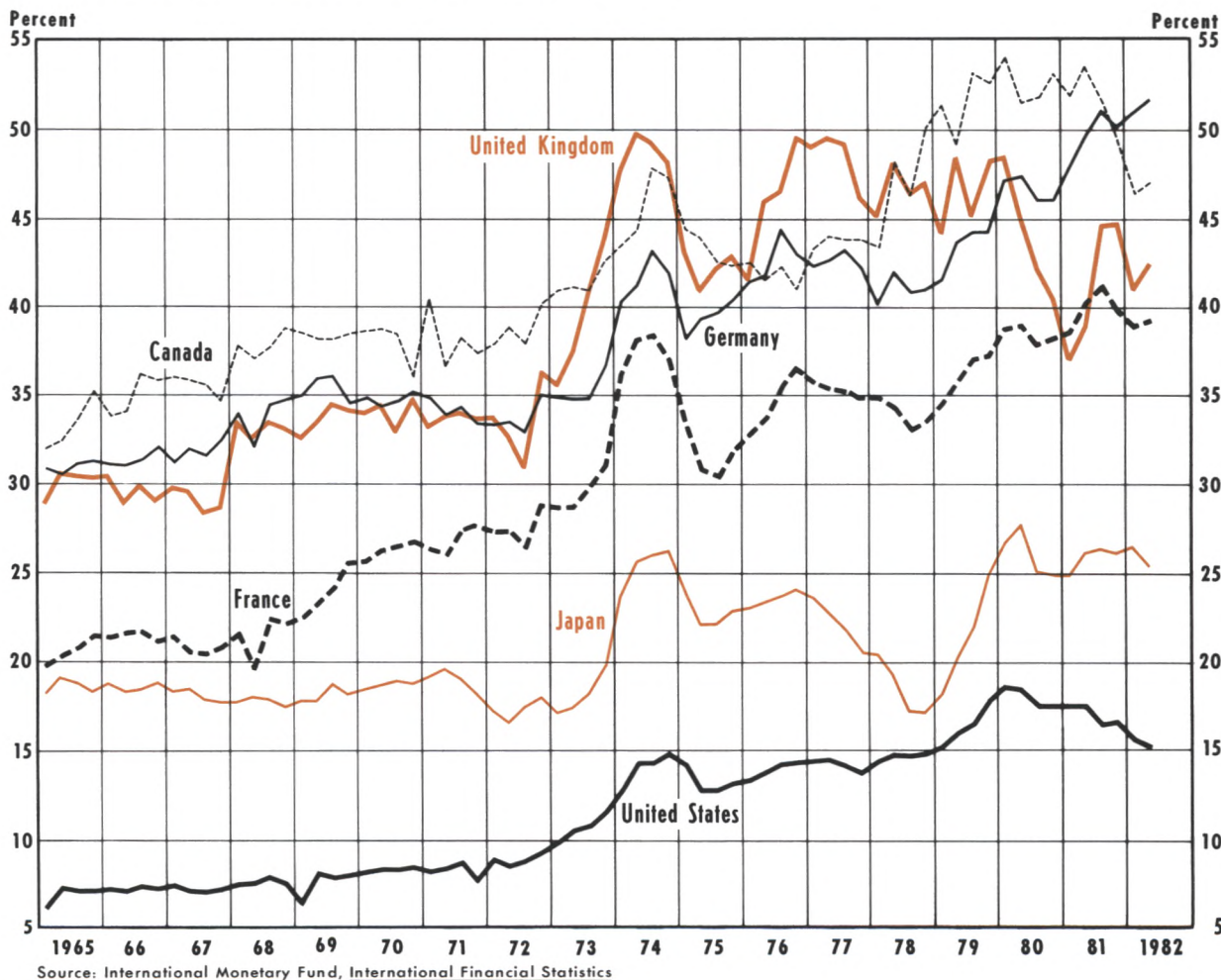
Conversely, a *fixed* exchange rate is one whose value is maintained by the monetary authority through variations in monetary policy. The appearance of less price uncertainty under fixed exchange rates is obtained at the cost of greater policy uncertainty. The maintenance of fixed rates implies following policies (especially monetary) that produce fixed rates. In particular, for an exchange rate to be maintained at a given level, inflation rates and real interest rates in the two countries cannot diverge; or, in other words, the two countries must follow monetary policies that result in such similarities. Any upward or downward pressure on the exchange rate, then, must be countered by appropriate policy changes. This uncertainty associated with potentially frequent and unpredictable policy changes in a system of fixed rates is not present in a system of floating rates. Thus, the appearance of less uncertainty with fixed exchange rates is an illusion. Consequently, the shift from a fixed to a floating exchange rate system should not have a significant negative impact on international trade.

One way of investigating whether or not floating exchange rates have had a negative impact on international trade is to examine the value of total trade (exports plus imports) as a percentage of nominal GNP over time; this is presented in chart 1 for the United States and five other major industrial countries. It is clear from this chart that since March 1973 (the date generally accepted as the beginning of the floating-rate period), there has been no decline in the ratio of trade to GNP. In fact, there is a marked increase in the trend of this ratio for some countries during the floating-rate period.⁹ More rigorous investigations have supported this casual analysis by failing to find any significant negative impact of floating exchange rates on international trade.¹⁰

⁹The trend growth rate of the ratio of trade to GNP in the floating-rate period is significantly larger in a statistical sense than that in the fixed-rate period for Germany, Japan, the United Kingdom and the United States.

¹⁰See Peter Hooper and Steven W. Kohlhagen, "The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade," *Journal of International Economics* (November 1978), pp. 483–511; Bela Balassa, "Flexible Exchange Rates and International Trade," in John S. Chipman and Charles P. Kindleberger, eds., *Flexible Exchange Rates and the Balance of Payments* (North-Holland Publishing Co., 1980), pp. 67–80; Richard N. Cooper, "Flexible Exchange Rates, 1973–1980: How Bad Have They Really Been?" in Richard Cooper, and others, eds., *The International Monetary System Under Flexible Exchange Rates* (Ballinger Publishing Co., 1982), pp. 3–15; and Andrew D. Crockett and Morris Goldstein, "Inflation Under Fixed and Flexible Exchange Rates," *IMF Staff Papers* (November 1976), pp. 509–44. For an analysis of periods other than the 1970s, see Leland B. Yeager, *International Monetary Relations: Theory, History, and Policy*, 2nd ed. (Harper and Row, 1976), pp. 252–77; and Myhrman, "Experiences of Flexible Exchange Rates in Earlier Periods."

Chart 1
Total Trade as a Percentage of Nominal GNP



MYTH 2: A DEPRECIATING CURRENCY GENERATES DOMESTIC INFLATION.

During the period of generally floating exchange rates in the 1970s, most industrial countries experienced episodes of accelerating domestic inflation and exchange rate depreciation. These experiences have given rise to a school of thought that a decline in the exchange rate induces an increase in domestic inflation through an increase in the domestic-currency price of imports. But, an increase in inflation is expected to cause a further decline in the exchange rate, which causes additional inflation and so forth.¹¹ This "vicious

circle" leaves little hope of ever obtaining price stability in a world of floating exchange rates.

This view confuses the relationship between exchange rates and domestic inflation in at least two ways. First, it implies that there is a causal relationship that runs *from* exchange rate changes *to* changes in the rate of domestic inflation. Second, it suggests that inflation is a cost-push phenomenon. An understanding of the relationship between money growth and

Rates, Inflation, and Vicious Circles," *IMF Staff Papers* (December 1980), pp. 679-711; Crockett and Goldstein, "Inflation Under Fixed and Flexible Exchange Rates"; Paul Lewis, "France Hits Record Low; Sharper Quarrel Is Seen," *New York Times*, May 28, 1983; Robert D. Hormats, "Currency-Rate Lessons," *New York Times*, March 27, 1983; and Robert Solomon, *The International Monetary System, 1945-1981* (Harper and Row, 1982), pp. 298-315.

¹¹See John F. O. Bilson, "The 'Vicious Circle' Hypothesis," *IMF Staff Papers* (March 1979), pp. 1-37; Marian E. Bond, "Exchange

inflation, however, should dispel each of these conceptual errors.

Inflation as a Monetary Phenomenon

A country's money supply essentially is determined by its monetary authority; the demand for money (i.e., an individual's desire to hold a portion of his wealth in the form of money) is determined primarily by income, real interest rates, prices and price expectations in that country. The equilibrium rate of inflation is the one at which the growth rate of the money supply equals the growth rate of individuals' desired money holdings. Any other inflation rate motivates individuals to alter their spending rate in an attempt to change their money holdings at a rate different from the rate at which the money supply is growing.

A monetary disequilibrium, through its impact on the rate of aggregate spending, simultaneously induces changes in the rate of domestic inflation and the foreign exchange rate. That is, changes in the rate of consumer spending affect not only domestically produced goods and services but also those produced abroad. Altered demands for foreign goods and services, in turn, produce changes in U.S. demand for foreign currencies and as a consequence, changes in the foreign exchange value of the dollar, all other things equal. Thus, the rate of domestic inflation and changes in the exchange rate are *determined jointly* by the rate of domestic money growth relative to the growth of the amount that individuals, domestic and foreign, desire to hold.

The Cost-Push Fallacy

The cost-push explanation of inflation is supported neither by economic theory nor empirical evidence.¹² This non-monetary explanation of inflation suggests that an exchange rate depreciation raises the domestic currency prices of imported goods and services and, consequently, the cost of living. Wage demands, and subsequently, wages, are presumed to rise to compensate for the increased cost of living. Higher wages would mean higher production costs and, as a result, producers would raise the prices of their commodities. The cost of living would rise, once again initiating a "wage-price spiral" and the vicious circle. This spiraling of wages and prices would be exacerbated within an international framework as the exchange rate would continue to depreciate with rising domestic prices, generating even more inflationary pressure.

¹²See Dallas S. Batten, "Inflation — The Cost-Push Myth," this *Review* (June/July 1981), pp. 20–26.

This argument confuses a change in relative prices with inflation. A depreciation of the foreign exchange value of a currency *does* raise the domestic currency prices of imported goods relative to the prices of those produced domestically. Other things equal, the higher prices of imports would cause the overall price level to rise. The rise in import prices, however, sets in motion both an adjustment in the public's money holdings and in its demand for non-traded goods — that is, domestically produced goods that are not internationally traded.

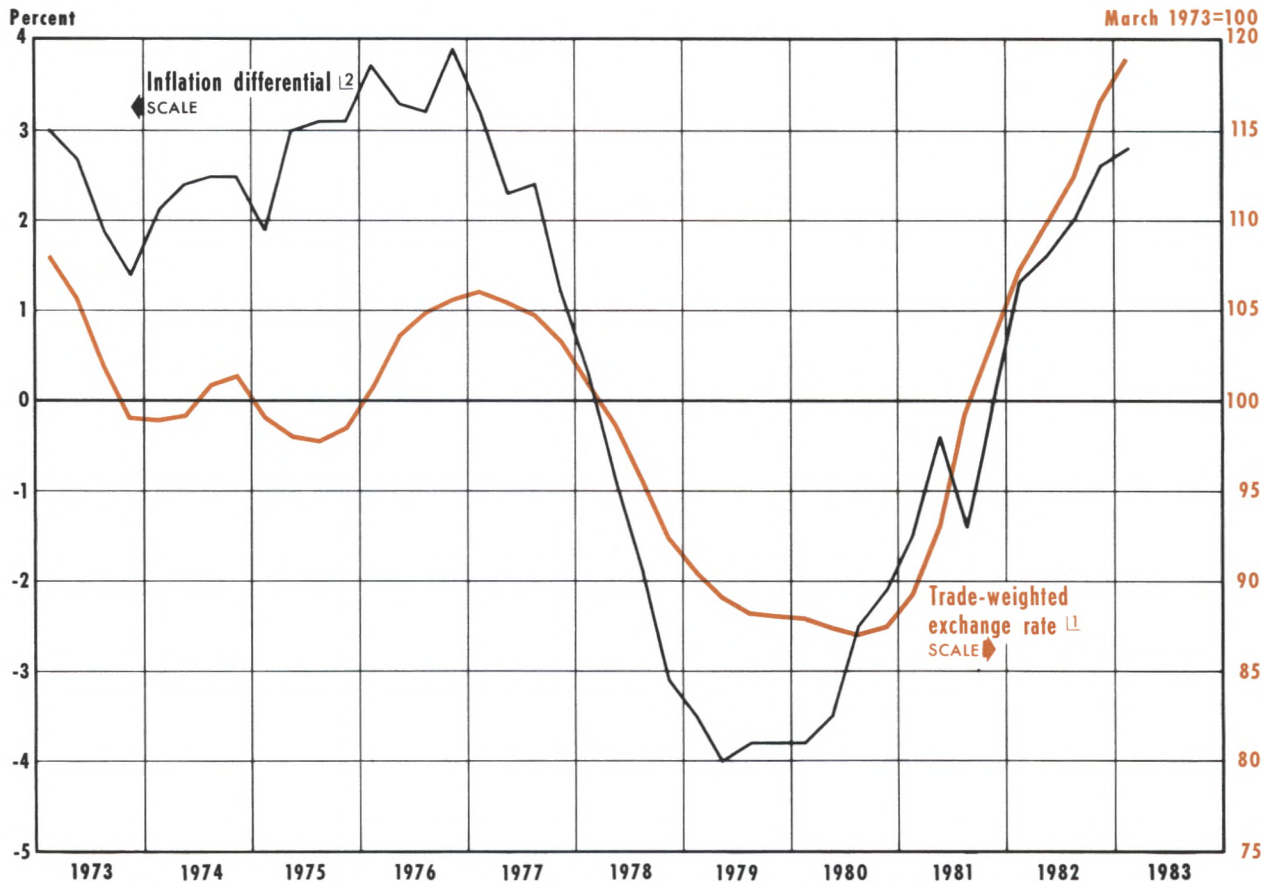
First, the relative increase in the price of imported goods temporarily causes a rise in the rate of inflation; in response, the public increases the rate of growth of its desired money balances. If the rate of growth of the money supply remains constant, there will not be enough additional money available for a new monetary equilibrium to be reached, given this higher rate of inflation. Consequently, in order to increase the rate of growth of their money balances to the desired rate (that is, the equilibrium rate after the exchange rate depreciation), individuals must decrease their spending rate on goods and services, both traded and non-traded.

Second, a decreased growth rate of aggregate spending brought about by the attempt to increase money balances causes a *decline* in the rate of price growth in those sectors of the economy that produce non-traded goods until the overall rate of inflation is the same as it was before the depreciation. The rate of inflation must decline to its original value — that which equates the growth rate of the money supply to that of money demand; it is, after all, the only rate of inflation that can be sustained without a change in the rate of money growth.

Of course, this adjustment in the rate of price growth in the non-traded goods sector does not occur immediately. During the adjustment period, the cost of adjusting is reflected by a decline in the growth of real output (and by a corresponding decline in employment). If the monetary authority confuses this with a permanent decline in the rate of aggregate demand, it may increase the rate of growth of the money supply. This action would accommodate the impact of the currency depreciation and allow the inflation to persist. That is, the cause of the vicious circle has been neither the depreciating currency nor the regime of floating exchange rates that allows such adjustments, but rather the accommodation by the monetary authority.¹³ Such a policy response to changes in the

¹³For additional support, see Bilson, "The 'Vicious Circle' Hypothesis"; and Bond, "Exchange Rates, Inflation, and Vicious Circles."

Chart 2
The Inflation Differential and the Exchange Rate



Sources: Board of Governors of the Federal Reserve System and International Monetary Fund, *International Financial Statistics*.
 L1 Four-quarter moving average.
 L2 Four-quarter growth of the trade-weighted CPI minus U.S. CPI growth.

relative prices of traded and non-traded goods creates the illusion of cost-push inflation, when in fact, the increased rate of inflation is generated by the increased rate of money growth.

MYTH 3: THE DOLLAR IS OVERVALUED.

A variety of pundits have claimed that the dollar is overvalued.¹⁴ The natural question this suggests is:

¹⁴For examples, consider: "Most of this country's current trade troubles — the falling exports, the disputes over other countries' trading tactics, the alleged decline of American industrial competitiveness — are the result of an overpriced dollar, lifted by high interest rates." "Mr. Reagan's Embarrassing Dollar," *Washington Post*, May 4, 1983; "Peter G. Peterson, Chairman of Lehman Brothers Kuhn Loeb, agreed on the question of budget deficits and argued that the dollar is 20 to 25 percent overvalued on a trade-weighted basis. In a year it will be more than that." Ripley

"With respect to what is the dollar overvalued?" In the main, individuals who claim that the dollar is overvalued are arguing that purchasing power parity currently does not hold.

As noted in our earlier discussion, short-run departures from PPP are common and, hence, tell us little about the over- or undervaluation of the dollar. Consequently, RPPP is a better indicator of the dollar's value in the short-run. According to RPPP criterion, the exchange rate should change *roughly* in accordance with changes in inflation rate differentials.¹⁵ To illustrate this relationship, the trade-weighted dollar ex-

Watson, Jr., "Two Obstacles to Economic Growth Cited," *New York Journal of Commerce*, May 3, 1983.

¹⁵Even here, however, short-run departures will be common. See Frenkel, "Flexible Exchange Rates, Prices, and the Role of 'News'," pp. 693-99.

change rate and the trade-weighted inflation rate differential are graphed in chart 2.¹⁶ There is a clear correspondence between the two series; as implied by RPPP, changes in the trade-weighted exchange rate have reflected changes in the trade-weighted inflation rate differential.¹⁷

Monetary Growth and the Speed of Exchange Rate Adjustment

Given the corrective forces brought to bear through floating exchange rates, it is puzzling that any currency could be over- or undervalued persistently. Yet, in the short-run adjustment to a monetary disequilibrium, producers probably cannot discern immediately whether the resulting change in aggregate demand (spending) is permanent or merely temporary. Thus, they respond initially by changing their rate of production. That is, the change in money growth results in a deviation of real economic activity from its "normal" rate. Only when this change in spending is recognized as permanent will producers change their prices and attempt to return their production to its normal rate. Hence, the impact of the monetary disequilibrium on output eventually vanishes, leaving only the rate of inflation permanently affected. These long-run adjustments, however, are not realized immediately.

On the other hand, the exchange rate responds to a monetary disequilibrium more rapidly than do the prices of domestic commodities.¹⁸ This more rapid adjustment occurs because the exchange rate is the relative price of two assets and, unlike commodity

prices, is determined in highly organized, internationally integrated markets that quickly and efficiently assimilate new information. Consequently, the exchange rate will change *before* commodity prices change sufficiently to regain a domestic monetary equilibrium.

During this adjustment period then, a currency will be over- or undervalued in the sense that the PPP condition will be violated. In the long run, however, the rate of domestic inflation generally will change sufficiently to offset deviations from PPP that may have existed in the short run.¹⁹

These deviations of exchange rates from PPP have engendered support for increased official intervention in foreign exchange markets.²⁰ Since these deviations may either be random fluctuations or represent short-run disequilibria, there is no reliable method of discerning the cause of short-run exchange rate movements.²¹ Consequently, policy actions are inappropriate and actually may exacerbate the equilibrating process, thereby lengthening the period of adjustment.²²

Finally, the overvalued dollar myth can also be interpreted as a complaint about domestic capital market conditions that cause the dollar's value to rise above what it otherwise would be. That is, the federal budget deficit may cause domestic interest rates to rise inviting a flow of capital to dollar-denominated assets,

¹⁶The trade-weighted exchange rate is an average of the value of the U.S. dollar against 10 other currencies, weighted by each country's trade share, relative to a base value of 100 in March 1973. The countries included are Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland and the United Kingdom. For a more detailed explanation, see "Index of the Weighted-Average Exchange Value of the U.S. Dollar: Revision," *Federal Reserve Bulletin* (August 1978), p. 700. The trade-weighted inflation differential, as usually expressed, is the difference between the rate of growth of the U.S. CPI and the rate of growth of the trade-weighted foreign CPI for the same countries using the same weights as above. The trade-weighted nominal interest rate differential which is used below is the difference between the U.S. 3-month commercial paper rate and a weighted average of comparable foreign interest rates for the same countries using the same weights as above. The trade-weighted *real* interest rate differential is an *ex post* measure calculated as the difference between the trade-weighted nominal interest rate differential and the same period's trade-weighted inflation rate differential.

¹⁷The correlation coefficient between the trade-weighted exchange rate and the trade-weighted inflation differential over the 1973-83 period was 0.780; the correlation coefficient between changes in the two series was 0.533.

¹⁸See Mussa, "Empirical Regularities," pp. 22-24.

¹⁹Even though the PPP condition has been violated frequently in the short run during the 1970s, there is no evidence that its usefulness as a condition of long-run equilibrium has been mitigated. See Jacob A. Frenkel, "The Collapse of Purchasing Power Parities During the 1970s," *European Economic Review* (May 1981), pp. 145-65.

²⁰See, for example, Valéry Giscard d'Estaing, "A Communique for Williamsburg," *The Economist* (May 21, 1983), pp. 15-18; Helmut Schmidt, "The World Economy at Stake," *The Economist* (February 26, 1983), pp. 19-30; Hobart Rowen, "Fed Chief Asks Action on Dollar," *Washington Post*, April 19, 1983; Paul Lewis, "U.S. Assailed in France Over Strength of Dollar," *New York Times*, April 21, 1983; and "Exchange Rate Woes Must Be Addressed," *Washington Post*, April 17, 1983.

²¹Martin Feldstein, chairman of the President's Council of Economic Advisers, recently wrote: "[T]here is no way in practice to distinguish an exchange-rate movement that is merely a random fluctuation from one that is part of a fundamental shift in the equilibrium exchange rate. Exchange-market intervention aimed at smoothing a transitory disturbance may in fact be a counterproductive or futile attempt to prevent a basic shift in the equilibrium exchange rate." Martin Feldstein, "The World Economy Today," *The Economist* (June 11, 1983), p. 48. See also Mussa, "Empirical Regularities."

²²See Frenkel, "Flexible Exchange Rates, Prices, and the Role of 'News'"; and Dean Taylor, "Official Intervention in the Foreign Exchange Market, or, Bet Against the Central Bank," *Journal of Political Economy* (April 1982), pp. 356-68.

thereby boosting the dollar's exchange rate.²³ Of course, this does not result in an "overvalued" dollar. Rather, it explains why its value is "high"; demand for a currency may violate PPP for a sustained period if an economy's asset yields in *real* terms are different than those of its trading partners. As such, complaints about an overvalued dollar are really complaints about policies causing a "high" exchange rate and should not be considered as criticisms of the floating exchange rate system.

MYTH 4: A DECLINE IN U.S. INTEREST RATES WILL CAUSE THE EXCHANGE RATE TO FALL.

It is widely alleged that changes in U.S. market interest rates relative to those in the rest of the world are the major determinants of short-run movements in the foreign exchange value of the dollar.²⁴ Yet, it is changes in *real*, not *nominal*, interest rate differentials that actually motivate the international movement of financial capital and, therefore, induce changes in exchange rates.

The interest rates quoted in financial markets are nominal interest rates. Each nominal interest rate can be divided into two components: the real interest rate (or real yield) and a premium for expected inflation. The real interest rate represents the payment to the lender (in terms of the ability to consume more real goods and services later) necessary to induce him to forego some of his current consumption. The inflation premium is the compensation for the erosion of purchasing power expected to occur during the life of the loan. The nominal interest rate is approximately the sum of these two components.

The key to understanding the short-run impact of relative changes in nominal interest rates on the foreign exchange value of the dollar, then, is to recall the implications of the fourth and fifth elements of exchange rate determination — namely, relative purchasing power parity and interest rate parity. RPPP

implies that exchange rates will move to offset changes in inflation rate differentials. Thus, as we saw in chart 2, a rise in the U.S. inflation rate relative to those of other countries will be associated with a fall in the exchange value of the dollar. Conversely, IRP implies that a rise in the real interest rate in the United States relative to that of other countries will cause the exchange value of the dollar to rise. Changes in the nominal interest rate differential, however, can be due either to changes in the relative inflation outlook or in the relative real yields between the United States and its trading partners. Since the two components of the nominal interest differential have opposite effects on the exchange rate, it is not clear, a priori, whether a change in the nominal interest rate differential will raise or lower the exchange rate.

As shown in chart 3, there is a rough correspondence between the trade-weighted real interest rate differential and the trade-weighted exchange rate for the United States since 1976. Periods when the exchange rate was declining also tended to be periods when the real interest rate differential was declining and vice versa. Conversely, as the chart reveals, there have been periods when the exchange value of the dollar and the nominal interest rate differential have moved in the same direction, but there also have been many periods when they have moved in opposite directions. That is, changes in the nominal interest rate differential, at times, have been dominated by changes in the real interest rate differential but, at other times, have been dominated by relative changes in inflationary expectations.²⁵ Consequently, there is no stable, predictable relationship between nominal interest rate differentials and the exchange rate.

MYTH 5: A DEFICIT IN THE INTERNATIONAL MERCHANDISE TRADE ACCOUNT WILL CAUSE A DEPRECIATING EXCHANGE RATE.

This myth alleges that the relative value of a country's currency is determined primarily by the differ-

²³Feldstein holds such a view:

"According to his analysis, the current high exchange rate of the dollar is produced by the anticipation of huge federal budget deficits, which in turn cause real interest rates to go up. The real interest rate increases boost the value of the dollar, and thus cause the larger trade deficit (as U.S. goods are marked up).

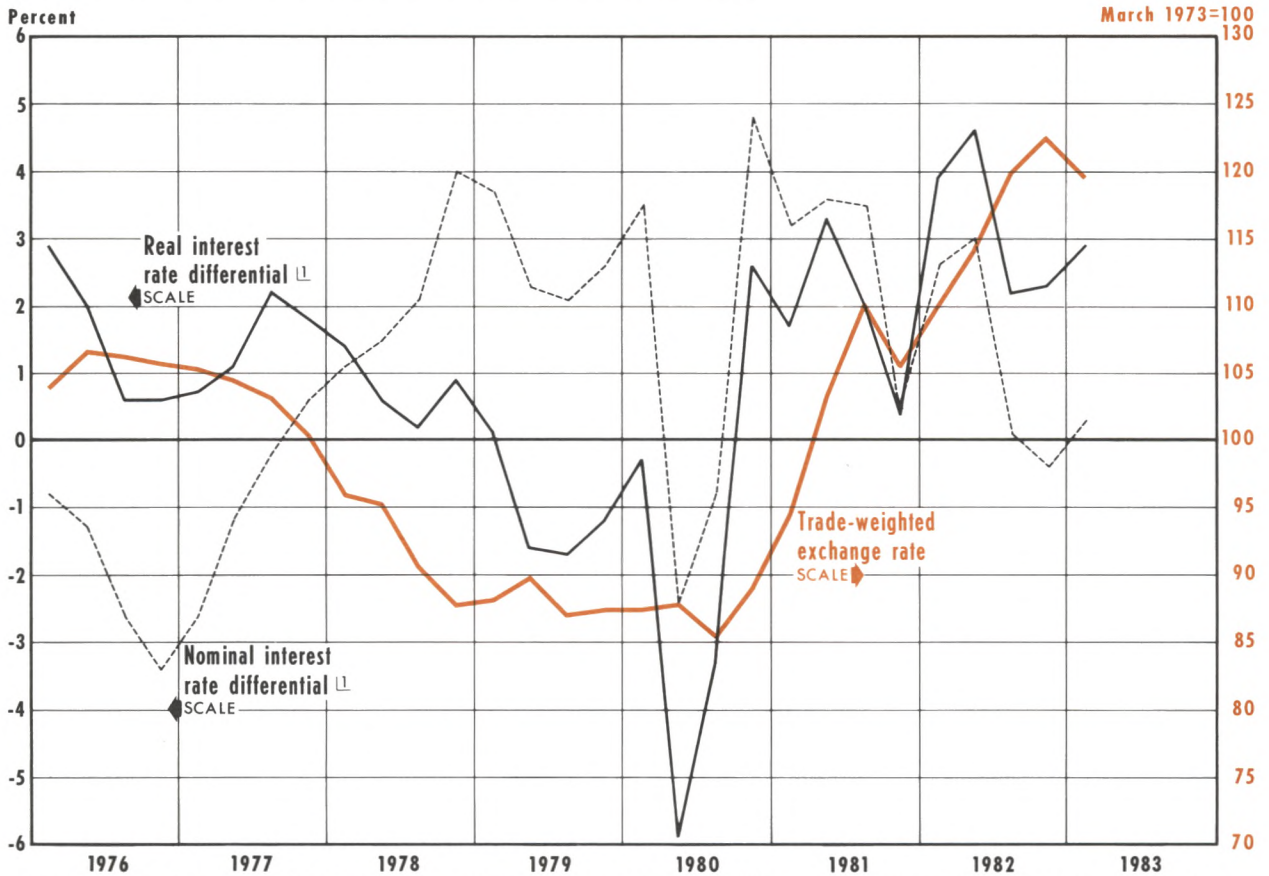
"In short, budget deficits beget trade deficits, and this requires a high exchange value of the dollar," Feldstein said." Hobart Rowen, "Feldstein Says U.S. Should Not Weaken Dollar," *Washington Post*, April 8, 1983. See also, "Dollar and Deficit, Both Too Strong," *New York Times*, June 3, 1983.

²⁴See, for example, John M. Leger, "Dollar's Strength Stuns Many Traders; More Gains by U.S., U.K. Units Predicted," *The Wall*

Street Journal, June 8, 1983; "The Dollar's Surprising Strength," *International Finance*, Chase Manhattan Bank, September 13, 1982; "What Keeps the Dollar Mighty," *Business Week* (September 6, 1982), p. 73; and "Mr. Regan's Embarrassing Dollar," *Washington Post*, May 4, 1983.

²⁵Indeed, for this eight-year period, the correlation coefficient between the trade-weighted exchange rate and the nominal interest rate differential was -0.331 indicating that relative inflation expectations outweighed real yield differentials. The correlation between the exchange rate and the real yield differential was, as theory predicts and chart 2 shows, positive (0.661).

Chart 3
Interest Rate Differentials and the Exchange Rate



Sources: Board of Governors of the Federal Reserve System, Morgan Guaranty, *World Financial Markets*, and International Monetary Fund, *International Financial Statistics*.

⌊ See footnote 16 of the text.

ence between its exports and imports of merchandise.²⁶ Yet, currencies flow between countries not only to finance merchandise trade, but also to finance investment (capital flows) and to pay for services. Hence,

²⁶Three examples of this are: "Most economists, however, believe that the dollar is due for a fall this year (to help correct the huge U.S. trade deficit), whatever happens to the EMS." Gary Yerkey, "On 4th Anniversary, Europe's Money System Rejigs," *Christian Science Monitor*, March 22, 1983.

"[T]he impact of an expected weakening in the dollar later this year [is] in response to a large and growing U.S. trade deficit." Lawrence Chimerine, *Executive Summary U.S. Macro*, Chase Econometrics, July 27, 1983, p. 2.

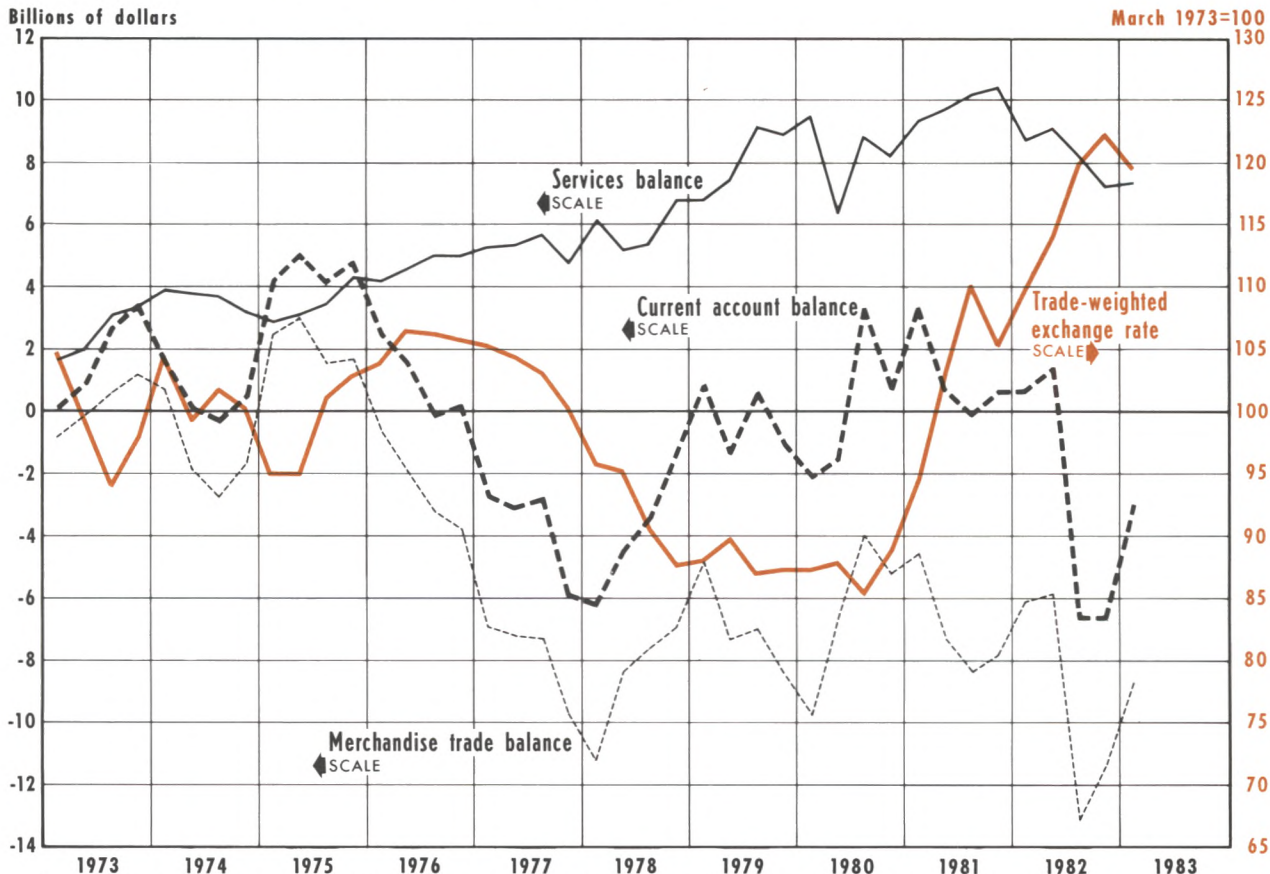
"Trade deficits cannot continue at current levels. We have to sell as well as buy abroad. Export earnings must come much closer to paying our import bills." Richard D. Lamm, "The Seven Deadly Economic Sins," *Christian Science Monitor*, August 3, 1983.

exchange rates reflect all of these flows as well as expectations concerning future changes in them.

The importance of capital inflows was discussed earlier. The role of income from capital services due to previous investments, however, almost always is overlooked in media discussions of exchange rates.²⁷ That is, American investors (individual and corporate) re-

²⁷Two exceptions to this neglect are Alfred L. Malabre, Jr., "Service Transactions Keep Balance of Trade In Surplus Despite the Large Deficit on Goods," *The Wall Street Journal*, February 10, 1982; and Robert A. Feldman and Allen J. Proctor, "U.S. International Trade in Services," Federal Reserve Bank of New York *Quarterly Review* (Spring 1983), pp. 30-36. Moreover, the currently strong dollar may increase U.S. foreign investment that will, in turn, contribute to further rises in future investment income. See, for example, "Dollar Fever Infects the World," *Business Week* (June 27, 1983), pp. 90-100.

Chart 4
The Balance of Payments and the Exchange Rate



Sources: Board of Governors of the Federal Reserve System and Department of Commerce, Bureau of Economic Analysis, Survey of Current Business.

ceive income from assets held in foreign economies; these service exports — particularly the services of the American-owned capital in foreign countries — offset merchandise imports and allow the United States to run a persistent merchandise deficit without necessarily inducing a decline in the exchange rate. Thus, the balance of trade that is relevant for anticipated exchange rate movements is not the merchandise trade balance alone, but rather the more inclusive current account balance, which includes services and government transfers as well.

As shown in chart 4, the current account has exhibited no apparent trend, but rather has fluctuated around zero during the floating rate era, 1973–83. While the merchandise trade balance has been consistently in deficit since 1976, the services balance (which is primarily investment income) generally has offset it. There is no apparent explanation in chart 4 for the

significant rise in the trade-weighted exchange rate since mid-1980. Consequently, a continuation of deficits in U.S. merchandise trade need not cause a depreciation of the U.S. exchange rate.

CONCLUSION

Exchange rates are determined by the actions of participants in active, internationally integrated currency markets. These markets reflect the information — the economic conditions, plans and expectations — assimilated by a diverse set of participants. Exchange rates adjust quite rapidly to incorporate any new information provided to these markets but, perversely, some of the economic processes that the information describes may be protracted. For example, internationally traded goods' prices adjust almost contemporaneously with changes in exchange rates, but

non-traded goods' prices adjust more slowly. Consequently, full adjustment to purchasing power parity takes place with a lag. Indeed, this adjustment can be counterposed by movements of real interest rates, which could cause exchange rate movements to be quite volatile during the progression to a long-run equilibrium.

While at any time there exists an exchange rate that incorporates all of this information, the conflicting influences emanating from different forces — for example purchasing power parity versus interest rate parity — may mislead individuals whose focus is on a single determinant of exchange rates. Furthermore, either misapprehension of the actual forces — say, nominal as opposed to real interest rate differentials — or an incomplete specification of the determination of exchange rates — a trade flow approach as opposed to an asset market approach — will produce a faulty under-

standing of why exchange rates move and how these movements affect the domestic economy.

In this article we have examined five common myths concerning floating exchange rates that arise from such incomplete understanding. Perhaps, by clarifying the mechanism of exchange rate determination, the temptation to blame floating exchange rates for international and domestic crises can be counteracted.²⁸ It should be clear that floating exchange rates reflect international economic conditions in a somewhat predictable way; they do not create them.

²⁸See, for example, Kemp, "A Floating Dollar Costs Us Jobs"; d'Estaing, "A Communique for Williamsburg"; Jacques R. Artus, "Toward a More Orderly Exchange Rate System," *Finance and Development* (March 1983), pp. 10-13; Leonard Silk, "Fixed Rates May Be Better," *New York Times*, March 23, 1983; Helen Ericson, "New Monetary Alternatives Urged," *New York Journal of Commerce*, May 25, 1983; and "A Call To Sink Floating Exchange Rates," *Business Week* (May 16, 1983), p. 147.

Seasonally Adjusting Money: Procedures, Problems, Proposals

SCOTT E. HEIN and MACK OTT

Seasonal variation in economic functions is pervasive; production, sales and leisure activities vary both substantially and systematically over the course of each week, month and year. Besides the obvious seasonal variation in agriculture, there are well-entrenched patterns in many other production, payment and consumption activities of firms and households. Automobile production lines, for example, shut down in the summer and new models are introduced in the fall; retail consumer sales are heaviest during the Christmas shopping months in the late fall; income taxes are paid in April; and July is the peak month for vacation and travel. As a result, the demand for money fluctuates seasonally as firms and households rearrange their financial portfolios to suit these varying patterns of economic activity.

For many reasons, it is useful to distinguish these seasonal variations in the data from longer-run cycles or trends. The procedures that enable these seasonal variations to be identified and, if desired, removed from the data are called seasonal adjustment techniques. In this article, we examine attempts to isolate the seasonal impulses in the money stock.

WHY SEASONALLY ADJUST MONEY STOCK MEASURES?

There are at least two different reasons for seasonally adjusting money stock measures. The first reason is for interpretative purposes. Many analysts simply want a time series for the money stock that reveals trend and cycle impulses but excludes the effects of seasonal

variation. In order to exclude such variation, some method of identifying seasonal variation in the money stock is required.

The second reason concerns the setting of monetary policy. The Federal Reserve states its annual and short-run objectives in terms of seasonally adjusted monetary aggregates. These policy objectives imply that seasonal changes in money demand will be accommodated, but these changes first must be identified by some method.

The Interpretative Reason

Many economic time series are seasonally adjusted for interpretative reasons. A standard analysis of time series data partitions each observation into three primary factors: (1) trend-cycle, C ; (2) seasonal, S ; and (3) irregular or random, E . Consider, for example, the time series for demand deposits, D . Traditional analysis would represent D as

$$(1) D_t = C_t S_t E_t.$$

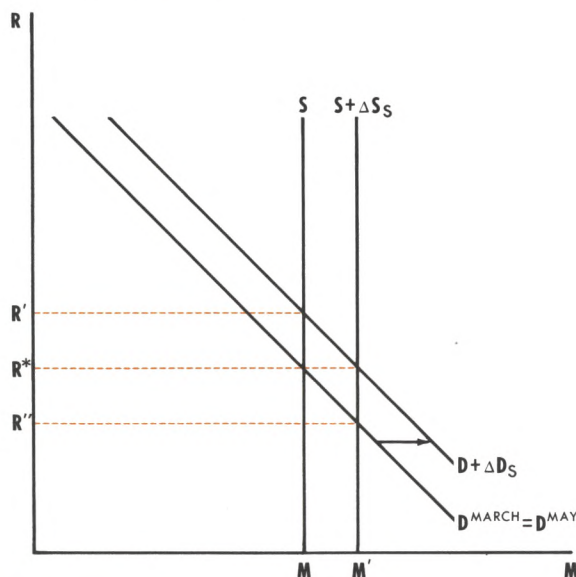
If the seasonal factor S_t is known, a "seasonally adjusted" measure of demand deposits can be obtained by dividing by the seasonal factor:

$$(2) \frac{D_t}{S_t} = C_t E_t.$$

Since the seasonal factor is intended to remove seasonal variation, it will be less than 1.0 when demand is seasonally low and greater than 1.0 when demand is seasonally high; over the year, by construction, it averages 1.0. Consequently, by seasonally adjusting the data, the trend-cycle variation is revealed more clearly. If analysts are interested primarily in the trend-cycle element in demand deposits, they will find seasonally adjusted demand deposit data useful in their analyses.

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Figure 1
The Effect of Seasonal Demand Variation Can Be Offset by Seasonal Supply Variation



The Policy Reason

The money stock is also of major interest to policymakers who are trying to promote desirable economic and financial conditions by exercising control over the money stock.

The effects of seasonal variation in the demand for money are illustrated in figure 1, which presents a simple money demand-supply relationship. The demand for money, given by economic trends and business cycle forces, is depicted as D ; the arrow indicates an increase in money demand caused by purely seasonal factors, for example, by an April income-tax-related shift. As the figure shows, if the money supply were not adjusted to offset this seasonal demand shift, there would be an excess demand for money at the original equilibrium interest rate R^* . Depending on the assumed adjustment process, this disequilibrium could result in increases in interest rates (to R') as individuals and firms attempt to adjust their portfolios, or in lower aggregate demand for goods and services as individuals and firms attempt to build up money balances by spending less.¹

If the seasonal demand shift is known in advance and if it is relatively costless to alter the money supply,

¹The reader should not conclude from figure 1 that the money market clears by interest rate changes alone; it can clear through many other important channels. Figure 1 is best thought of as a pedagogical device.

then the money supply could be increased — from S to $S + \Delta S_s$ — to eliminate the disequilibrium effects of the seasonal demand shift. Conversely, if money demand declines seasonally after April and if monetary authorities want to eliminate any adjustment process associated with an excess supply of money, the money supply could be reduced to offset the impact of this seasonal disturbance.

By targeting on seasonally adjusted measures of money, the Fed essentially has indicated a willingness to accommodate the estimated seasonal influences.² Yet, the graphical analysis suggests this policy response will be successful in easing seasonally induced disruptions in money demand only if 1) the seasonal impulses coming from the demand side are correctly estimated, and 2) these estimates are available in a timely fashion. Successful policy actions require that the preliminary or original estimates of seasonal variation be reliable, because it is the preliminary estimates that are used to guide policy. Revisions in seasonally adjusted money stock estimates that come about one, two or more years from now, for example, are of no use to policymakers who must make their decisions now. Before evaluating the accuracy of seasonally adjusted money measures in terms of their timeliness and reliability, we briefly outline the procedures employed in seasonal adjustment of the money stock.

CURRENT SEASONAL ADJUSTMENT PROCEDURES

Seasonal adjustment of monetary data by the Federal Reserve Board of Governors currently is accomplished by the X-11 ARIMA procedure, an extension of the X-11 seasonal adjustment program first developed by Julius Shishkin at the Bureau of the Census of the U.S. Commerce Department.³ The X-11 seasonal

²While there is no explicit statement by the Board explaining its use of seasonally adjusted data, William Poole and Charles Lieberman, "Improving Monetary Control," *Brookings Papers on Economic Activity* (2:1972), pp. 293-335, conclude that:

"efficient resource allocation requires the monetary authorities to eliminate seasonality in interest rates arising from seasonality in the demand for money, while giving full scope to seasonality in interest rates arising from that in aggregate demand." (p. 332)

³For a detailed description of the basic procedure, see Julius Shishkin, Allan H. Young and John C. Musgrave, "The X-11 Variant of the Census Method II Seasonal Adjustment Program," U.S. Department of Commerce, Bureau of the Census, Technical Paper 15. Washington, D.C.: Government Printing Office, 1967. For a concise description, see Thomas A. Lawler, "Seasonal Adjustment of the Money Stock: Problems and Policy Implications," *Economic Review*, Federal Reserve Bank of Richmond (November/December 1977), pp. 19-27, especially p. 23; also William P. Cleveland and David A. Pierce, "Seasonal Adjustment Methods," *Federal Reserve Bulletin* (December 1981), pp. 875-81.

adjustment procedure is used worldwide to seasonally adjust a broad variety of social and economic data from U.S. unemployment to Israeli tourism. Consequently, its application to monetary data is both well-understood and widely accepted.⁴

The present seasonal adjustment of the monetary aggregates is accomplished in two steps. First, each component of the monetary aggregate is seasonally adjusted separately. Second, the resulting data are summed to obtain the seasonally adjusted monetary aggregate. This procedure is used because the individual components have different seasonal patterns; for example, checkable deposits have a different seasonal pattern than currency, and both have different patterns from those of small time deposits or large certificates of deposit.⁵

The Basic X-11 Procedure

The X-11 procedure for estimating the seasonal factors consists of two steps: First the data are detrended. Then, the seasonal factors are estimated from the detrended series.

The first step is accomplished by fitting a trend line to the actual series over a sufficient time span so that the estimate will be unaffected by shorter-term seasonal or random variations. Once estimated, the trend, C_t , can be removed from equation 1 to yield

$$(3) \quad \frac{D_t}{C_t} = S_t E_t.$$

Fluctuations of this series around its mean value of 1.0 are due to either seasonal or random causes.

The second step, that of estimating S_t , is accomplished by calculating the ratio of the detrended monetary measure at time t to a weighted moving average of monetary data centered around t . The

weighting scheme is symmetric; for example, an observation 4 periods before t will receive the same weight as an observation 4 periods after t . Moreover, the weights are chosen so as to emphasize near observations in time more than distant ones; thus, an observation 4 periods away will receive more weight than an observation 5 periods away. The weights for months more than three and a half years away in either direction are very small.

If at any point this ratio of the detrended monetary component to its weighted moving average exceeds unity, either seasonal or random variation probably has caused it to rise at that point. If the ratio consistently exceeds unity for the same point in a year for a number of years in succession, however, random variation can be disregarded.

In the basic X-11 process, these steps of detrending and deseasonalizing are undertaken iteratively with a variety of refinements at each phase, primarily to reduce the influence of so-called "outliers," that is, observations whose discrepancies are so much greater than other observations that trend-cycle or seasonal variation cannot reasonably account for the discrepancy.⁶

The basic X-11 procedure, as just noted, uses data symmetrically centered about the observation being seasonally adjusted. Thus, fully adjusting current data is impossible; to do so would require having the as yet unknown future values of the variable. Consequently, the basic X-11 program does not adjust current observations based on a symmetric weighted moving average calculation. Instead, it has an arbitrary set of end-weights for adjusting current and recent past data. Thus, the preliminary estimates of the seasonal factors are based only on known, past data. As the data required for the moving average calculation become available, they are incorporated in the X-11 seasonal adjustment process, and the estimates of seasonal fac-

⁴Nonetheless, alternative procedures have been proposed to improve on various perceived shortcomings of the X-11 method. See Arnold Zellner, ed., *Seasonal Analysis of Economic Time Series*, Proceedings of the Conference on the Seasonal Analysis of Economic Time Series (Washington, D.C., September 9-10), 1976; and Geoffrey Moore, and others, *Seasonal Adjustment of the Monetary Aggregates*, Report of the Committee of Experts on Seasonal Adjustment Techniques (Board of Governors of the Federal Reserve System, October 1981).

⁵This procedure, however, may be inferior to seasonal adjustment of the components jointly. For example, the currency and checkable deposit components each should be seasonally adjusted separately but use information from the other series. See John Geweke, "The Temporal and Sectoral Aggregation of Seasonally Adjusted Time Series," in *Seasonal Analysis of Economic Time Series*, pp. 411-27, and comments by Michael Lowell, pp. 428-30, and John B. Taylor, pp. 431-32.

⁶This culling of outliers is accomplished by computing a moving standard deviation and reducing the weight of any observation lying, say, more than three standard deviations from the trend-cycle seasonal expected value. The rationale for this removal is that failure to do so would bias the estimates of the seasonal factors due to the presence of a deviation in the data for $S_t E_t$ which is not a seasonal or random factor; however, this procedure injects a judgmental element into the estimation that, while well-intentioned, dilutes the objectivity of any analysis performed using the adjusted data. See "The BLS Seasonal Factor Method," *BLS Handbook of Methods for Surveys and Studies*, U.S. Department of Labor, Bureau of Labor Statistics (1976), p. 273; also, Pierce, "Seasonal Adjustment Methods." In the BLS study, the foundation for this outlier adjustment is called a credence factor, which refers to the low probability of an observation lying more than two or three standard deviations from the mean. In the Board study, the method is referred to as judgmental.

Table 1
Tests for Bias in Preliminary 1982 Monthly Seasonally Adjusted M1 Growth Rates

Equation 1:				Equation 2:			
$\% \Delta M1R_t^u = \beta_0 + \beta_1 \% \Delta M1P_t^u$				$\% \Delta M1R_t^s = \beta'_0 + \beta'_1 \% \Delta M1P_t^s$			
β_0	β_1	R^2	DW	β'_0	β'_1	R^2	DW
-0.105	0.998	0.999	1.65	3.419	0.581	0.681	2.26
(0.119)	(0.005)			(1.480)	(0.126)		
t-statistic testing $H_0: \beta_0 = 0$; $t_c = -0.88$				t-statistic testing $H_0: \beta'_0 = 0$; $t_c = 2.31^*$			
t-statistic testing $H_0: \beta_1 = 1$; $t_c = -0.40$				t-statistic testing $H_0: \beta'_1 = 1$; $t_c = -3.33^*$			

NOTE: *Denotes rejection of null hypothesis at the 5 percent level. Standard error of coefficient estimate in parentheses.

tors are revised. On many occasions these revisions have been quite sizeable.

The Current X-11 ARIMA Procedure

The Board of Governors' Committee of Experts on Seasonal Adjustment Techniques felt that the revisions resulting from application of the basic X-11 program were excessive and recommended changes to reduce the size of revisions.⁷ One of the procedures recommended was the adoption of the X-11 ARIMA procedure, which replaces the use of the arbitrary end-weights in the adjustment of current data with the application of centered weights using forecasts of the underlying series for the future values needed.

These forecasts come from Autoregressive, Integrated Moving Average (ARIMA) time series models. Revisions in the seasonal adjustment factors are limited only to the errors associated in forecasting future values. Unlike the basic X-11 program then, the weights which are applied to the not seasonally adjusted data (including any forecasted data) associated with specific time periods will be the same for the preliminary seasonal adjustment and all subsequent revisions. In this regard, it was believed that the X-11 ARIMA would result in smaller revisions of seasonally adjusted money stock measures.⁸

⁷See Moore, and others, "Seasonal Adjustment of the Monetary Aggregates."

⁸The current seasonal adjustment of monetary data also encompasses one further refinement referred to as intervention analysis. Intervention analysis is undertaken when extraordinary events — such as a redefinition of monetary aggregates or other change in the rules governing monetary institutions — is believed to have altered the behavior of the observed monetary aggregates. An example of

X-11 ARIMA: THE PROBLEM OF MONEY STOCK REVISIONS

Previous analyses indicated that revisions in the estimates of seasonally adjusted money stock measures based on the basic X-11 program were large and that the preliminary seasonally adjusted data generally were biased measures of the subsequently revised data.⁹ In 1982, the X-11 ARIMA seasonal adjustment procedure was adopted with the intent of improving the preliminary seasonally adjusted estimates by reducing the size of these subsequent revisions in money measures. We now evaluate the performance of this new procedure.

Not-Seasonally-Adjusted Money Growth Rates

Table 1 evaluates this new procedure by examining the relationship between preliminary and revised

this was the imposition of credit controls from March through June of 1980. This program imposed restraints on commercial bank lending and, therefore, reduced demand deposits. Without somehow offsetting this effect, the estimated seasonal adjustment factors would have been distorted by this non-seasonal event. Although the X-11 ARIMA program has the capability of removing individual outliers, it can incur difficulties when such outliers represent a run of consecutive, unusual observations, as with the credit controls. In the case when a sharp swing in the series occurs over a few periods in succession, the present procedure *preadjusts* the underlying series, through intervention analysis, to minimize the effects such occurrences would have on the seasonal adjustment procedure. See Cleveland and Pierce, "Seasonal Adjustment Methods," pp. 876-78.

⁹See Poole and Lieberman, "Improving Monetary Control," pp. 320-33; Lawler, "Seasonal Adjustment," pp. 24-25; and Courtenay C. Stone and Jeffrey B.C. Olson, "Are the Preliminary Week-to-Week Fluctuations in M1 Biased?" this *Review* (December 1978), pp. 13-20.

monthly growth rates in the narrow money stock, M1. Equation 1 evaluates the importance of revisions in the not-seasonally-adjusted (NSA) M1 measures. In this equation, revised growth rates of NSA M1 ($\% \Delta \text{MIR}_t^u$) are regressed against the preliminary NSA growth rates ($\% \Delta \text{MIP}_t^u$).¹⁰ If these revisions of NSA measures, attributable to the removal of processing errors and benchmark revisions, are random in nature, then the preliminary growth rate measures will be reliable estimates of revised growth rates.¹¹ If so, we expect to find the intercept coefficient β_0 in equation 1 of table 1 to be insignificantly different from zero, and the slope coefficient β_1 to be not different from unity. Moreover, the residuals should show no evidence of serial correlation, and the R^2 should be close to 1.0. If these conditions are not met, the preliminary growth rates are providing poor and/or biased estimates of revised growth rates. An examination of the results in table 1 reveals that all of these conditions are met for equation 1. Therefore, we conclude that the preliminary NSA M1 growth rates are unbiased and reliable estimates of the revised unadjusted growth rates.

Seasonally Adjusted Money Growth Rates

Now consider the same issue regarding seasonally adjusted M1 growth rates. Equation 2 regresses the revised seasonally adjusted growth rate of M1 ($\% \Delta \text{MIR}_t^s$) on the preliminary seasonally adjusted measure ($\% \Delta \text{MIP}_t^s$). Again, if the preliminary growth rate is a good estimate of the revised growth rate, we should observe that β_0 is close to zero, that both β_1 and the R^2 are close to one, and that the error term is serially uncorrelated. The empirical results indicate that only this last condition is satisfied. Both the estimate of the intercept term, β_0 , and the slope coefficient, β_1 , are significantly different from their desired values. The R^2 is also much smaller than that for equation 1.

The findings imply that preliminary seasonally adjusted estimates are biased predictors of revised seasonally adjusted monthly growth rates, and that the effects of revisions in seasonal factors on M1 growth rates are large relative to the effects of revisions in the underlying NSA data. Thus, adopting the new adjustment procedure has not eliminated the bias problem or the effects of large revisions in seasonal factors.

¹⁰All percent changes ($\% \Delta$) are calculated as delta logs of monthly data expressed in annual rates. For example, $\% \Delta \text{MIP}_t^u = (\ln \text{MIP}_t^u - \ln \text{MIP}_{t-1}^u) \times 1200$.

¹¹For a discussion of these revisions, see Richard W. Lang, "Benchmark Revisions of the Money Stock and Ranges of Money Stock Growth," this *Review* (June 1978), pp. 11-19.

X-11 ARIMA AND THE PROBLEM OF EX-POST SMOOTHING

To better understand the bias problem, consider chart 1, in which revised and preliminary monthly M1 growth rates for 1982 are plotted. If the preliminary growth rates were good estimates of revised growth rates, then a plot of both growth rates should be along the "perfect fit" line — the 45° dashed line, designated as A. As illustrated, however, the estimated line (shown as the solid line B) relating revised and preliminary growth rates, as given by equation 2, is significantly different from this.

The results in table 1 and chart 1 indicate that preliminary money data are not reliable estimates of revised data, and that the revisions have "smoothed" the monthly growth rates relative to preliminary estimates as well. Line B intersects Line A at a growth rate of 8.1 percent — very close to the 1982 average monthly growth rate using either revised or preliminary data (8.2 percent each). Consider observations of preliminary growth rates above this 8.1 percent level. The fact that line B is below the perfect fit line A in such cases indicates that the revised growth rates generally will be less than preliminary growth rates. That is, preliminary growth rates above the mean will be revised downward, closer to the sample period mean.

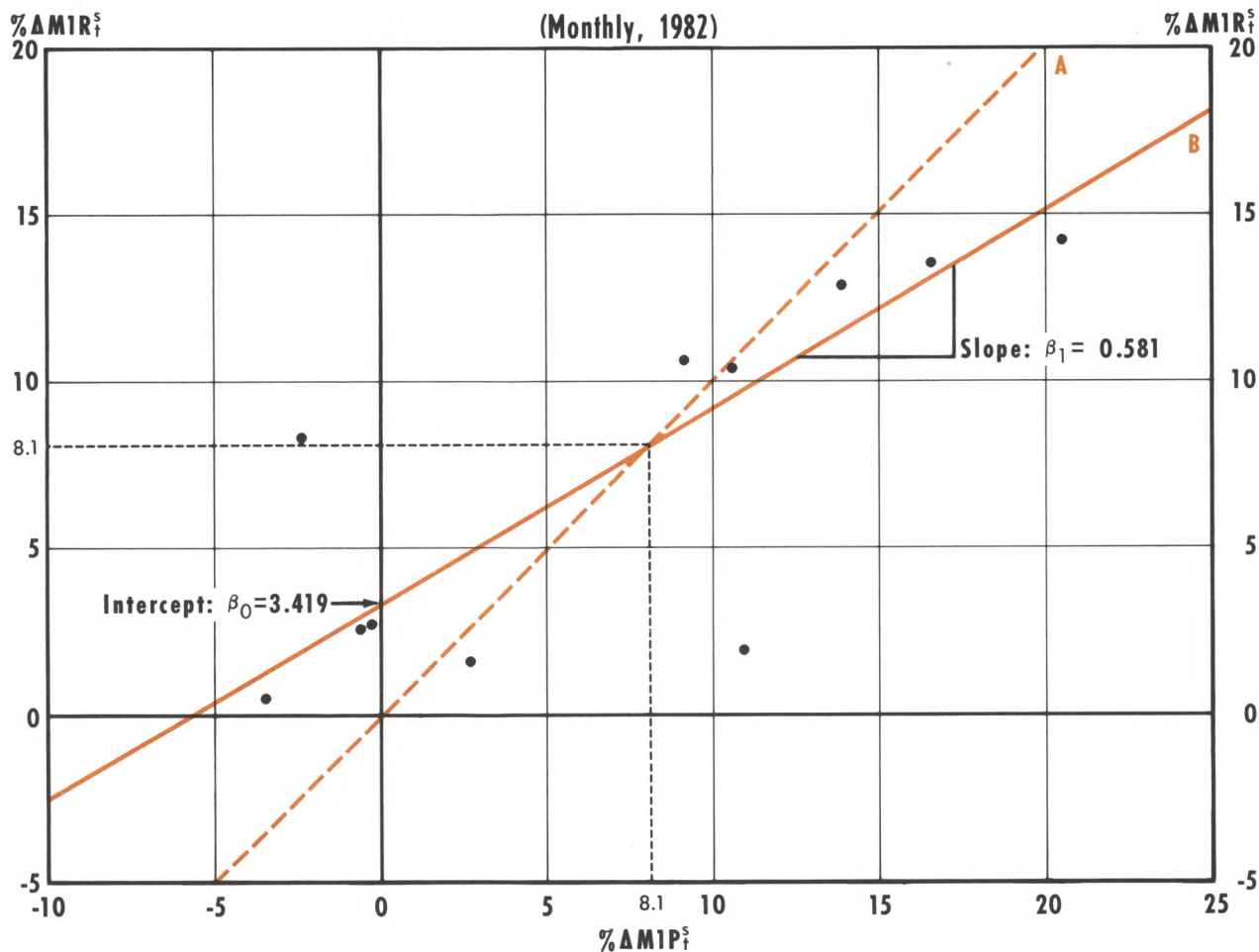
Alternatively, when preliminary growth rate estimates are less than 8.1 percent, line B lies above line A, indicating that the revised growth rates generally will be larger than the preliminary growth rates. In these cases, the growth rates generally will be revised upward closer to the sample period mean. It is not at all surprising, then, that the variance of revised seasonally adjusted growth rates is much less than that of the preliminary — 38.6 and 71.7 percent, respectively. This smoothing can be seen directly in chart 2 by the wider distribution of the preliminary (black line) relative to the revised seasonally adjusted growth rates (orange line).

While the use of the X-11 ARIMA seasonal adjustment procedure has not eliminated the bias problem, there is evidence to suggest that its preliminary estimates represent some improvement over those of the basic X-11 procedure. When Stone and Olsen estimated a weekly growth rate equation similar to equation 2 in table 1, they found the R^2 to be only 0.44 and β_1 to be only 0.21 for 1977.¹² The fact that both of these

¹²Stone and Olson, "Are the Preliminary Week-to-Week Fluctuations in M1 Biased?" table VI, p. 19. For a more direct comparison using weekly data, see table 2 below.

Chart 1

The Relationship Between Preliminary and Revised M1 Growth Rates



coefficients have moved closer to 1 in 1982 suggests that the X-11 ARIMA procedure provides preliminary seasonally adjusted estimates that are closer to the revised numbers. This improvement is encouraging. It remains true, however, that the preliminary measures upon which policy is based are biased.

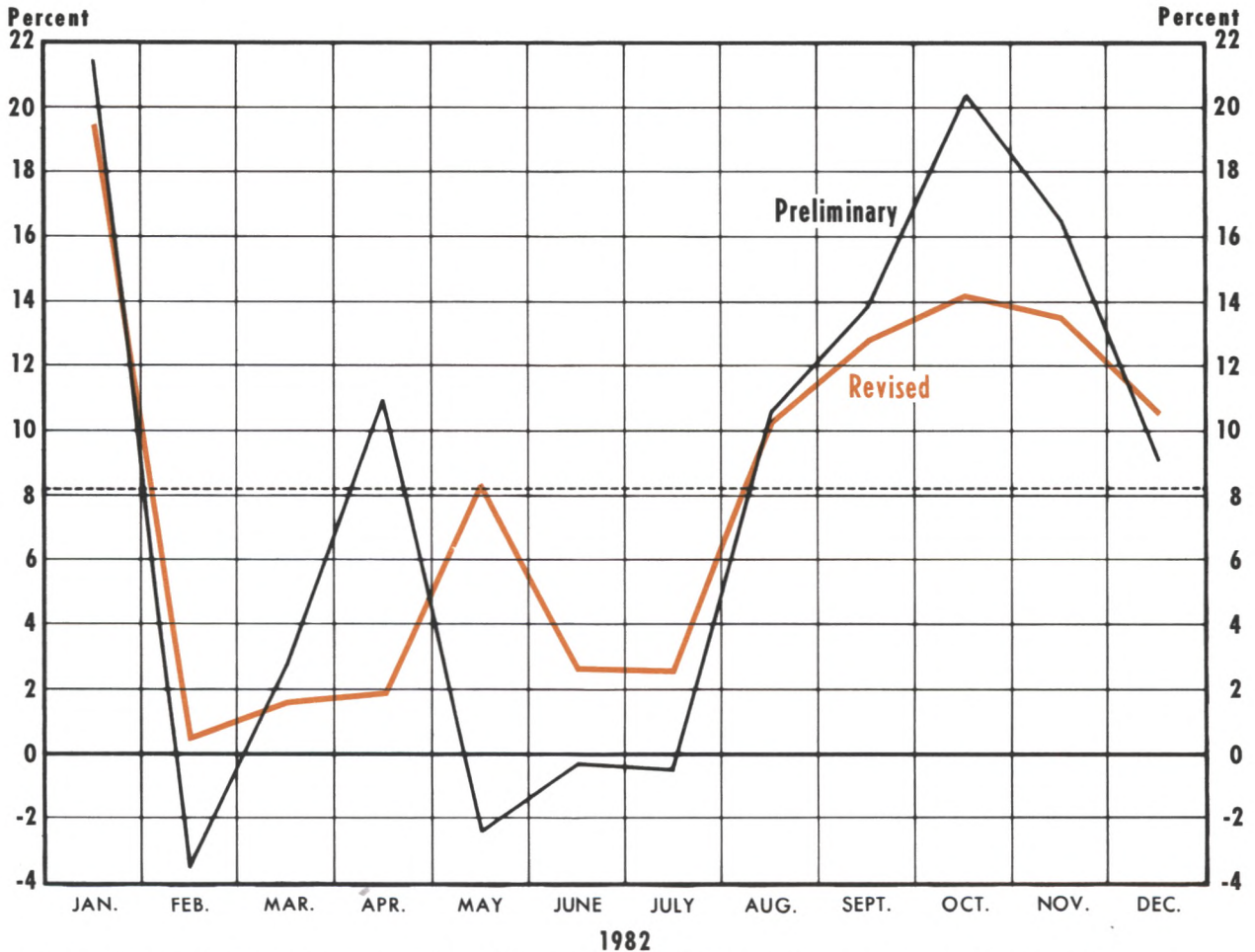
X-11 ARIMA AND THE PROBLEM OF MONEY SUPPLY SHOCKS

In order to accommodate seasonal money demand variation, the money supply must be varied seasonally. The influence that the Federal Reserve has on the money stock complicates the issue of seasonal adjustment. Fluctuations in the quantity of money may be due to supply-side variations as a result of actions taken by the Federal Reserve, as well as demand-side varia-

tions whether seasonal, random or trend-cycle. The fact that the money stock is affected by Fed actions makes it important that the seasonal variation in the demand for money be isolated. Presumably, it is this effect that the Fed would want to accommodate. Unfortunately, the present seasonal adjustment procedure fails to isolate demand shifts from supply impulses.

As we have seen, this procedure is based on the behavior of the money stock itself. The problem is that the time series of money stock data records the history of both demand- and supply-side effects. For example, figure 2 shows the same increase in the money stock from one month to the next that was illustrated earlier in figure 1. Since the change in the money stock is identical in both cases, present seasonal adjustment

Chart 2
Seasonally Adjusted M1 Growth Rates



NOTE: Horizontal dashed line represents an 8.2 average of preliminary and revised seasonal growth rates.

procedures would result in identical estimates of the seasonal factors. Yet, there is an important difference. It is only in the case of figure 1 that the change was due to seasonal variation in the demand for money. In figure 2, the increase in money stock is a result of Fed actions with no seasonal change in the demand for money.

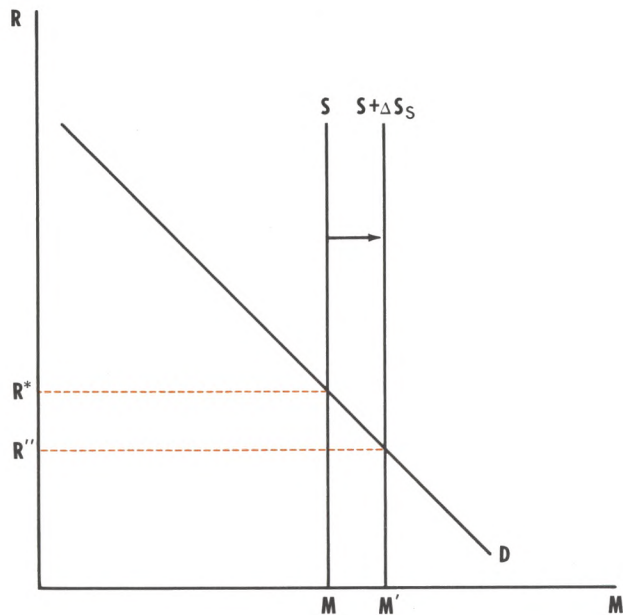
Why is this estimation problem a concern? To see the inherent difficulties, consider a policy action based on a faulty seasonal estimate. Suppose, for example, that a seasonal increase in the demand for money is "expected", but never occurs (figure 2 is again relevant). The Fed would increase the supply of money, but demand would remain unchanged. As an excess supply of money developed, the public would increase its purchases of goods and services or financial assets.

Thus, as a result of the incorrect estimation of the seasonal impulse, the monetary authorities would cause the type of economic disruptions they were trying to mitigate. Additionally, since the quantity of money would increase, the seasonal adjustment procedure would continue to show that there was a seasonal impulse in the data. Consequently, monetary authorities would have little reason to suspect that there were any problems with their actions when they examined the behavior of seasonally adjusted money stock.

PROPOSED ALTERNATIVE METHODS

These problems and others have led to a number of proposals for modifying or replacing current procedures. They range from improving the specifications of

Figure 2
Misestimated Seasonal Demand Variation Leads to Inappropriate Money Supply Variation



seasonal demand variation — for example, a model-based seasonal adjustment — to forsaking seasonal adjustment altogether.¹³

Model-Based Seasonal Adjustment

The Board of Governors' Committee of Experts on Seasonal Adjustment Techniques recommended consideration of another seasonal adjustment procedure: "Model-based approaches to seasonal adjustment of monetary aggregates should be developed and applied on a current and a continuing basis."¹⁴ The advantages of this procedure with respect to the currently employed X-11 ARIMA include explicit allowance for both deterministic and stochastic influences within the seasonal adjustment procedure and separation of short-run variations in seasonal factors from long-run

¹³These problems with seasonal adjustment procedures are not unknown to the Federal Reserve Board of Governors; they are outlined in the report of its Committee of Experts on Seasonal Adjustment Techniques. Of the Committee's 10 recommendations for improving seasonal adjustment procedures, five addressed the need for reducing revisions of the estimated seasonal factors, and five, in various ways, asserted the need for the Board to "set forth its views on policy with respect to seasonal variations in the demand for and supply of money and credit." Moore, and others, "Seasonal Adjustment."

¹⁴Moore, and others, "Seasonal Adjustment," Recommendation 3, p. 2.

stable factors. Thus, this procedure has the potential of avoiding ex-post smoothing, which plagues the X-11 adjustment procedures, while at the same time allowing for endogenous estimation of changes in seasonal factors.¹⁵ It is clear, however, that this procedure would depend on the judgment of the modeler in selecting the deterministic elements.

The model-based procedure's potential advantage over the purely statistical analysis of the X-11 ARIMA procedure is its ability to explicitly model the behavioral aspects underlying money demand. These aspects include both the calendar characteristics and the opportunity costs and motivations of money holding; their inclusion, at least in principle, provides a way to distinguish between supply- and demand-induced movements of the money stock.¹⁶

Table 2 presents tests on weekly growth rates of seasonally adjusted M1, using both the model-based and the X-11 ARIMA procedure. As in table 1, the revised estimated growth rates, seasonally adjusted by each procedure, are regressed on the preliminary estimated growth rates. Once again, reliable policy guidance requires that the preliminary estimates be unbiased predictors of the revised estimates, which implies that the β_0 and β_1 shall be, respectively, insignificantly different from zero and unity. As can be seen, the X-11 ARIMA estimates are biased at the weekly level as they were at the monthly level, but the model-based procedure estimates satisfy both criteria. The Durbin-Watson statistic, however, is in the ambi-

¹⁵Another substantial advantage of this procedure is that it is a weekly model. Thus, in contrast to the X-11 ARIMA procedure, the model-based procedure directly handles calendar quirks such as holidays, the varying number of weeks in a month or even the day of the week upon which schedule-by-date transactions occur. These anomalies change the monthly transaction patterns in a way that a monthly based procedure cannot systematically or dependably assess.

¹⁶In order to obtain these advantages, the model-based procedure assumes that the seasonality in a monetary aggregate has both a deterministic and a stochastic component. The procedure first obtains estimates of the deterministic component in order to isolate the stochastic component as a residual; then it identifies the stochastic structure as an ARIMA model; and finally, it estimates simultaneously both deterministic and stochastic components. See David A. Pierce, Michael R. Grupe, and William P. Cleveland, "Model-Based Seasonal Adjustment of the Weekly Monetary Aggregates" (Board of Governors of the Federal Reserve System, October 1982), mimeo. This multipart procedure has been used to estimate seasonal factors and to provide an alternative seasonally adjusted M1 series since January 1982 (reported in the Board of Governors' H. 6 statistical release). As the Committee of Experts suggested, this will "build up a fund of experience with model-based approaches so that their advantages and disadvantages can be appraised in a realistic environment." Moore, and others, "Seasonal Adjustment," p. 2.

Table 2

Comparative Results of Tests for Bias in Preliminary 1982 Weekly Seasonally Adjusted M1 Growth Rates — X-11 ARIMA and Model-Based Procedures

X-11 ARIMA				Model-Based			
$\% \Delta M1R_t^s = \beta_0 + \beta_1 \% \Delta M1P_t^s$				$\% \Delta M1R_t^s = \beta'_0 + \beta'_1 \% \Delta M1P_t^s$			
β_0	β_1	R^2	DW	β'_0	β'_1	R^2	DW
4.080	0.492	0.579	2.46	2.011	1.140	0.486	2.50
(1.779)	(0.060)			(3.565)	(0.167)		
t-statistic testing $H_0: \beta_0 = 0;$ $t_c = 2.29^*$				t-statistic testing $H_0: \beta_0 = 0;$ $t_c = 0.56$			
t-statistic testing $H_0: \beta_1 = 1.0;$ $t_c = -8.47^*$				t-statistic testing $H_0: \beta_1 = 1.0;$ $t_c = 0.83$			

NOTE: *Denotes rejection of null hypothesis at the 5 percent level. Standard error of coefficient estimate in parentheses.

guous region for negative serial correlation (2.43–2.53 at the 5 percent level), and the R^2 is much lower than 1.0 and even low relative to that for the X-11 ARIMA estimates. Nonetheless, these model-based results are an improvement over the X-11 ARIMA results to the extent that the preliminary estimates of the revised growth rates are both unbiased and not subject to the smoothing criticism of the current procedure.

Year-Over-Year Growth Rates

Some monetary economists have become so skeptical of seasonally adjusted money stock data that they now suggest that it no longer be calculated. For example, Poole and Lieberman were concerned that “one of the dangers of the X-11 model is that outliers are all too easily explained away by superficial appeal to changing seasonals.”¹⁷ Thus, concerned observers of monetary targeting have suggested using the year-over-year growth rates of NSA aggregates, thereby avoiding the problem of biased preliminary seasonally adjusted data. Since both the current and one year earlier NSA values would be from a similar point in the seasonal cycle, the only seasonal effect on the year-over-year

growth rate would result from a change in the seasonal factor from one year to the next. This change will be minor relative to the seasonal factor itself and will not yield any long-run seasonal impulse in the data reported in this fashion.¹⁸

This procedure would avoid both the criticism that the seasonal adjustment procedure has overly smoothed the data, thereby destroying important information, and the misinterpretation of supply-side shocks as seasonal demand shifts (see figure 2). Reporting NSA aggregate growth rates in this fashion alleviates the concern that important information may be discarded in the adjustment process.

CONCLUSIONS

Money stock measures currently are adjusted for seasonal variation via a variant of the X-11 seasonal adjustment program. The use of this program has many shortcomings, especially for policymakers. The preliminary estimates of the seasonal factors, which policymakers must use in implementing policy, are biased. This implies that policies may have been executed on faulty information. There is also a concern that revised estimates of seasonally adjusted money measures under the present procedure have been

¹⁷Poole and Lieberman, “Improving Monetary Control,” p. 332. The Shadow Open Market Committee has recommended eliminating seasonal adjustment of the monetary aggregates altogether. In its place, the Committee has recommended reporting NSA aggregates for the most recent period and for the corresponding period of the previous year. See also the “Policy Statement of the Shadow Open Market Committee, March 16, 1981,” *Annual Report*, Center for Research in Government Policy and Business, Graduate School of Management, University of Rochester (June 1981), pp. 31–35, especially p. 33.

¹⁸The Committee of Experts on Seasonal Adjustment Techniques noted the usefulness of measuring money growth in this fashion:

“The ordinary 12-month change does have the advantage of not being affected at all by seasonal adjustment revisions because it can be computed from unadjusted data.”

Moore, and others, “Seasonal Adjustment,” p. 48.

overly smoothed, destroying information for ex-post analyses of policy. Finally, the present seasonal adjustment technique does not differentiate among the various factors affecting the monetary stock. It has been suggested that monetary policy should accommodate seasonal demand impulses, yet the present technique does not attempt to isolate these impulses from those due to non-seasonal changes in the money supply.

There currently are two alternative solutions to the problems cited above. One solution would be to improve upon the seasonal adjustment procedure itself. A model-based adjustment procedure, which does not result in systematic revisions of seasonal factors, is one possibility. The model-based approach investigated here satisfies both the unbiasedness and the no-

smoothing criteria. There remains a question, however, regarding the ability of this procedure to isolate seasonal demand variation.

At the other extreme, there is the belief that estimation problems associated with seasonal adjustment are insuperable. Some critics have even recommended that seasonally adjusted data no longer be published. In this case, monitoring year-over-year growth rates of not-seasonally-adjusted money represents a feasible process for tracking the trend-cycle component of the money stock. Whether or not one of these extremes is selected, it is clear that seasonal adjustment problems present a challenge for a policy based on the targeting of a monetary aggregate that cannot be ignored.

Lagged and Contemporaneous Reserve Accounting: An Alternative View

DANIEL L. THORNTON

RECENT volatility in both money and interest rates has prompted the Federal Reserve Board to adopt a plan for contemporaneous reserve accounting (CRA).¹ This move follows a number of requests from both inside and outside the Federal Reserve System to return to CRA. These requests stem from empirical investigations that show that both money and interest rates became more volatile after the adoption of lagged reserve accounting (LRA) in September 1968, and from theoretical work that shows an increase in volatility of money and possibly interest rates when the System moves from CRA to LRA.²

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¹In the Board's plan, CRA applies only to transactions accounts. Reserve requirements on time and savings accounts will continue to be set on a lagged basis. For a concise summary of the Board's plan for CRA, see Michael R. Pakko, "Lagged and Contemporaneous Reserve Accounting, Money Market Stability and Monetary Control: A Topical History of Recent U.S. Monetary Policy," Federal Reserve Bank of Richmond (1983).

²The empirical work includes Albert E. Burger, "Lagged Reserve Requirements: Their Effects on Federal Reserve Operations, Money Market Stability, Member Banks and the Money Supply Process," unpublished paper for the Federal Reserve Bank of St. Louis (1971); Warren L. Coats, "Lagged Reserve Accounting and the Money Supply Mechanism," *Journal of Money, Credit and Banking* (May 1976), pp. 167-180; Edgar L. Feige and Robert McGee, "Money Supply Control and Lagged Reserve Accounting," *Journal of Money, Credit and Banking* (November 1977), pp. 536-51; and William Poole and Charles Lieberman, "Improving Monetary Control," *Brookings Papers on Economic Activity* (2:1972), pp. 293-335.

The theoretical work includes Daniel E. Laufenberg, "Contemporary Versus Lagged Reserve Accounting," *Journal of Money, Credit and Banking* (May 1976), pp. 239-45; Stephen F. LeRoy, "Monetary Control Under Lagged Reserve Accounting," *Southern Economic Journal* (October 1979), pp. 460-70; William Poole, "Federal Reserve Operating Procedures: A Survey and Evaluation of the Historical Record Since October 1979," *Journal of Money, Credit and Banking* (November 1982, part 2), pp. 575-96; and Bennett T. McCallum and James G. Hoehn, "Instrument Choice for Money Stock Control With Contemporaneous and Lagged

Reserve Requirements," *Journal of Money, Credit and Banking* (February 1983), pp. 96-101.

Recently, Feige and McGee presented evidence that the effect of LRA on federal funds rate volatility has not been substantial when week-to-week relative changes are considered.³ Thus, previous empirical work on the volatility of short-term interest rates under LRA, which considered longer time periods or absolute measures of variability, may be misleading. This article presents a theoretical argument to further support this conclusion. It should be emphasized that only the case of a move from CRA to LRA is considered, but the premise applies equally well to the return to CRA.

The outline of the article is as follows: First, the rationale for claiming that the case against LRA is overstated is presented. This idea is then formalized in the context of a simple linear stochastic model of the money supply process. Finally, the variability of various interest rates and money is examined and some concluding comments are made.

THE RATIONALE

The concern that the theoretical case against LRA is overstated is based on the application of a simple principle: additional constraints are binding only if indi-

Three recent empirical studies that employ stochastic model simulations suggest that the gain to monetary control from the return to CRA will be modest under a nonborrowed reserve operating target. See David Lindsey and others, "Monetary Control Experience Under the New Operating Procedures," Federal Reserve Staff Study, *New Monetary Control Procedures*, February 1981, pp. 53-56; David S. Jones, "Contemporaneous vs. Lagged Reserve Accounting: Implications for Monetary Control," *Economic Review*, Federal Reserve Bank of Kansas City, November 1981, pp. 3-19; and Peter Tinsley and others, "Policy Robustness: Specification and Simulation of a Monthly Money Market Model," *Journal of Money, Credit and Banking* (November 1982, part 2), pp. 829-56.

³See Edgar L. Feige and Robert McGee, "Federal Reserve Policy and Interest Rate Instability," *The Financial Review* (May 1982), pp. 50-62.

viduals behave differently than they would in the absence of these constraints.⁴ That is, if banks already were behaving in much the same way that LRA permitted them to, then the effect of its introduction on individual and aggregate behavior would be small.

In order to see why this is the case, consider how a depository institution might manage its reserve position under CRA. Such an institution would be required to keep a fraction of its current checkable and time and savings deposit liabilities in the form of reserves (vault cash and deposits with the Federal Reserve).⁵ When the institution makes loans and investments, it creates deposits. Thus, it is usually presumed that there is a direct link between the institution's current lending and investment activities and its current holdings of reserves. In a simplified and, perhaps, naive form, institutions lend only the amount of their excess reserves.⁶ Some argue that LRA severs this link. Under LRA, depository institutions' reserve requirements are based on deposit liabilities from a preceding period. Depository institutions are free to make all the loans and investments they desire in the current period without affecting their current reserve requirements.⁷

A depository institution's decision to make additional loans and investments need not be closely related to its current holdings of reserves. In the short run it can obtain additional reserves by purchasing federal funds, borrowing from the Federal Reserve, selling Treasury securities, managing its liabilities — such as marketing certificates of deposits (CDs) more aggressively — or by temporarily holding fewer excess reserves than it

would otherwise like to hold. Thus, even under CRA, a depository institution's decision to make current loans and investments is not constrained by its current holdings of reserves.⁸

Of course, if there was a reserve deficiency and if it were to run for an extended period of time, the institution would have to adjust its lending and investment activities to bring deposits into line with its reserves. Furthermore, since only three of the above techniques of reserve adjustment relieve reserve pressure on the system as a whole, depository institutions eventually may find it necessary to adjust their lending and investment activities if rates on short-term reserve adjustment assets rise relative to the institutions' lending rates.⁹

Thus, depository institutions must eventually adjust their reserve positions by adjusting their loan and investment portfolios. For short-run (week-to-week) changes, however, they can rely on either the money market, changes in their holdings of excess reserves or the discount window. The link between current lending and investment activities and current reserves need not be strong.

A SIMPLE STOCHASTIC MODEL

In this section, the conjecture of the previous section is formalized with a simple linear stochastic model of the money stock. The model is intended only to capture the essential features of money stock determination under CRA and LRA and to illustrate the basic restriction associated with moving from CRA to LRA.¹⁰ In this sense, the model is illustrative and is not

⁴Nearly all of the theoretical work on this subject starts with a model that is completely static. LRA is introduced, transforming the static model to a dynamic one. It is clear that the conclusions of these models are based, in part, on the fact that they introduce a dynamic structure to an otherwise static model; hence, these models preclude the possibility that LRA introduces a dynamic structure that is, at least in part, redundant. This paper considers this possibility.

⁵Because of the Monetary Control Act of 1980, depository institutions need not hold reserves directly on deposit with the Federal Reserve. Instead, they may hold them with another depository institution on a pass-through basis.

⁶Actually, each individual bank has its own short-run deposit multiplier, which enables it to lend more or less than its excess reserves in the short run. See Boris P. Peseck and Thomas R. Saving, *The Foundations of Money and Banking* (MacMillan 1968), chapters 12 and 13.

⁷For a discussion of this possibility, see R. Alton Gilbert, "Lagged Reserve Requirements: Implications for Monetary Control and Bank Reserve Management," this *Review* (May 1980), pp. 7–20. Furthermore, some argue that, because of this, the Federal Reserve can only accommodate deposit expansion or contraction under LRA. For an alternative view, see Daniel L. Thornton, "Simple Analytics of the Money Supply Process and Monetary Control," this *Review* (October 1982), pp. 22–39.

⁸Spindt and Tarhan also argue, along similar lines, that the case against LRA may be overstated. Furthermore, they provide some empirical evidence of the extent to which banks rely on each of the reserve adjustment mechanisms listed above. See Paul A. Spindt and Vefa Tarhan, "Bank Earning Asset Behavior and Causality Between Reserves and Money: Lagged Versus Contemporaneous Reserve Accounting," *Journal of Monetary Economics*, forthcoming.

⁹Both federal funds trading and reducing the level of excess reserves tend to reduce the average level of excess reserves for the system as a whole. This allows a given reserve base to support a larger money stock. Discount window borrowing increases the total reserve base of the system.

¹⁰The essential features are: (1) a contemporaneous link between the reserve aggregate and the money stock, even under LRA, (2) an explicit dynamic structure under both CRA and LRA, and (3) random disturbances on both the supply and demand side. In this model, the contemporaneous link between the reserve aggregate and the money stock is established only through the excess reserve equation. This is done as a matter of convenience. The link could be established through the currency equation. See Thornton, "Simple Analytics of the Money Supply Process."

presumed to be a complete description of money stock determination.

The model consists of the following four equations:

- (1) $R_t = RR_t + ER_t$
- (2) $RR_t = \theta rM_t + (1 - \theta) rM_{t-1}$
 $\theta = 0, 1$
- (3) $ER_t = \delta M_t + \rho i_t - \lambda (RR_t - rM_{t-1}) + u_{et}$
 $\delta > 0, \rho \leq 0, 0 \leq \lambda \leq 1$
- (4) $M_t = \beta Y_t + \alpha i_t + \mu M_{t-1} + u_{mt}$
 $\beta > 0, \alpha \leq 0, \mu \geq 0.$

The random errors, u_{et} and u_{mt} , are assumed to have zero expected values and finite variances, σ_e^2 and σ_m^2 , respectively. Equations 1 through 3 represent the money supply process.¹¹ The first defines total reserves as required plus excess reserves. The second defines required reserves as some required reserve ratio, r , times the money stock; the parameter θ allows for either CRA ($\theta = 1$) or LRA ($\theta = 0$). In the third equation, excess reserves are proportionally related to the current money stock and inversely related to the market interest rate, i_t . The excess reserve equation differs from most in that depository institutions make some proportional adjustment, λ , to changes in required reserves. If $\lambda = 1$, depository institutions do not adjust their current deposits to changes in required reserves. Instead, they absorb such changes by altering their holdings of excess reserves.¹² Equation 4 is the standard short-run money demand specification, where the market equilibrium condition has been imposed.

Equation 3 is important because it allows the LRA model to be given as a special case of the CRA model ($\theta = 1$). This can be seen by solving for the equilibrium money stock and interest rate. The reduced forms for the equilibrium money stock and interest rate are given by equations 5 and 6:

$$(5) \quad M_t = \frac{\alpha}{\Delta_0} R_t + \frac{\beta \rho}{\Delta_0} Y_t + \frac{\rho \mu - \alpha(r(1-\lambda)(1-\theta) + \lambda r)}{\Delta_0} M_{t-1} - \frac{\alpha}{\Delta_0} u_{et} + \frac{\rho}{\Delta_0} u_{mt}$$

$$(6) \quad i_t = \frac{1}{\Delta_0} R_t - \frac{\beta(\theta r(1-\lambda) + \delta)}{\Delta_0} Y_t - \frac{(\mu - 1)\theta(1-\lambda)r + \delta\mu + r}{\Delta_0} M_{t-1} - \frac{1}{\Delta_0} u_{et} - \frac{\theta r(1-\lambda) + \delta}{\Delta_0} u_{mt}, \text{ where } \Delta_0 = \alpha(r\theta(1-\lambda) + \delta) + \rho < 0.$$

Note that equation 5 is the same if $\theta = 0$ or if $\lambda = 1$; the same is true of equation 6. That is, the equilibrium money stock and interest rate are the same in a model with CRA, where depository institutions do not initially alter their current lending and investment activities to adjust their reserve positions ($\lambda = 1$) as in a model with LRA. Thus, imposing lagged reserve accounting on the above model by letting $\theta = 0$ when $\lambda = 1$ has no effect on the money supply; depository institutions would not have altered their lending and investment activities immediately in response to changes in total reserves anyway. The imposition of LRA is redundant if $\lambda = 1$.¹³

Effects of LRA on the Money Supply

Solving the first three equations, the money supply, M^s , is given by

$$(7) \quad M_t^s = \frac{1}{\Delta_1} R_t - \frac{(r - (1-\lambda)\theta r)}{\Delta_1} M_{t-1} - \frac{\rho}{\Delta_1} i_t - \frac{1}{\Delta_1} u_{et},$$

where $\Delta_1 = \theta r(1-\lambda) + \delta$. A comparison of the money supply when $\theta = 1$ and when $\theta = 0$ reveals basic differences between LRA and CRA that should be noted. First, the money supply schedule is more interest-sensitive under LRA, as figure 1 illustrates.

Second, the multiplier on the reserve aggregate is smaller for CRA than for LRA.¹⁴ Thus, a given change in the reserve aggregate shifts the money supply schedule further under LRA. The shift is significantly further so that the initial change in the equilibrium money stock is greater under LRA (figure 1). Thus, a given change in the policy variable (or any exogenous shock on the supply side) produces a larger initial

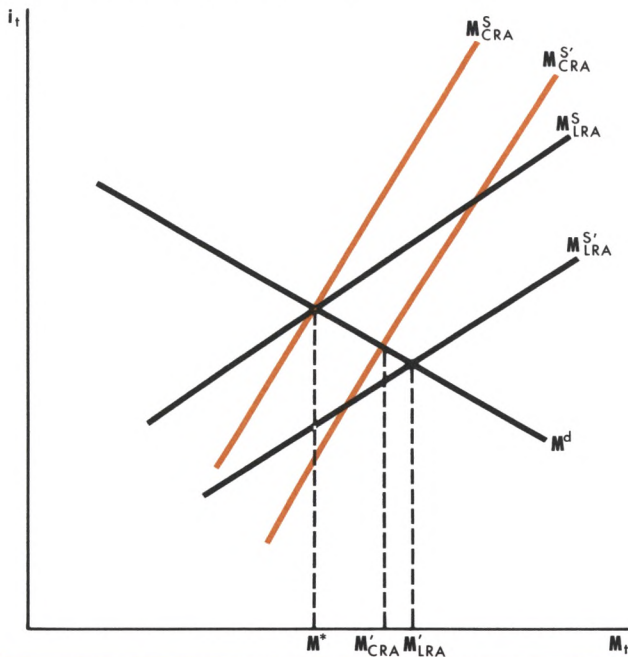
¹¹It should be noted that this model contains only a one-period lag, whereas, as implemented, LRA has a two-period lag. The one-period lag was adopted for computational convenience.

¹²Excess reserves are treated as a buffer-stock asset. Furthermore, they are assured to be strictly positive and sufficient to deal with any required reserve surprises due to random fluctuations in u_{et} or u_{mt} . This model is kept simple by considering explicitly only reserve adjustment through excess reserve holdings. It should be clear, however, that the other adjustment mechanisms could be modeled.

¹³There is an implicit assumption that bank reserve adjustment behavior is invariant to the reserve accounting system. Recently, Spindt and Tarhan have provided empirical evidence that this was the case after LRA was introduced in 1968. It is interesting to note, however, that their evidence indicates that banks relied less on adjusting current loans and investments and more on changes in excess reserves, federal funds, discount window borrowings and CDs after LRA was introduced. The differences, however, were not statistically significant. See Spindt and Tarhan, "Bank Earning Asset Behavior and Causality Between Reserves and Money."

¹⁴The multipliers are $1/\delta$ and $1/(r(1-\lambda) + \delta)$ for LRA and CRA, respectively.

Figure 1
Money Supply Shifts under CRA and LRA



change in the money stock and the interest rate under LRA.

Finally, the money supply equation is dynamic under LRA, but not under CRA unless $\lambda > 0$. This is an important difference. If the money supply schedule is assumed to be static, as is common for CRA specifications, then the adjustment from initial to long-run equilibrium is determined solely by the dynamic structure of the demand for money. If μ , the money demand coefficient on lagged money, is positive (as nearly all the empirical work on the money demand equation suggests), then the initial equilibrium under CRA will be below the long-run equilibrium.¹⁵ If only a static model is considered (CRA with $\lambda = \mu = 0$) then the imposition of LRA introduces a dynamic structure to the model.¹⁶ In this case, the initial equilibrium money

¹⁵This would not be the case if there were strong distributed lag effects on interest rates in the money demand equation dominating the distributed lag effects on the money supply. However, such effects seem absent from most empirical estimates of money demand. For an exception, see Daniel L. Thornton, "Maximum Likelihood Estimates of a Partial Adjustment-Adaptive Expectations Model of the Demand for Money," *Review of Economics and Statistics* (May 1982), pp. 325-29.

¹⁶It should be noted that neither LRA nor an excess reserve equation like equation 3 is necessary to get a lagged effect on the money supply. All that is required is that there be a lagged effect in the public's demand for a component of a particular monetary aggregate or reservable asset. For example, a positive coefficient on either lagged currency or the time deposits in a standard money stock model will be sufficient to cause an initial overshooting of the

stock would be above its long-run equilibrium: depository institutions initially would overexpand the money stock and oscillate toward long-run equilibrium.¹⁷

LRA allows the current money stock to affect the future money supply. In the complete model, with lagged money in the money demand function, the long-run equilibrium can be above or below the initial equilibrium. The particular outcome depends on the relative strength of the supply-side and demand-side effects.

These results can be illustrated by noting that equation 5 can be lagged and substituted into equations 5 and 6 to obtain the dynamic equations for the equilibrium money stock and interest rate:

$$(8) \quad M_t = \frac{\alpha}{\Delta_0} \sum_{j=0}^{\infty} \xi^j R_{t-j} + \frac{\beta\rho}{\Delta_0} \sum_{j=0}^{\infty} \xi^j Y_{t-j} - \frac{\alpha}{\Delta_0} \sum_{j=0}^{\infty} \xi^j u_{et-j} + \frac{\rho}{\Delta_0} \sum_{j=0}^{\infty} \xi^j u_{mt-j}$$

$$(9) \quad i_t = \frac{1}{\Delta_0} R_t - \frac{\alpha\eta}{(\Delta_0)^2} \sum_{j=0}^{\infty} \xi^j R_{t-j-1} - \frac{\beta(\theta r(1-\lambda) + \delta)}{\Delta_0} Y_t - \frac{\eta\beta\rho}{(\Delta_0)^2} \sum_{j=0}^{\infty} \xi^j Y_{t-j-1} - \frac{1}{\Delta_0} u_{et} + \frac{\alpha\eta}{(\Delta_0)^2} \sum_{j=0}^{\infty} \xi^j u_{et-j-1} - \frac{r\theta(1-\lambda) + \delta}{\Delta_0} u_{mt} - \frac{\eta\rho}{(\Delta_0)^2} \sum_{j=0}^{\infty} \xi^j u_{mt-j-1},$$

where $\xi = \frac{\rho\mu - \alpha(r(1-\lambda)(1-\theta) + \lambda r)}{\Delta_0}$

and $\eta = (\mu - 1)\theta(1-\lambda)r + \delta\mu + r$.

Letting $E(M_t)$ and $E(i_t)$ denote the expected value of these variables, the long-run response of money and the interest rate to a change in the reserve aggregate is

$$\frac{\partial E(M_t)}{\partial R_t} = \frac{\alpha}{\alpha(\delta + r) + (1-\mu)\rho}$$

$$\frac{\partial E(i_t)}{\partial R_t} = \frac{1-\mu}{\alpha(\delta + r) + (1-\mu)\rho}$$

long-run equilibrium in these models if their effect is sufficiently large relative to μ .

¹⁷This is the result obtained by Laufenberg. He bases his result on a comparison of basic LRA and CRA models with $\mu = 0$; his CRA model is completely static while his LRA model is dynamic. Thus, his long-run LRA multiplier was always less than his instantaneous LRA multiplier. See Laufenberg, "Contemporary Versus Lagged Reserve Accounting."

These results require the stability condition $|\xi| < 1$.

Note that the long-run effect of a given change in the reserve aggregate does not depend on θ : it is invariant to the reserve accounting system.¹⁸ The reserve accounting system affects only the dynamic adjustment toward long-run equilibrium, and then only if depository institutions follow a path different from the one they otherwise would have followed. Furthermore, a comparison of the long-run money multiplier above with the instantaneous multiplier of equation 5 shows that, under CRA ($\theta = 1$), the long-run multiplier is strictly smaller only if $\mu = 0$, but may be larger or smaller if $\mu > 0$, as discussed above.¹⁹

Effects on the Variability of Money and Interest Rates

We turn now to the important question of the variability of money and interest rates under LRA and CRA. In order to simplify the analysis, the following assumptions are made:

$$E(u_{it} u_{jt}) \begin{cases} = \sigma_i^2 \text{ for } t = t' \text{ and } i = j \\ = 0 \text{ for } t \neq t' \text{ or } i \neq j \end{cases} \quad i, j = e, m.$$

Given these assumptions, the variance of money and the interest rate for a k -period time horizon can be expressed as

$$\begin{aligned} \text{Var}(M_t^k) &= \left[\left[\frac{\alpha}{\Delta_0} \right]^2 \sigma_e^2 + \left[\frac{\rho}{\Delta_0} \right]^2 \sigma_m^2 \right] \psi \\ \text{Var}(i_t^k) &= \left(\left[\frac{1}{\Delta_0} \right]^2 + \left[\frac{\alpha\eta}{\Delta_0^2} \right]^2 \psi \right) \sigma_e^2 + \left(\left[\frac{r\theta(1-\lambda)+\delta}{\Delta_0} \right]^2 \right. \\ &\quad \left. + \left[\frac{\eta\rho}{\Delta_0^2} \right]^2 \psi \right) \sigma_m^2, \text{ where } \psi = \frac{1-\xi^{2(k+1)}}{1-\xi^2}. \end{aligned}$$

It seems appropriate to consider the variance around the long-run equilibrium. If the variance of money and the interest rate around their long-run equilibria are denoted by $\text{Var}(M_t^*)$ and $\text{Var}(i_t^*)$, respectively, then

$$\text{Var}(M_t^*) = \lim_{k \rightarrow \infty} \text{Var}(M_t^k)$$

and

$$\text{Var}(i_t^*) = \lim_{k \rightarrow \infty} \text{Var}(i_t^k).$$

These expressions reduce to

$$(10) \quad \text{Var}(M_t^*) = \frac{(\alpha)^2 \sigma_e^2}{\Gamma} + \frac{\rho^2 \sigma_m^2}{\Gamma}$$

and

$$(11) \quad \text{Var}(i_t^*) = \left(\left(\frac{1}{\Delta_0} \right)^2 + \frac{(\alpha\eta)^2}{\Delta_0^2 \Gamma} \right) \sigma_e^2 + \left(\left(\frac{r\theta(1-\lambda)+\delta}{\Delta_0} \right)^2 + \frac{(\eta\rho)^2}{\Delta_0^2 \Gamma} \right) \sigma_m^2,$$

where $\Gamma = [\alpha(r\theta(1-\lambda)+\delta)+\rho]^2 - [\rho\mu - \alpha(r(1-\lambda)(1-\theta)+\lambda r)]^2$.

These expressions are independent of θ if $\lambda = 1$. That is, if depository institutions already behave under CRA as LRA would require them to behave, the introduction of LRA would have no effect on the variance of money or interest rates. If $\lambda < 1$, however, the move to LRA will increase the variance of money and may increase the variance of interest rates, depending (in part) on the relative magnitude of the variance of supply-side and demand-side shocks: the variance of interest rates is smaller under LRA the larger the variance of demand-side shocks. The essential conclusion, however, remains: the increase in the variance of money associated with a shift in the reserve accounting system from CRA to LRA is smaller the closer depository institutions conform to LRA behavior already — in this model, the closer λ is to 1.

A Graphical Presentation of The Results

The results are summarized conveniently in figures 2 and 3. Note that the variances of equilibrium money stock and interest rates given in equations 10 and 11 have both demand-side and supply-side components. That is, they depend on both σ_e^2 and σ_m^2 . Thus, the variance of M^* can be decomposed into $\sigma_m^{d*} + \sigma_m^{s*}$, where σ_m^{d*} and σ_m^{s*} denote the variance of M^* due solely to demand- and supply-side shocks, respectively. The variance of i^* can be decomposed likewise.

Given the probability density function of u_m and u_e , it is conceptually possible to construct a probability region for σ_m^{d*} and σ_m^{s*} from the corresponding region for u_m . This can be done for supply-side shocks as well.

¹⁸It may seem odd that the long-run equilibrium is independent of θ and λ but not of μ . To see why this is the case, note that in long-run equilibrium, where $M_t = M_{t-1} = \dots$ and $RR_t = RR_{t-1} = \dots$, the parameters θ and λ drop out of equations 2 and 3, respectively. This is not true of μ in equation 4. This would be the case even if a growth rate model had been specified.

¹⁹Compare $\frac{\alpha}{\alpha(\delta+\theta)+(1-\mu)\rho}$ with $\frac{\alpha}{\alpha(r\theta(1-\lambda)+\delta)+\rho}$. The long-run multiplier will be larger, equal to or smaller than the initial multiplier, depending on whether $\alpha^2 r(\theta-1) - \alpha^2 \theta r \lambda + \alpha \mu \rho \geq 0$. If $\mu = 0$, this expression will be strictly negative. If $\mu > 0$, this expression could be positive or negative, depending on the relative magnitudes of the various parameters.

Figure 2
Demand-Side Variability under CRA and LRA

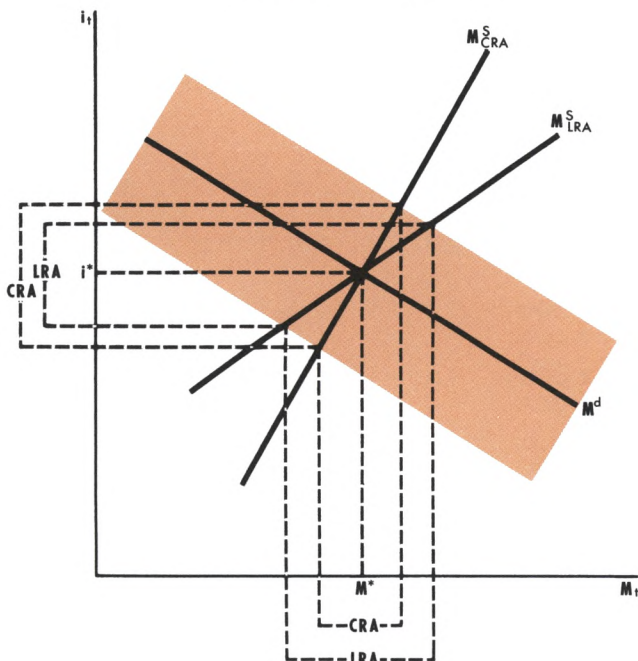


Figure 3
Supply-Side Variability under CRA and LRA

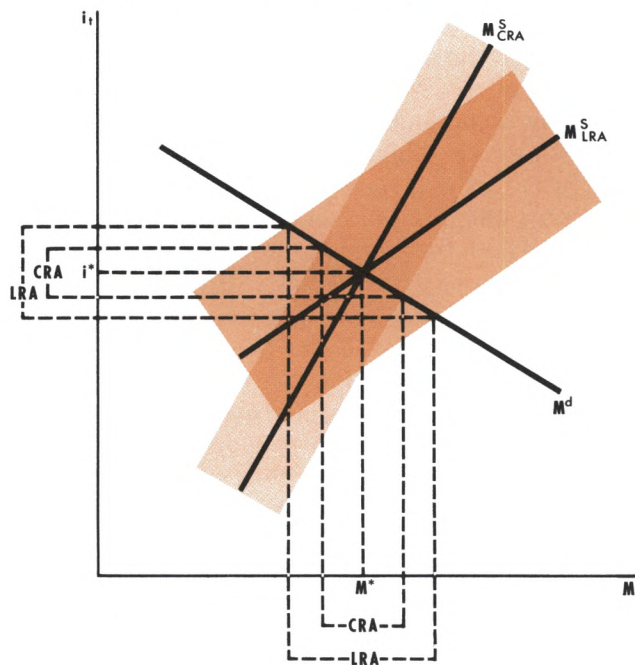


Figure 2 shows a hypothetical 95 percent region for both M^* and i^* associated with a corresponding 95 percent region of demand-side shocks. The region for M^* is larger under LRA than under CRA because the slope of the money supply schedule is flatter under LRA. By the same token, however, the region is smaller for i^* under LRA. The slope of the LRA curve approaches that of the CRA curve as λ approaches 1. If $\lambda = 1$, the curves coincide and the variability of M^* and i^* associated with demand-side shocks is independent of the reserve accounting system.

Figure 3 shows the 95 percent region for i^* and M^* associated with the corresponding 95 percent region for supply-side shocks. Both regions are larger under LRA because the corresponding supply-side component multipliers (equations 10 and 11) are larger. These multipliers for LRA approach those for CRA as λ approaches 1. If $\lambda = 1$, these multipliers are identical and the variability of i^* and M^* associated with supply-side shocks is independent of the reserve accounting system.

Thus, if banks initially relied on changes in excess reserves (or the discount window or the money market)

to adjust to short-run changes in required reserves before the introduction of LRA in September 1968, the effect of its introduction on the variability of money and interest rates would have been considerably less than previous theoretical work would indicate. Moreover, the return to CRA may not reduce the variability of money and interest rates as much as many analysts anticipate, if depository institutions do not change the manner in which they make short-run adjustments in their reserve positions.

Furthermore, it could be argued that the new procedure for CRA may have a minimal effect because it lengthens the reserve accounting period from one to two weeks. Thus, even if depository institutions make loans in the current period regardless of the consequences of these activities on required reserves under LRA, this practice may not be reduced markedly because of the lengthening of the reserve accounting period. Depository institutions may continue to make loans early in the period, waiting to settle (perhaps at the discount window, the money market or through changes in excess reserves) toward the end of the period. Of course, curtailment of lending activities will affect their current-period reserve requirements under CRA, but not under LRA.

EMPIRICAL EVIDENCE ON THE VARIANCE OF MONEY AND INTEREST RATES

Given that the effect of the reserve accounting system on the variability of money and interest rates appears to be in doubt, it would be desirable to estimate this effect. Unfortunately, empirical estimates from historical data may be of limited value. The observed variability of money and interest rates is a function of both the random components of the model and of movements associated with changes in the policy variable through time, as well as of changes in the structure of the system due to other changes, such as the introduction of LRA. This fact, coupled with documented and undocumented changes in the objectives of monetary policy, makes it difficult to separate the effect of the reserve accounting structure alone on the variability of money and interest rates. Nevertheless, it may be interesting to examine the data to see if a picture consistent with increased variability under LRA emerges.

Three measures of variability are used: two relative measures, the coefficient of variation (CV) and the average absolute percentage change (AAPC), and one absolute measure, the standard deviation (SD).²⁰ Weekly data are used for various subperiods from January 1966 to November 1982. The subperiods were chosen on the basis of the introduction of LRA on September 12, 1968, and on the basis of announced changes in Federal Reserve procedures.²¹ The three measures of variability, and the mean (\bar{X}) of M1 appear in table 1. The same statistics appear in table 2 for the federal funds rate, the 3-month Treasury bill rate and the 4–6 month commercial paper rate.

²⁰The standard deviation is not independent of the unit of measure: $SD(kx) = kSD(x)$, where k is a constant. Thus, if the level of the variable increases through time, the SD will increase even if the variability relative to the mean has not changed. The coefficient of variation adjusts for this effect.

²¹Lagged reserve accounting was introduced on September 12, 1968; at its January 15, 1970, meeting, the Federal Open Market Committee stated a desire to place increased emphasis on the growth of certain monetary aggregates; Congress passed Resolution 133 on March 24, 1975, requesting that the Board of Governors set long-run ranges for the aggregates; the Federal Open Market Committee adopted a reserve aggregate targeting procedure on October 6, 1979. See Jerry L. Jordan and Neil A. Stevens, "The Year 1970: A Modest Beginning for Monetary Aggregates," this *Review* (May 1971), pp. 14–32; Nancy Jianakoplos, "The FOMC in 1975: Announcing Monetary Targets," this *Review* (March 1976), pp. 8–22; and Richard W. Lang, "The FOMC in 1979: Introducing Reserve Targeting," this *Review* (March 1980), pp. 2–25.

Table 1
Measures of Absolute and Relative Variability of M1

Period ¹	M1 (SA)			
	AAPC	SD ²	CV	\bar{X} ²
1/ 5/66– 9/11/68	.16%	\$ 7.28	4.06	\$179.63
9/18/68– 1/15/70	.12	3.07	1.52	202.09
1/22/70– 3/26/75	.16	23.16	9.50	243.73
4/ 2/75– 10/ 3/79	.18	31.18	9.53	327.02
10/10/79– 11/26/82	.36	24.93	5.87	424.62

¹Data for week ending date shown.

²Billions of dollars.

These data show that there was no increase in the week-to-week absolute or relative variability of M1 immediately after the introduction of LRA in September 1968. If anything, there was a reduction in variability.²² Furthermore, though there was an increase in the absolute variability of the federal funds and the Treasury bill rates, there was essentially no change in the relative variability. The exception was the commercial paper rate. It became more variable in both absolute and relative terms.²³ These data are broadly at odds with the general conclusion that the move to LRA increased the variability of money and interest rates.

Of course, one could argue that the theoretical results of the previous section are based on a model in which money is controlled through reserve aggregate targeting, and that the Federal Reserve was operating on an interest rate target during this period. Thus, the results of the theoretical model may not be forthcoming over this period. Even an interest rate targeting

²²If one assumes that the absolute percentage change has a positive and finite variance, then one can rely on the Central Limit Theorem to construct an asymptotic "t-test" of the differences in the AAPC for two subperiods. The t-ratio for the test of the first against the second subperiod was -2.75 for M1, indicating a significant reduction (at the 5 percent level) in the AAPC for M1 after the introduction of LRA. See Robert V. Hogg and Allen T. Craig, *Introduction to Mathematical Statistics*, 4th ed. (MacMillan 1978), p. 192, for the conditions necessary to invoke the Central Limit Theorem.

²³The asymptotic t-ratios for FFR, TBR and CPR for the AAPC were 1.56, -0.87 and 2.82, respectively. See footnote 22 for details.

Table 2

Measures of Absolute and Relative Variability of Three Interest Rates

Period	Federal Funds Rate ¹				Treasury Bill Rate				Commercial Paper Rate			
	AAPC	SD	CV	\bar{X}	AAPC	SD	CV	\bar{X}	AAPC	SD	CV	\bar{X}
1/ 5/66– 9/11/68	5.10%	0.76%	15.51	4.88%	1.66%	0.53%	11.06	4.76%	0.65%	0.46%	8.55	5.48%
9/18/68– 1/15/70	6.35	1.37	17.95	7.61	1.48	0.75	11.60	6.44	1.13	1.12	15.06	7.44
1/22/70– 3/26/75	3.83	2.58	6.67	7.05	2.92	1.63	27.60	5.92	1.91	2.15	30.34	7.08
4/ 2/75– 10/ 3/79	1.61	2.05	30.24	6.80	1.73	1.71	26.59	6.43	1.25	1.92	27.50	6.97
10/10/79– 11/26/82	4.45	3.08	21.81	14.13	3.94	2.56	21.12	12.13	3.90	2.65	19.90	13.34

¹Data for week ending two days later than date shown.

procedure, however, requires the Federal Reserve to forecast money demand. Hence, errors in short-run money demand forecasts should have produced more variable money under LRA.

The Federal Reserve placed more emphasis on monetary aggregates in March 1970 and set long-run targets for the aggregates beginning in 1975. Assuming no other change occurred that would affect the variability, one might expect the variability of M1 to increase in these subperiods relative to the pre-LRA period. Here the results are mixed. Both the SD and the CV show an increase in the variability of M1, while the AAPC shows essentially no change. Broadly similar results are obtained for the three interest rates in table 2. The only significant increase in the AAPC for M1 comes with the Federal Reserve's adoption of reserve aggregate targeting in October 1979.

CONCLUSIONS

The analysis presented in this article indicates that the type of reserve accounting structure has no effect on the long-run equilibrium money stock; it can, however, influence the dynamic path to equilibrium if it forces depository institutions to adjust their reserve positions differently than they would have done other-

wise. In this instance, the variance of money would increase with the shift from CRA to LRA and the variance of the interest rate might increase as well, depending on relative variability of demand- and supply-side shocks. In the absence of more detailed information about the exact nature of the dynamic adjustment process, the question of whether money or interest rates are more variable under CRA or LRA is empirical.

Unfortunately, the observed variability of money and interest rates is not simply a function of the reserve accounting system; it depends also on the random components of the model and movements associated with changes in the policy variable through time. Thus, it is difficult to assess the effect of changes in the reserve accounting structure alone on the observed variability of money and interest rates. The simple evidence from weekly data does not give a clear picture of whether the movement to LRA in September 1968 increased the variability of money and interest rates. The results differ depending on the measure of variability one uses. Nevertheless, if the average absolute percentage change is used as the measure of variability, there was no significant change in the week-to-week variability of M1 from January 5, 1966, to November 3, 1979.

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