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Review
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In This Issue . . .

After expanding rapidly throughout the 1970s, the volume of U.S. exports of agricultural products has declined in recent years. Many economists have argued that the high value of the dollar — caused, at least in part, by what they view to be restrictive monetary policy — is responsible for these declines. In the first article of this *Review*, Dallas S. Batten and Michael T. Belongia attempt to separate fact from fiction in the debate over monetary policy's role in determining the value of the dollar and the effect of exchange rate movements on the volume of U.S. agricultural exports.

Batten and Belongia first draw distinctions between nominal and real changes in the exchange rate and conclude that monetary policy causes nominal changes in the value of the dollar whereas real changes — associated primarily with nonmonetary factors — are the exchange rate movements that affect trade flows. The authors examine data on real exchange rate changes and agricultural exports from several perspectives and conclude that the exchange rate has been only one factor in the recent export decline. Their analysis finds that foreign real income, depressed by the recent world recession, has also been a primary reason for the lower volume of U.S. agricultural exports.

In the second article, "Hedging Interest Rate Risk with Financial Futures: Some Basic Principles," Michael T. Belongia and G. J. Santoni discuss the problem of interest rate risk facing depository institutions in an era of financial deregulation and volatile interest rates. The authors use simple examples to show how changes in interest rates affect a depository institution's equity value. Because share owners are interested in protecting their wealth, some institutions have initiated efforts to hedge the value of their equity.

Belongia and Santoni then discuss the economic principles of hedging the interest rate risk of a financial portfolio with futures contracts. They show how interest rate risk can be measured and, based on that measurement, how futures contracts can preserve a given equity value whether interest rates rise or fall. The examples also illustrate that a variety of cash flows are consistent with a true hedge based on insulating a firm's equity. This result is important because many hedging strategies are designed to maintain a fixed cash flow. While this may be important for some management purposes, such a strategy will often result in a hedge that does not protect the wealth of share owners. Therefore, focusing attention solely on cash flows, as many hedging strategies seem to do, will often result in a hedge that does not protect equity.

In the third article, "An Early Look at the Volatility of Money and Interest Rates Under CRR," Daniel L. Thornton examines whether the Federal Reserve's adoption of a system of contemporaneous reserve requirements (CRR) in February 1983 has had any noticeable effects on the variability of money growth and interest rates. Although CRR was adopted with the expectation that it would reduce the variability of money growth, Thornton points out that there are two reasons why this would not necessarily occur. First, depository institutions may react in ways that reduce the contemporaneous link between reserves and deposits (and, hence, money) under CRR. Second, the October 1982 change in the Federal Reserve's operating procedures may have weakened the contemporaneous relationship between reserves and money; the argument that CRR would reduce the variability in money growth was predicated on the use of a strong reserve aggregate targeting procedure.

Thornton then examines the week-to-week variability of money growth and interest rates before and after February 1984 and to see if the adoption of CRR had any impacts. He finds that there have been no significant changes in the variability of money growth on interest rates associated with CRR.

The Recent Decline in Agricultural Exports: Is the Exchange Rate the Culprit?

Dallas S. Batten and Michael T. Belongia

AFTER increasing at an annual rate of 5.9 percent between 1973 and 1980, the volume of U.S. exports of agricultural products exhibited no growth in 1981 and declined at a 5.0 percent annual rate in 1982 and 1983. Many analysts blame these export declines on the appreciation of the U.S. dollar.

Chattin and Lee, for example, attribute at least half of the export decline in 1982 and 1983 to this cause:

> "Over the last two years, the real value of the dollar has appreciated just over 25 percent (on a trade-weighted basis) for importers of U.S. corn and 16 percent for importers of U.S. wheat. Our analysts estimate that . . . the United States has lost up to $6 billion in farm export sales due to the strong dollar."[1]

Similarly, Schuh, using the nominal agricultural export and exchange rate data plotted in chart 1, concludes that "the export boom of the 1970s is seen to be closely tied to the fall in the value of the dollar. The decline in our export performance is closely associated with the rise in the value of the dollar in the 1980s."[2]

The problem with these statements is that such simple analyses generally are inadequate in establishing a cause-and-effect relationship between exchange rates and agricultural exports. First, the comparison in chart 1 fails to distinguish nominal changes in exchange rates, which reflect changes in relative rates of inflation across countries, from real changes in exchange rates, which reflect structural changes. An analysis of the impact of exchange rates on trade must first separate these two types of exchange rate changes, because only changes in real magnitudes influence trade flows.

Second, a simple two-variable comparison will not correctly identify the relationship between exchange rate movements and exports because factors other than exchange rate fluctuations influence export flows. This being the case, the relevant procedure is to isolate the *marginal* impact of exchange rates on trade, holding constant the impact of the other forces that affect export flows.

The purpose of this article is to explain the fundamental differences between nominal and real changes in exchange rates and to show why only real changes in exchange rates influence trade flows. In addition, the effects of real changes in exchange rates on export volume during the 1982–83 decline are estimated by using a simple econometric model of the determinants of world trade.

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[1]Chattin and Lee (1983), p. 19.

[2]Schuh (1984), p. 244. Other papers drawing a similar causal relationship between exchange rates and agricultural exports include Chambers and Just (1982), Tweeten (1983) and Hathaway (1983).

THE SOURCES OF EXCHANGE RATE FLUCTUATIONS

Analysts generally agree that observed changes in exchange rates are either nominal or real in nature.[3] Nominal changes occur when the rates of inflation differ among countries. For example, if the U.S. rate of inflation is consistently below those of its trading partners, then the U.S. dollar should appreciate at rates roughly equal to the spread between inflation rates.[4] Real changes, on the other hand, reflect changing relative prices (due to diverging structural developments among countries) that have different effects on the exchange rate than on the relative rates of domestic inflation. For example, some would argue that the discovery of North Sea oil in the United Kingdom induced a substitution of domestically produced for imported oil, thereby causing the British pound to rise in value independent of any differences in inflation rates.[5]

Money Growth and Nominal Exchange Rate Changes

The rate of domestic inflation and, hence, nominal changes in the exchange rate are determined *jointly* by the rate of domestic money growth relative to the growth of the amount of money that individuals, domestic and foreign, desire to hold. A country's money supply is determined primarily by its monetary authority; the demand for money (i.e., the sum total of individual desires to hold a portion of their wealth in the form of money) is determined primarily by income, real interest rates, prices and price expectations in that country and abroad. The equilibrium rate of inflation is the one that maintains continuous equality between the aggregate supply of and demand for money. Any other inflation rate generates a "monetary disequilibrium," which motivates individuals to alter their spending rate in order to bring their money holdings nearer to the amount they desire to hold.

Changes in the rate of consumer spending affect the demand for both domestically produced goods and services and those produced abroad. Altered demands for foreign goods and services, in turn, produce changes in the U.S. demand for foreign currencies and, as a consequence, changes in the foreign exchange value of the dollar, all other things equal. Thus, a monetary disequilibrium, through its impact on the rate of aggregate spending, simultaneously induces a change in the rate of domestic inflation and the foreign exchange rate.

In the long run, the change in the foreign exchange rate will offset exactly the change in the rate of domestic inflation, all other things equal. Therefore, while domestic inflation changes the domestic prices of exportable goods, it also changes the number of domestic currency units that a unit of foreign currency can purchase in proportion to the difference between the foreign and domestic inflation rates. Consequently, changes in the rate of money growth should have no long-run effects on either the foreign currency price of U.S. exports or the competitive positions of U.S. exporters in foreign markets.

Purchasing Power Parity

This link between nominal changes in the exchange rate and relative rates of domestic inflation is summarized by the concept of purchasing power parity (PPP), which can be expressed as:

$$(1)\quad \%\Delta e = \pi_F - \pi_{US},$$

where $\%\Delta e$ is the rate of change of the foreign currency price of a U.S. dollar, and π_{US} and π_F denote the rates of inflation in the United States and a foreign country, respectively.[6] If, for example, the rate of inflation in the United States falls relative to inflation rates abroad, the number of units of foreign currency per dollar will rise; that is, the dollar will appreciate. Under PPP, nominal changes in exchange rates will offset differences in domestic inflation rates across countries. Therefore, if PPP is maintained, the offsetting effects of foreign and domestic inflation rates do not permit a change in the value of the dollar — over the long run — to affect trade of any type, including agricultural trade. Consequently, if the appreciation of the dollar has produced the recent decline in U.S. agricultural exports, PPP must not have been maintained during this era of flexible exchange rates.

Money Growth and Real Exchange Rate Changes: Deviations from PPP

Real changes in exchange rates imply deviations from PPP. Even though real changes in the exchange

[3]See, for example, Korteweg (1980) and Pigott (1981).

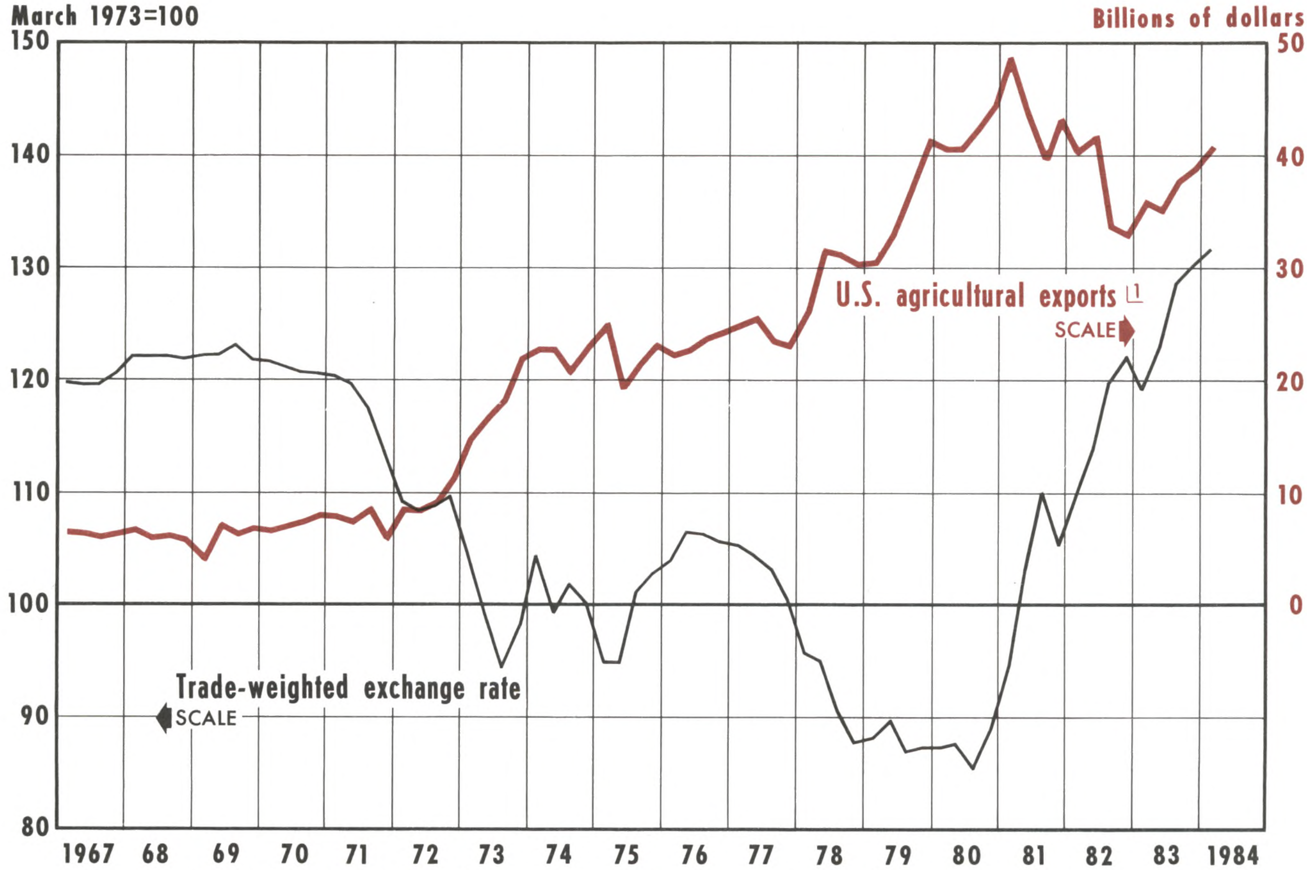
[4]For a more detailed discussion, see Batten and Ott (1983).

[5]For example, see Chrystal (1984) and Korteweg.

[6]Equation 1 actually represents the concept of *relative* PPP, which states that changes in the exchange rate will exactly offset the inflation differential. See Frenkel (1981).

Chart 1

Nominal U.S. Agricultural Exports and Nominal Exchange Rate



Sources: U.S. Department of Commerce Survey of Current Business and Board of Governors of the Federal Reserve System.

1 Seasonally adjusted annual rate.

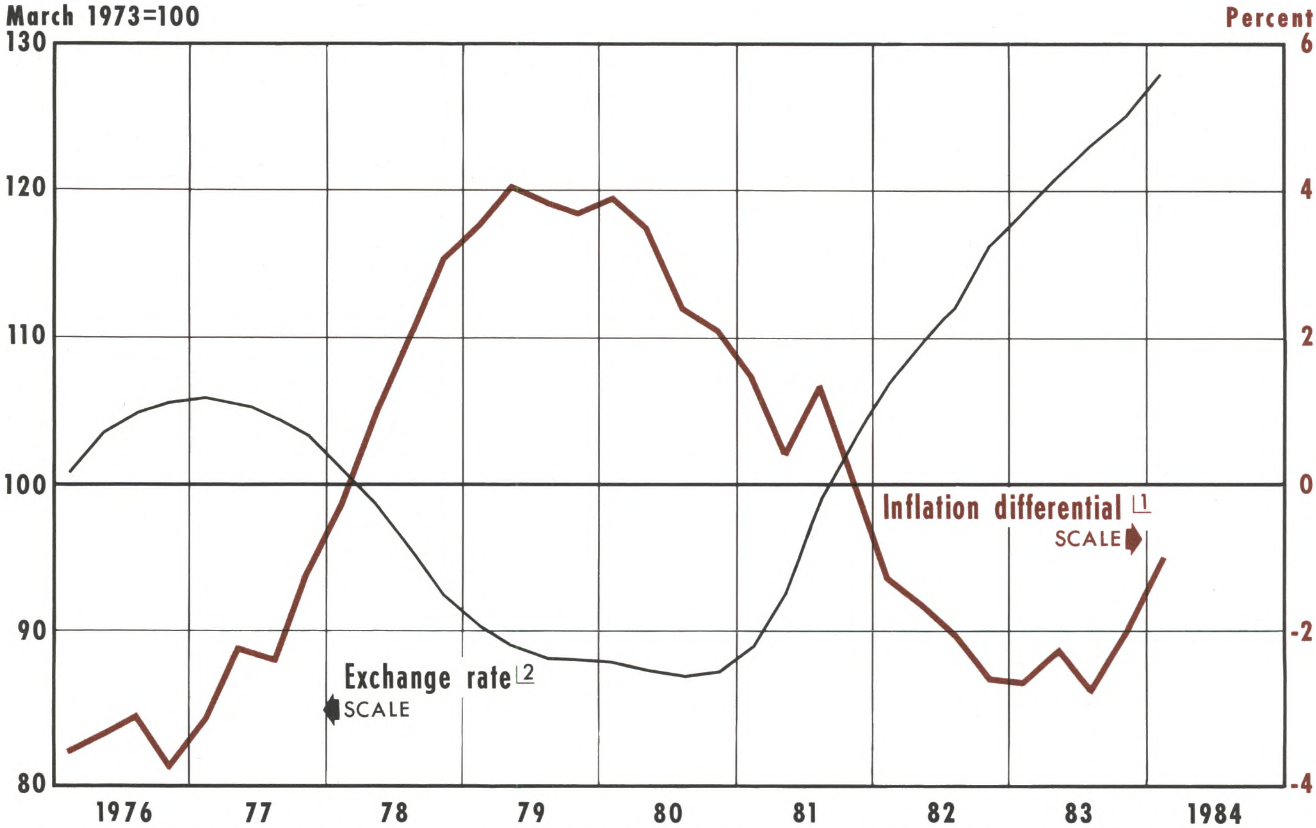
rate typically are associated with structural differences in real economic performance across countries, the short-run adjustment to a monetary disequilibrium may generate temporary deviations from PPP.

If, for example, there is an unexpected decline in money growth, producers cannot discern immediately whether the associated decline in aggregate demand (spending) is permanent or merely temporary. Thus, they respond initially to a monetary-induced reduction in demand by lowering their rate of production, which reduces the rate of real economic activity below its normal rate. Only when producers recognize that the decline in spending is a permanent adjustment to slower money growth will they respond by reducing prices and returning production to its normal rate. Hence, the impact of the monetary disequilibrium on output eventually vanishes, leaving only the rate of inflation permanently lowered. These long-run adjustments do not occur immediately, however, because there are lags in the transmission of information on the origin and magnitude of the shock to aggregate demand.

Unlike domestic commodity prices, exchange rates respond quickly to a monetary disequilibrium.[7] The exchange rate is determined in highly organized, internationally integrated markets that quickly and efficiently assimilate new information. Consequently, it will change *before* commodity prices change sufficiently to regain the domestic monetary equilibrium.

[7]See Mussa (1979, 1982) and Dornbusch (1976).

Chart 2
Inflation Differential and Nominal Exchange Rate



Sources: International Monetary Fund International Financial Statistics and Board of Governors of the Federal Reserve System

1 U.S. inflation minus trade-weighted foreign inflation

2 Four-quarter moving average of nominal trade-weighted exchange rate.

Between these two events, exporters will face a temporarily deteriorating competitive position in foreign markets. The exchange value of the dollar — and, therefore, the prices paid by foreign importers of U.S. goods — will rise before the rate of domestic inflation and domestic commodity prices have declined by the full amount consistent with the reduction in the rate of money growth. This monetary-induced deviation from PPP, however, cannot persist for long.

MONEY SHOCKS AND DEVIATIONS FROM PPP: THE EVIDENCE

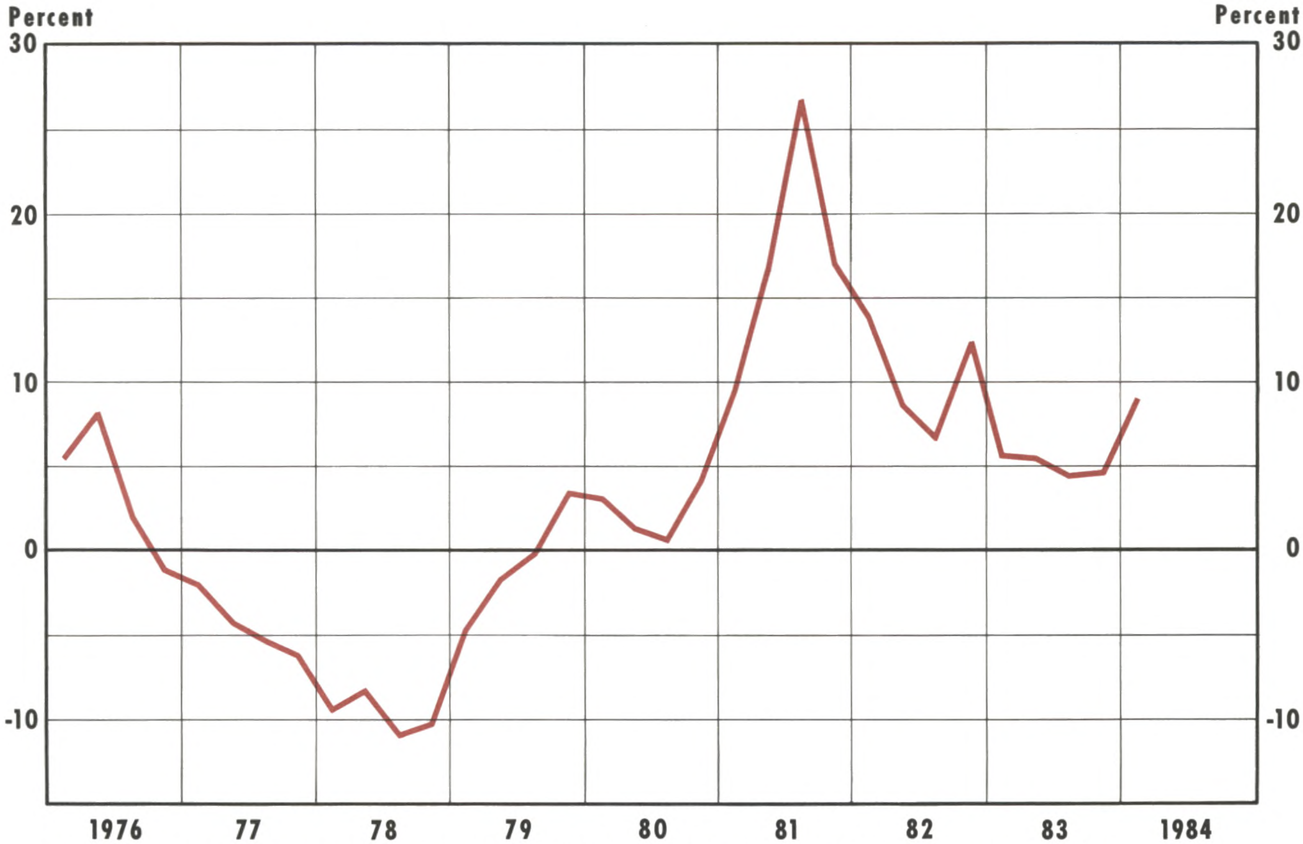
The general relationship between exchange rates and inflation differentials since 1976 is exhibited in chart 2. This chart shows the trade-weighted foreign currency value of the U.S. dollar and the difference between the U.S. rate of inflation (as measured by the CPI) and the trade-weighted rate of inflation of the U.S.'s 10 major trading partners.[8]

It is apparent from the chart that the foreign currency value of the dollar rises when the rate of domestic inflation falls relative to that of its major trading partners, and vice versa.[9] This chart should not be

[8]For a description of the calculation of the trade-weighted exchange rate and the weights employed, see "Index of the Weighted-Average Exchange Value of the U.S. Dollar" (1978). The trade-weighted inflation differential 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 and weights as used for the exchange rate.

[9]The simple correlation coefficient between the two series for the period I/1976–I/1984 is −0.766; the correlation between changes in the two series for the same period is −0.465. Each is statistically significant at the 5 percent level. This analysis simply extends Batten and Luttrell (1982).

Chart 3
Deviations from Purchasing Power Parity [1]



Sources: International Monetary Fund International Financial Statistics and Board of Governors of the Federal Reserve System

[1] Four-quarter percent change in the nominal trade-weighted exchange rate plus the corresponding inflation differential

interpreted as proof of the existence of PPP; it does, however, demonstrate that these series are inversely related, which is consistent with the notion that the rate of inflation and nominal changes in the exchange rate are jointly determined by excess money growth.

The issue of PPP is examined more closely in chart 3. Using the data in chart 2 to calculate values for equation 1 reveals that there have been significant and consistent positive deviations from PPP during the past four years. In other words, the rise in the value of the dollar has more than compensated for the decline in U.S. inflation relative to inflation in the rest of the world.[10] Although this indicates the existence of deviations from PPP, there is no way to tell directly whether short-run adjustments to changes in money growth or changes in real phenomena are responsible. Attributing a cause-and-effect relationship between some event and exchange rates is difficult because it involves a complete understanding of the dynamic process that characterizes the adjustment to a monetary shock. There are, however, several indirect routes to take.

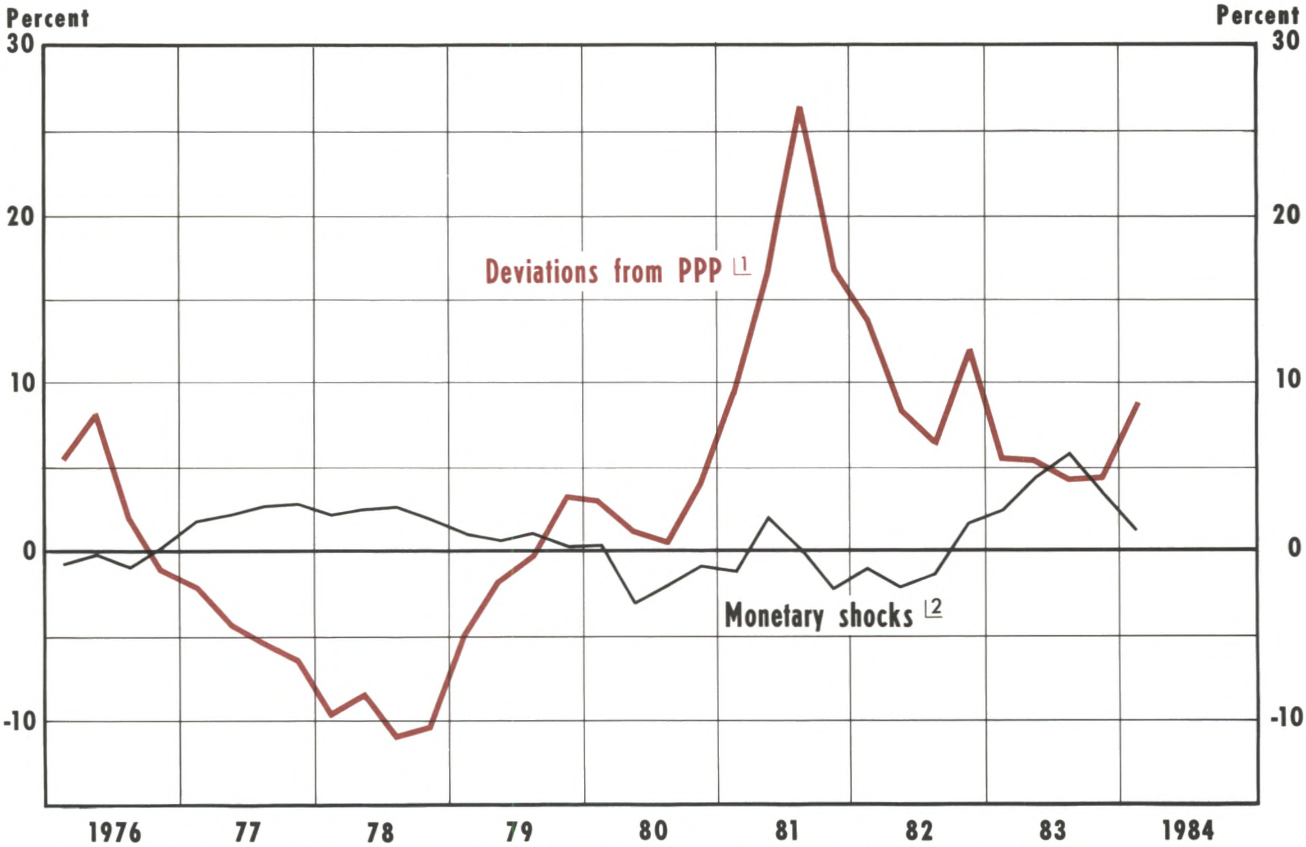
Previous Empirical Studies

One source of evidence is the existing literature on changes in money growth and exchange rates. Frankel (1979), for example, has analyzed the deutsche mark/dollar relationship over the period from July 1974 to February 1978. He found that with a once-and-for-all 1 percent expansion of the U.S. money supply, the DM/$

[10]The use of a trade-weighted index of the foreign exchange value of the U.S. dollar may bias the calculation of PPP. Its use here is mainly for illustrative purposes.

Chart 4

Deviations from Purchasing Power Parity and Monetary Shocks



Sources: International Monetary Fund International Financial Statistics and Board of Governors of the Federal Reserve System

[1] Four-quarter percent change in the nominal trade-weighted exchange rate plus the corresponding inflation differential

[2] Current one-quarter money growth minus previous 12-quarter money growth

exchange rate overshot its PPP rate by 0.23 percent, all other things constant. After one year, approximately 44 percent of this PPP deviation was eliminated.

Pigott also investigated the relative importance of real and nominal sources of monthly exchange rate changes. Using data from May 1973 to August 1980 for six currencies, he found that "real factors have represented a major source . . . of exchange-rate fluctuations. . . ."[11] Moreover, monetary influences did not appear to have been substantially responsible for real changes in the exchange rate.

Finally, using Granger causality tests, Throop (1984) could find no statistically significant relationship between changes in the real exchange rate and current and past rates of money growth during the period from 1973 to 1980. Therefore, unless the world has changed dramatically since 1980, it appears unlikely that monetary shocks could have been the primary cause of the substantial and persistent deviations from PPP that we have seen in the past four years.[12]

A Comparison of the Data

Another approach to assessing the link between money and PPP is simply to compare deviations from PPP with a measure of monetary shocks. Chart 4 does this using deviations from PPP (from chart 3) and monetary shocks measured as deviations of the quar-

[11] Pigott (1981), p. 49.

[12] M1 growth does not Granger-cause changes in the real trade-weighted exchange rate even when the sample is extended to March 1984.

Table 1

Changes in Bilateral Real Exchange Rates and Real Imports of U.S. Agricultural Products: Selected Countries

	1981		1982		1983	
Country	Exchange Rate	Imports	Exchange Rate	Imports	Exchange Rate	Imports
France	21.3%	−35.6%	15.5%	20.8%	12.3%	−19.4%
United Kingdom	3.8	−19.8	16.4	12.7	14.4	−8.9
Germany	27.5	−16.8	10.1	2.8	5.7	−5.5
Venezuela	−7.2	35.3	−3.2	−5.3	−3.0	−15.3
Brazil	−18.8	10.3	0.0	−20.0	57.6	−28.7
Japan	−1.9	6.1	15.0	−3.2	3.0	5.1
Morocco	26.3	15.0	13.4	15.7	14.6	37.1
Saudi Arabia	8.5	31.3	8.0	5.2	2.8	−1.1
Mexico	−12.5	25.4	44.1	−33.6	40.2	21.0
Spain	22.9	−25.0	11.6	63.8	20.9	−27.1
Canada	1.5	5.1	−1.9	2.9	−2.9	3.3
Netherlands	26.5	−18.3	9.4	15.6	7.4	−12.3

NOTE: Figures are percent changes from previous fiscal year. A positive change in the real exchange rate indicates an appreciation of the dollar against that country's currency.

SOURCES: IMF's *International Financial Statistics, Agricultural Statistics, Annual Supplement to Foreign Agricultural Trade of the U.S.*

terly rate of U.S. M1 growth from the previous 12-quarter moving average. If quarterly deviations of M1 growth from its trend growth accurately measure monetary shocks, and if monetary shocks were responsible for generating deviations from PPP, a negative relationship should be revealed between the series in chart 4. That is, faster than expected money growth should induce negative deviations from PPP, and vice versa. A comparison, however, reveals no statistically significant relationship between monetary shocks and deviations from PPP over the entire period.[13]

FACTORS AFFECTING AGRICULTURAL EXPORT DEMAND

The evidence presented above suggests that monetary policy has not been responsible for deviations from PPP during the 1980s. Thus, the real rise in the exchange rate came from other sources. Whatever the source, the real appreciation of the exchange rate over this period has been blamed as the primary cause of the recent decline in agricultural exports. The extent to which the real appreciation of the exchange rate has actually affected exports, however, remains to be investigated.

To do so requires identifying the marginal impact of real changes in the exchange rate on exports. A variety of factors other than exchange rates could be important determinants of the world's demand for U.S. agricultural exports. In fact, these factors could dominate the effect that exchange rates have had on the competitive trade position of U.S. agriculture.

Agricultural Exports and Exchange Rates

As an introduction to investigating the relationship between exchange rate changes and U.S. trade, consider how the volume of agricultural exports to specific countries has behaved since the dollar began to appreciate in real terms in 1981. The countries listed in table 1 represent a broad cross-section of developed

[13]The simple correlation coefficient between the two series in chart 4 is −0.137, which is not statistically different from zero at the 5 percent level. There is a subperiod, however, during which the hypothesized relationship is supported. In particular, the correlation between these series for the period I/1976–IV/1979 is −0.84. The correlation over the subsequent period (I/1980–I/1984) is only −0.085. Thus, monetary shocks are highly correlated with deviations from PPP during the former period, but not at all during the latter one.

Furthermore, when Granger causality tests were performed between monthly changes in the real trade-weighted exchange rate and monthly monetary shocks for the period March 1973–March 1984, Granger-causality was statistically significant at the 5 percent level in only one of 144 different lag specifications investigated.

and developing nations with a variety of capacities for domestic agricultural production. Moreover, because each nation's currency has changed in value relative to the dollar by a different amount, these data show individual cases for which a given movement in the real exchange rate has been associated with a particular change in a nation's imports of U.S. agricultural products. The nations listed represent about half of U.S. agricultural exports in the three years shown.

The data in the table reveal no consistent relationship across countries between changes in the real value of their currencies relative to the dollar and changes in their real imports of U.S. agricultural products. No country's trade pattern was completely consistent with an exchange rate explanation of trade flows: imports decreasing in years when the value of the dollar rose and increasing when the value of the dollar fell. Indeed, Morocco and Saudi Arabia generally increased their imports even though their currencies depreciated against the dollar in all three years. The import patterns of the other countries followed no consistent pattern over this interval. For example, the pound/dollar exchange rate increased between about 4 percent and 16 percent over the period, but changes in British imports ranged between 12.7 percent and −19.8 percent. Similarly, the Spanish peseta declined in both 1981 and 1982; imports in those two years, however, first fell by 25 percent, then rose by 64 percent.

A Simple Model of U.S. Agricultural Exports

Since the data in table 1 reveal no consistent relationship between real changes in the exchange rate and the volume of U.S. agricultural exports, other factors must also be important determinants of foreign demand for U.S. agricultural products. To isolate the relative importance of these other influences, as well as to assess the marginal impact of exchange rate changes, a simple model of agricultural exports was constructed.[14]

This model focuses on the forces that affect the world demand for and the supply of U.S. agricultural exports. The world demand for U.S. agricultural exports was assumed to depend on just two factors: the level of foreign real economic activity and the price of U.S. exports relative to those of other countries. The higher the level of foreign real economic activity, other things equal, the larger would be foreign demand for U.S. agricultural exports. The higher the price of U.S. exports relative to those abroad, other things equal, the smaller would be the demand for U.S. agricultural exports.

On the other side of the market, the supply of U.S. agricultural exports was expressed as a function of the prices of U.S. agricultural exports relative to the prices of other goods and services produced in the United States and exogenous factors such as weather, embargoes, etc. Other things equal, the higher the price of U.S. agricultural exports relative to prices of other goods, the larger the production of U.S. agricultural products for export.

To generate an estimating equation for this model, a market equilibrium was assumed and a reduced form obtained. Furthermore, since adjustment to price changes will not occur immediately, each relative price variable was specified as a distributed lag to capture the dynamics of this adjustment process.[15] The real exchange rate was included to measure U.S. prices relative to those in the rest of the world (expressed in dollars), net of changes in inflation differentials. Finally, a log-linear specification was employed, yielding the following equation estimated for the period I/1971–I/1984:

$$(2)\ \ln(AGX)_t = \underset{(0.54)}{0.73} + \underset{(10.93)}{1.32} \ln(FGNP)_t - \underset{(5.43)}{0.30} \sum_{i=1}^{2} b_i \ln(USAGP/USCPI)_{t-i} - \underset{(4.49)}{0.71} \sum_{j=1}^{5} c_j \ln(RTWER)_{t-j}$$

$\bar{R}^2 = 0.94$ $SE = 0.058$ $DW = 1.51$

where AGX = the volume of U.S. agricultural exports (in 1972 dollars),

FGNP = the trade-weighted index of foreign real GNP,

USAGP = the price index of U.S. agricultural exports,

USCPI = the U.S. consumer price index,

RTWER = the real trade-weighted index of the foreign exchange value of the U.S. dollar, and

[14]This model is fashioned after those in Clark (1974), Goldstein and Khan (1978), Spitäller (1980) and Stevens, et al. (1984).

[15]The lag lengths were chosen using procedures described in the appendix to Batten and Thornton (1984). A search for a distributed lag for foreign real income was also conducted, but none was found.

ln = the natural logarithm.[16]

The absolute value of the t-statistic for testing the hypothesis that the estimated coefficient equals zero is reported in parentheses below each estimate. The equation fits the data well, explaining 94 percent of the variance of the natural logarithm of the volume of U.S. agricultural exports.[17]

Since our objective is to assess the relative impacts of foreign economic activity and real exchange rates on export volume, the coefficients of FGNP and RTWER are of particular interest. The log-linear specification generates estimated coefficients that are partial elasticities. A partial elasticity measures the percentage change of the dependent variable (AGX here) resulting from a 1 percent change in one of the independent (right-hand-side) variables, holding all other variables constant. For example, the estimated coefficient of RTWER measures the percentage change in the volume of U.S. agricultural exports resulting from a 1 percent change in the real exchange rate. In this case, a 1 percent increase in the real exchange rate leads to a 0.71 percent decline in the volume of U.S. agricultural exports. The significantly negative coefficient of RTWER suggests that increases in the value of the dollar indeed have contributed to the recent decline in U.S. agricultural exports. At the same time, however, the estimated equation contradicts the notion that exchange rate changes are the most important determinant of U.S. agricultural exports.

This contradiction can be seen by calculating the standardized regression coefficients for the explanatory variables in the equation. The reported coefficients give no indication of the relative explanatory power of the independent variables, because these variables are expressed in different units. In contrast, the standardized regression coefficient is calculated from an equation in which the variables have been standardized (i.e., expressed in the same units). Consequently, a comparison of these coefficients indicates the relative importance of the independent variables in explaining the dependent variable.

In this case, the estimated standardized regression coefficient of foreign real income is 0.69, while that of the real trade-weighted exchange rate is −0.39. In other words, foreign demand for U.S. agricultural exports has been about 75 percent more sensitive to changes in foreign real economic activity (FGNP) than to changes in the real exchange value of the dollar. Based on these reduced-form coefficients, changes in foreign income have been primarily responsible for the changes in foreign demand for U.S. agricultural exports from I/1971 to I/1984.

The 1982–83 Decline

Though the data demonstrate that the level of foreign real economic activity has been a more important determinant of real U.S. agricultural exports than the real exchange rate since the early seventies, they shed no light on the question of why the volume of agricultural exports has declined recently. Since the income effect and the exchange rate effect have opposite signs, identifying whether the recent impact of changes in foreign real income is larger or smaller than that of changes in the real exchange rate would be straightforward if both world real income and the real exchange rate had risen during 1982 and 1983. During this period, however, the world experienced an economic recession as well as a real appreciation of the dollar. Consequently, both effects resulted in lower exports of U.S. agricultural products.

To isolate these two effects, the following experiment was performed. First, the level of foreign real income was held at its IV/1981 level. (This date was chosen because it marks the beginning of the world recession.) Next, the model's predicted values for exports, holding foreign income constant, were compared with predicted export values, allowing foreign income to vary for the period I/1982–I/1984. The difference represents the marginal impact of changes in foreign real income on the predicted level of real agricultural exports. The simulation was repeated under conditions that held the real exchange rate constant, then allowed it to vary as it did between I/1982 and I/1984.

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[16]Since weather is an important exogenous determinant of agricultural production, a dummy variable (0, 1) was included initially to reflect periods of below-normal rainfall in the United States. The estimated coefficient of this variable is not statistically significant and, consequently, is not reported.

The real trade-weighted exchange rate, included to capture relative price changes, was calculated as:

RTWER = TWER × (USCPI/TWFCPI),

where TWER = nominal trade-weighted exchange rate, and

TWFCPI = trade-weighted foreign CPI (see footnote 9 for further details).

[17]The sum of the estimated coefficients of (USAGP/USCPI) should be positive. The significantly negative coefficient may represent an example of the classical identification problem. For example, this may denote that the supply of agricultural exports may be shifting relatively more than the demand for agricultural exports during the period over which the equation is estimated.

The results are striking. From I/1982 to IV/1982, the marginal impact of the world recession was to reduce predicted U.S. agricultural exports by almost 2 percent, while the marginal impact of the appreciation of the U.S. dollar was negligible. As the world economy began to recover in I/1983, the marginal impact of foreign income became positive, stimulating predicted U.S. agricultural exports by nearly 5 percent from I/1983 to I/1984. During the latter period, however, the continued appreciation of the dollar depressed predicted U.S. agricultural exports by almost 7 percent, outweighing the positive impact of the world recovery. In sum, only during the past five quarters can the fall in U.S. agricultural exports be "blamed" on the appreciating dollar. Before that, the world recession was the culprit.

SUMMARY AND CONCLUSIONS

A number of economists have argued that increases in the foreign exchange value of the dollar have been responsible for recent declines in exports of U.S. agricultural commodities. These arguments, however, generally have been based on simple comparisons of exchange rates and exports. Moreover, they have not recognized essential distinctions between real and nominal exchange rate changes.

The analysis presented in this article explained the fundamental differences between nominal and real movements in exchange rates and investigated the effects of variables other than the exchange rate on exports. Tabular data for 1981–83 indicated no consistent pattern between changes in the real value of the dollar and imports of U.S. agricultural commodities by foreign countries. More detailed empirical evidence on factors affecting the volume of U.S. agricultural exports showed that real exchange rates were related negatively to exports, but their impact was dominated by the level of real GNP in importing nations. Overall, the analysis suggests a weak link between U.S. money growth and real exchange rates and indicates that foreign income — not exchange rates — has been the primary determinant of agricultural exports.

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Hedging Interest Rate Risk with Financial Futures: Some Basic Principles

Michael T. Belongia and G. J. Santoni

FOR much of the postwar period, stable rates of inflation — accompanied by stable levels of interest rates — created a comforting economic environment for managers of depository institutions. Beginning in the mid-1970s, however, more variable interest rates, brought about in part by more variable inflation, caused a substantial change in the economic conditions facing depository institutions. Offering long-term credit at fixed rates became riskier as larger and more frequent unexpected changes in interest rates introduced more variation into the market value of these assets.[1]

This article describes how variation in interest rates affects the market value of depository institutions. The discussion then demonstrates how financial futures contracts might be used to hedge some of the interest rate risk of a portfolio composed of interest-sensitive deposit accounts and loans of unmatched maturities. Although some regulatory authorities have denied or strictly regulated the use of futures contracts by depository institutions in the belief that futures trading is risky and unduly speculative, we argue that the judicious use of futures can reduce the firm's exposure to interest rate fluctuations.[2]

DURATION GAP AND INTEREST RATE RISK

In the mid-1970s, when large fluctuations in interest rates began to occur, it became increasingly evident that depository institutions needed some measure of the relative risks associated with various portfolio holdings. One approach to the measurement of interest rate risk is called Duration Gap analysis. "Duration" refers to the "average" life of some group of assets or liabilities. "Gap" refers to the difference between the durations of an institution's assets and its liabilities.[3]

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[1]For a general description of events that have introduced or increased interest rate risk, see Carrington and Hertzberg (1984) and Koch, et al. (1982).

[2]Legal restrictions and guidelines on the use of financial futures by different types of financial institutions are summarized in Lower (1982). A comparison of statutes on the use of futures by insurance companies is made in Gottlieb (1984).

[3]For more detailed discussions of duration analysis and its application to financial institution portfolios, see Kaufman (1984); Bierwag, Kaufman and Toevs (1983); Toevs (1983); Santoni (1984); Samuelson (1944); and Hicks (1939), pp. 184–88.

Table 1
Expected Streams of Receipts and Payments

	Day 0	90	180	270	360
Panel A: No Change in Interest Rates					
Asset (loan)					
Receipts					$1,000.00
Payments	$909.09				
Liabilities (borrowings)					
Receipts	909.09	$926.75	$944.76	$963.11	
Payments		926.75	944.76	963.11	981.82
Net Receipts	-0-	-0-	-0-	-0-	$ 18.18
Present Value $18.18/1.10 = $16.53					
Panel B: Interest Rates Rise by 200 Basis Points					
Asset (loan)					
Receipts					$1,000.00
Payments	$909.09				
Liabilities (borrowings)					
Receipts	909.09	$926.75	$949.10	$971.98	
Payments		926.75	949.10	971.98	995.42
Net Receipts	-0-	-0-	-0-	-0-	$ 4.58
Present Value = $4.58/1.12 = $4.09					
Panel C: Interest Rates Fall by 200 Basis Points					
Asset (loan)					
Receipts					$1,000.00
Payments	$909.09				
Liabilities (borrowings)					
Receipts	909.09	$926.75	$940.35	$954.15	
Payments		926.75	940.35	954.15	968.15
Net Receipts	-0-	-0-	-0-	-0-	$ 31.85
Present Value = $31.85/1.08 = $29.49					

An Example

The risk introduced into a portfolio of assets and liabilities of different duration is illustrated in tables 1 and 2. In this example, for expositional simplicity, the firm's planned life is assumed to be only one year. It has extended a loan with a face value of $1,000 to be repaid in a single payment at the end of the year at an interest rate of 10 percent. The present value of the loan, and, thus, the amount paid out by the firm to the borrower, is $909.09. To finance this loan, the firm borrows $909.09 for 90 days at 8 percent interest. The two percentage-point spread is the return earned by the firm for employing its specialized capital in intermediating between borrowers and lenders.

The amount that the firm will owe in three months' time is $926.75 (= $909.09(1.08)^{.25}$), which it plans to pay by borrowing this amount for another 90 days. Because the firm's proceeds from the new loan and its payment of the old loan cancel, its net receipts at this time are zero. The firm anticipates being able to roll the loan over every 90 days at the same interest rate. Consequently, at the end of 180 days, the firm expects to owe $944.76 (= $926.75(1.08)^{.25}$), which it plans to pay with new borrowings. At the end of the year, the firm

Table 2

Interest Rate Changes and the Present Value of a Portfolio of Assets and Liabilities of Different Durations

Panel A: Initial Conditions

Present Values

Asset:

$\frac{\$1{,}000.00}{1.10} = \$909.09$

Liability:

$\frac{\$981.82}{1.10} = \$892.56$

Equity:

$909.09 − $892.56 = $16.53

Panel B: All Interest Rates Rise by 200 Basis Points

Present Values

Asset:

$\frac{\$1{,}000.00}{1.12} = \$892.86$

Liability:

$\frac{\$995.42}{1.12} = \$888.77$

Equity:

$892.86 − $888.77 = $4.09

Percentage change in equity = −75.26

anticipates having to pay $981.82 (= $909.09 × 1.08). This amount will be paid out of the $1,000 proceeds from its matured asset. The firm's expected net receipt at year-end is $18.18, as shown in panel A of table 1.

Panel A of table 2 is a balance sheet summary of the present value of this investment plan. The present value of the expected net receipt at year-end is $16.53 and is equal to the difference between the present value of the asset, $909.09 (= $1,000/1.10), and the present value of the expected liability, $892.56 (= $981.82/1.10). Both future values are discounted at 10 percent, the firm's opportunity cost.

The Effects of Changing Interest Rates on Equity

This package of assets and liabilities is subject to considerable interest rate risk because the 10 percent interest rate on the firm's loan is fixed for one year while its borrowings must be refunded every 90 days. In this example, the gap between the durations of the asset and liability is 270 days (= 360 − 90).[4] As a practical matter, the asset's longer duration implies that a given change in interest rates will change the present value of the asset more than it will affect the present value of the liability. This difference, of course, will change the value of the firm's equity.

Panel B of table 1 shows the effect of an unexpected 200 basis-point rise in interest rates. The increase raises the firm's anticipated refunding costs. As a result, the amount the firm expects to pay at year-end increases to $995.42. Net receipts fall to $4.58 and the present value of the investment plan falls to $4.09.

Panel B of table 2 presents a balance sheet summary of the effect of the change on the present values of the asset, liability and owner equity. The increase in interest rates reduces the present values of both the asset and liability, but the asset value falls by relatively more because its life is fixed for one year, while the liability must be rolled over in 90 days at a higher interest rate. The increase in interest rates causes owner equity to fall by $12.44, or about 75 percent. In contrast, had the interest rate declined by 200 basis points, the net present value of the firm's equity would have risen to $29.49 (see panel C of table 1), an increase of about 78 percent.

This extreme volatility in the firm's equity is due to the mismatch of the durations of the asset and liability that make up the firm's portfolio. Table 3 illustrates this point. The only difference between this and earlier examples is that, in table 3, the duration of the liability has been lengthened to match the duration of the asset. While a 200 basis-point increase in the interest rate still causes the present value of the portfolio to fall, the change, −$0.30 or −1.8 percent, is much less than before. Clearly, matching the durations of the asset and liability exposes the value of the portfolio to much lower interest rate risk.

COPING WITH THE GAP

Depository institutions, particularly savings and loan associations, maintain portfolios of assets and liabilities that are similar to the one shown in the initial example.[5] That is, the duration of their assets

[4]The durations of single-payment financial instruments are equal to the maturities of the instruments. In other cases, calculation of duration is not as straightforward. See footnote 3.

[5]Savings and loan associations are required to maintain a significant share of their portfolios in long-term home mortgages in order to obtain federal insurance of deposits. See Federal Home Loan Bank Act of 1932, sec. 4(a).

Table 3

Interest Rate Changes and the Present Value of a Portfolio of Assets and Liabilities of the Same Duration

Panel A: Initial Conditions

Present Values	
Asset:	Liability:
$\frac{\$1,000.00}{1.10} = \$909.09$	$\frac{\$981.82}{1.10} = \$892.56$
	Equity:
	$909.09 − $892.56 = $16.53

Panel B: All Interest Rates Rise by 200 Basis Points

Present Values	
Asset:	Liability:
$\frac{\$1,000.00}{1.12} = \$892.86$	$\frac{\$981.82}{1.12} = \$876.63$
	Equity:
	$892.86 − $876.63 = $16.23
	Percentage change in equity = − 1.8

typically is longer than the duration of their liabilities. As a result, the market values of these institutions have been particularly sensitive to interest rate fluctuations. This, along with the recent experience of highly variable interest rates, has led these institutions to seek out methods to reduce their exposure to interest rate risk. Among other things, these firms have made greater use of floating rate loans and interest rate swap agreements. Recent regulatory changes have allowed them to allocate more of their loan portfolios to short-term consumer loans. In addition, a number of institutions are using financial futures to reduce their exposure to interest rate risk.[6]

Futures Markets and Risk

It may seem odd that the futures market, which is generally thought of as being very risky, can be used to reduce risk. Futures trading is risky for people who bet on the future price movements of particular commodities or financial instruments by taking long or short positions in futures contracts. Such speculative bets on future price movements, however, are not unique to futures market trading. The nature of most types of businesses requires a speculative bet about the future course of a particular price.

Growing crops, for example, gives farmers long positions in physical commodities during the growing season. These long positions expose the farmer to the risk of price declines — declines that can reduce the profits from efficient farming (the activity that the farmer specializes in). Judicious use of the futures market allows the farmer to offset his long position in the commodity by selling futures contracts. Since the sale reduces his net holdings of the commodity, the farmer's exposure to the risk of future price declines is reduced. Similarly, futures trading presents depository institutions with the opportunity to reduce their exposure to the risk of interest rate changes.

Futures Contracts

A futures contract is an agreement between a seller and a buyer to trade some well-defined item (wheat, corn, Treasury bills) at some specified future date at a price agreed upon *now* but paid in the future at the time of delivery. The futures price is a prediction about what the price of the item will be at the time of delivery.

In the case of commodities, the price of the good today (the spot price), on average, will be equal to the futures price minus the cost of storage, insurance and foregone interest associated with holding the good over the interval of the contract. A similar relationship exists between the spot and futures prices of financial instruments. However, since the storage and insurance cost of holding these instruments is very low, the spread between the spot and futures prices is largely determined by the interest cost.

[6]See Booth, Smith and Stolz (1984). While a number of financial firms are employing the futures market, it seems that accounting requirements have discouraged the use of futures to hedge interest rate risk. Until recently, regulators and accountants feared that losses from futures transactions could be hidden in financial reports. Therefore, they would not permit a hedge to count as one transaction with spot gains or losses offsetting futures markets losses or gains. Instead, they required futures losses to be marked to the market while spot gains could be deferred. This asymmetric treatment of gains and losses on the two sides of a hedge distorted earnings estimates and, therefore, discouraged the use of futures. See Morris (1984) for more detail on changes in accounting standards. Asay, et al. (1981) provide examples of how former accounting standards discouraged the use of futures by banks and thrift institutions.

The Relationship Between Spot and Futures Markets for Treasury Bills: An Illustration

In January 1976, the International Monetary Market (IMM), now part of the Chicago Mercantile Exchange (CME), began trading futures contracts in 13-week Treasury bills.[7] The basic contract is for $1 million with contracts maturing once each quarter in the third week of March, June, September and December. Since there are eight contracts outstanding, the most distant delivery date varies between 21 and 24 months into the future.

Panel A of table 4 presents quotations for Treasury bill futures for the trading day of August 7, 1984. Panel B of table 4 lists spot quotations for Treasury bills for the same trading day.[8]

Panel A of table 4 is interpreted as follows: September Treasury bill futures were trading at a discount of 10.49 percent on August 7, 1984. Any person trading this contract obtained the right to buy (sell) a Treasury bill the third week in September with a remaining maturity of 13 weeks at a discount rate of 10.49 percent. A similar statement holds for the other contracts listed in panel A.

Panel B lists spot market quotations. For example, Treasury bills due to mature August 9, 1984, traded at a discount of 9.91 percent (bid) to 9.79 percent (ask), while those maturing September 20, 1984, traded at a discount of 9.95 (bid) to 9.91 (ask), etc.

We noted earlier that the spot and futures markets must be closely related, and the data in panels A and B can be used to illustrate this point. For example, on August 7, 1984, an investor could purchase a Treasury bill due to mature December 20, 1984 (i.e., 134 days later). If he purchases the bill on the spot market, he obtains the asked discount of 10.39 percent. At this discount rate, the price he pays for the bill is $96.41 per $100 of face value.[9]

Table 4

Market Quotations for U.S. Treasury Bills: August 7, 1984[1]

Panel A: Treasury Bill Futures (IMM)

	Contract	Discount settle
1984	September	10.49
	December	10.85
1985	March	11.13
	June	11.35
	September	11.52
	December	11.66
1986	March	11.79
	June	11.90

Panel B: Treasury Bill Spot

Maturity Date	Discount Bid	Discount Ask
August 9, 1984	9.91	9.79
September 20, 1984	9.95	9.91
December 20, 1984	10.45	10.39
March 21, 1985	10.63	10.56
June 13, 1985	10.72	10.66
July 11, 1985	10.73	10.69

[1]*Wall Street Journal*, August 8, 1984, pp. 38–9.

Alternatively, the investor could purchase a futures contract that gives him the right to buy a Treasury bill in September that will mature the third week in December. This alternative gives him a discount rate of 10.49 percent. Buying the Treasury bill in September at this discount would require a payment of $97.54.[10] This payment will be made 43 days into the future, roughly, September 20, and the present value of the payment on August 7 is $96.44.[11] Notice that this is very near the amount that the investor would pay ($96.41) if he were to purchase a Treasury bill on the spot market that matured during the third week of December.

Of course, other alternatives are open to the investor as well. He could, for example, buy a Treasury bill that matured the third week in March on the spot market.

[7]Futures contracts in other types of financial instruments, such as GNMA passthrough certificate contracts, 90-day CDs, Treasury bonds and Treasury notes, also are available at the Chicago Board of Trade.

[8]The information in table 3 is taken from pages 38 and 39 of the August 8, 1984, *Wall Street Journal*. The actual tables in the *Wall Street Journal* contain more information than is presented here. For our purposes, however, the additional information is extraneous.

[9]$\$96.41 = \$100/(1.1039)^{.37}$. The discount factor is raised to the power of 134/360 = .37. This calculation is slightly different from the discount calculation used in determining actual trading prices, but numerical differences between the two formulas are small. See Stigum (1981) for the market's discount formula.

[10]$\$97.54 = \$100/(1.1049)^{.25}$.

[11]$\$96.44 = \$97.54/(1.0991)^{.12}$. The interest rate used in the calculation is the rate on August 7 for a security maturing on September 20 (43 days in the future).

The present cost of doing this should be near the present cost of buying a futures contract that allows him to purchase a Treasury bill in December maturing the third week in March. Table 5 uses the data in table 4 to compare the present costs of this and other alternatives. In each case, the present costs of employing the spot vs. the futures market are very close.[12] Because a close relationship between these markets exists, the Treasury bill futures market can be used effectively to hedge interest rate risk.[13]

Table 5

The Relationship Between Treasury Bill Spot and Futures Prices: August 7, 1984, Per $100 of Face Value

Case 1: Purchase of a Treasury bill that matures the third week in December 1984

	Present Cost
Spot Market Purchase	$96.41
September Futures Purchase	96.44
Difference	.03

Case 2: Purchase of a Treasury bill that matures the third week in March 1985

	Present Cost
Spot Market Purchase	$93.92
December Futures Purchase	93.94
Difference	.02

Case 3: Purchase of a Treasury bill that matures the third week in June 1985

	Present Cost
Spot Market Purchase	$91.45
March Futures Purchase	91.47
Difference	.02

HEDGING THE GAP

The Streams of Receipts and Payments

The example in table 1 can be used to illustrate how futures contracts can be applied to hedge the interest rate risk caused by the mismatch in the lives (durations) of the firm's assets and liabilities. Considerable confusion appears to exist as to what the firm's hedging objective should be and how hedges should be constructed. One possible hedging strategy is to protect the equity of the firm (in the present value sense) from interest rate fluctuations. Another often-cited strategy is to minimize discrepancies between cash flows over time. It seems clear, however, that firm owners will choose a hedge that protects their net wealth (present value of the firm's equity). This focus on net wealth is crucial because, as the examples show, reducing cash flow mismatches to zero does not minimize the exposure of the firm's equity to interest rate changes.

Hedging Net Wealth: An Example

Suppose it is September 15, 1984, and the firm initiates the transactions summarized earlier in panel A of table 1. In addition, to hedge each of its three refunding requirements, the firm sells December, March and June futures contracts at 10 percent discounts.[14] The price of each contract is $\$1{,}000/(1.10)^{.25} =$ $976.45. These contracts obligate the firm to deliver a 13-week Treasury bill with a face value of $1,000 during the third week of December, March and June in exchange for $976.45.

Panel A of table 6 presents the firm's expected streams of receipts and payments given the structure of interest rates on September 15. It is identical to panel A of table 1 except that the streams of receipts and payments generated by the futures contract are included. The futures contract generates a certain stream of receipts equal to $976.45 in December, March and June in exchange for delivery of the 90-day Treasury bills. The firm must acquire these bills in order to make delivery and, on September 15, the expected cost of acquiring each of the Treasury bills is $976.45. If interest rates remain unchanged, expected and actual costs will be the same so that the actual receipts and payments generated by the futures contract net out in each period. The net flow of receipts is zero until year-end when the firm receives $18.18. The present value of this amount is $16.53.

In panel B, interest rates are assumed to rise unexpectedly by 200 basis points immediately following

[12]Small differences are due to the existence of transaction costs. If the differences were large, profitable arbitrage opportunities would exist. These, of course, would vanish quickly as traders took advantage of the situation.

[13]There is, of course, the problem that the spot instrument being hedged may not be identical to the futures market instrument. If so, the price of one may diverge from the other because of a change in a factor that affects the price of one but not the other. This is called "basis risk" and is ignored in the following examples.

[14]A flat yield curve is assumed for ease of exposition. The examples become more complicated if the yield curve slopes up or down and/or the spread between borrowing and lending rates changes.

Table 6

Expected Streams of Receipts and Payments

	Day 0	90	180	270	360
Panel A: No Change in Interest Rates					
Asset (loan)					
Receipts					$1,000.00
Payments	$909.09				
Asset (futures)					
Receipts		$976.45	$976.45	$976.45	
Liabilities (borrowings)					
Receipts	909.09	926.75	944.76	963.11	
Payments		926.75	944.76	963.11	981.82
Liabilities (futures)					
Payments		976.45	976.45	976.45	
Net Receipts	-0-	-0-	-0-	-0-	$ 18.18
Present Value = $18.18/1.10 = $16.53					
Panel B: Interest Rates Rise by 200 Basis Points					
Asset (loan)					
Receipts					$1,000.00
Payments	$909.09				
Asset (futures)					
Receipts		$976.45	$976.45	$976.45	
Liabilities (borrowings)					
Receipts	909.09	926.75	949.10	971.98	
Payments		926.75	949.10	971.98	995.42
Liabilities (futures)					
Payments		972.07	972.07	972.07	
Net Receipts	-0-	$ 4.38	$ 4.38	$ 4.38	$ 4.58
Present Value = $4.38/(1.12)^.25 + $4.38/(1.12)^.50 + $4.38/(1.12)^.75 + $4.58/(1.12) = $16.50					
Panel C: Interest Rates Fall by 200 Basis Points					
Asset (loan)					
Receipts					$1,000.00
Payments	$909.09				
Asset (futures)					
Receipts		$976.45	$976.45	$976.45	
Liabilities (borrowings)					
Receipts	909.09	926.75	940.35	954.15	
Payments		926.75	940.35	954.15	968.15
Liabilities (futures)					
Payments		980.94	980.94	980.94	
Net Receipts	-0-	$ -4.49	$ -4.49	$ -4.49	$ 31.85
Present Value = −$4.49/(1.08)^.25 − $4.49/(1.08)^.50 − $4.49/(1.08)^.75 + $31.85/(1.08) = $16.52					

the firm's September 15 transactions. As in panel B of table 1, the increase in interest rates raises the firm's refunding cost and reduces the net year-end receipt to $4.58. In addition, however, the increase in interest rates reduces the expected cost of acquiring the Treasury bill to $972.07. Since the firm will receive $976.45 upon delivery of the Treasury bills, the futures contract will generate a net flow of receipts equal to $4.38 in December, March and June. The present value of this flow added to the present value of the net receipt at year-end ($4.58) is $16.50, which is nearly identical to the present value for the case in which interest rates remained unchanged (the small difference is due to rounding errors).

Panel C illustrates the outcome for a 200 basis-point decline in interest rates. In this case, the futures contract generates negative net receipts for the firm in December, March and June. The present value of this negative flow added to the present value of the higher positive net receipt at year-end sum to $16.52. As the examples show, this hedge protects the net wealth of the firm regardless of the direction of the change in interest rates.

While this hedge protects net wealth from changes in interest rates, it does so by allowing net cash receipts to vary. Net cash receipts, both in amount and timing, are considerably different in panels A, B and C. In panel A, net receipts are $18.18 at year-end while in panel B net receipts are spread out over the year and total only $17.72. In panel C, the firm has negative net receipts during the year and a large positive net receipt at year-end for a total of $18.38. However, the present value of the firm is the same in all three cases.

The Balance Sheet

Panel A of table 7 presents the firm's balance sheet position in terms of present values. The futures contracts are entered as both assets and liabilities, leaving equity the same as that shown in panel A of table 2.[15] The futures asset is the present value of the future receipt of a *fixed* amount. The futures liability, on the other hand, is the present value of the *expected* cost of covering the futures contract given the structure of interest rates on September 15. Panels B and C illustrate the effect on the present values of the firm's assets, liabilities and equity if, immediately following the above transactions, interest rates rise unexpectedly (panel B) or fall unexpectedly (panel C) by 200 basis points.

An unexpected increase in interest rates causes the present value of the loan to fall relative to the present value of the liability. By itself, this would cause a reduction in the firm's equity. At the same time, however, the increase in interest rates generates a positive expected net cash flow from the futures contracts, which, of course, has a positive net present value. Other things the same, this causes equity to rise. The net effect of both changes is that equity remains unchanged. The reverse occurs if interest rates decline by 200 basis points.

This hedge has eliminated the firm's exposure to interest rate risk. In contrast, recall that a 200 basis-point change in the interest rate causes the equity of the unhedged firm in table 2 to change by about 75 percent.

Hedging as a "Profit Center"

The purpose of hedging is to reduce the variance of a firm owner's wealth. In a textbook example of a perfect hedge, the gain or loss from a short position in the futures market will offset exactly the compensating loss or gain on the spot assets and liabilities held by the firm. A hedge is constructed because — in the presence of an uncertain future — wealth is greater if the institution foregoes a profit stream that is higher on average (if it goes unhedged) in exchange for a profit stream that is lower on average (by the cost of the hedging operations) but more certain.

Some portfolio managers, however, lose sight of this fact and assume speculative positions in the futures market with the objective of earning profits from the position if interest rates change in their favor. While speculative positions in futures (or spot instruments) can increase earnings, they can have the opposite effect as well.

One potentially significant danger in the use of futures contracts to hedge interest rate risk is that the firm may misunderstand the nature of the hedging function. Trading futures for hedging is *not* intended to generate profits from the trading itself. Rather, its purpose is to establish futures positions so that the owner's wealth is held constant; this will occur if the increase (decrease) in the value of the firm's spot holdings of assets and liabilities is offset exactly by the loss (gain) in the futures market.

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[15]Strictly speaking, futures contracts entered into by member banks of the Federal Reserve System are treated as balance sheet memoranda items. These are reported on Schedule L, Commitments and Contingencies, of the Call Report. Hence, for accounting purposes, futures contracts do not affect the assets and liabilities of the firm until the contracts are exercised.

Table 7

Interest Rate Changes and the Present Value of a Hedged Firm

Panel A: Initial Conditions (9/15/84)

Present Values

Assets:		Liabilities:	
Loan: $1,000.00/1.10 =	$ 909.09	90-day CD: $981.82/1.10 =	$ 892.56
Contracted Future Receipts		Expected Cost of Covering the Futures Contract:	
December Future: $976.45/(1.10)$^{.25}$ =	953.46	December Future: $976.45/(1.10)$^{.25}$ =	953.46
March Future: $976.45/(1.10)$^{.50}$ =	931.01	March Future: $976.45/(1.10)$^{.50}$ =	931.01
June Future: $976.45/(1.10)$^{.75}$ =	909.09	June Future: $976.45/(1.10)$^{.75}$ =	909.09
	3,702.65		3,686.12
		Equity:	16.53
			3,702.65

Panel B: All Interest Rates Rise by 200 Basis Points

Note: The expected cost of covering each contract falls to $1,000/(1.12)$^{.25}$ = $972.07 while the contracted future receipt remains unchanged.

Present Values

Assets:		Liabilities:	
Loan: $1,000.00/1.12 =	$ 892.86	90-day CD: $995.42/1.12 =	$ 888.77
Contracted Future Receipts:		Expected Cost of Covering Futures Contract:	
December Future: $976.45/(1.12)$^{.25}$ =	949.17	December Future: $972.07/(1.12)$^{.25}$ =	944.92
March Future: $976.45/(1.12)$^{.50}$ =	922.66	March Future: $972.07/(1.12)$^{.50}$ =	918.52
June Future: $976.45/(1.12)$^{.75}$ =	896.88	June Future: $972.07/(1.12)$^{.75}$ =	892.86
	3,661.57		3,645.07
		Equity:	16.50
			3,661.57

Panel C: All Interest Rates Fall by 200 Basis Points

Note: The expected cost of covering each contract rises to $1,000/(1.08)$^{.25}$ = $980.94

Present Values

Assets:		Liabilities:	
Loan: $1,000.00/1.08 =	$ 925.93	90-day CD: $968.15/1.08 =	$ 896.44
Contracted Future Receipts:		Expected Cost of Covering Futures Contract:	
December Future: $976.45/(1.08)$^{.25}$ =	957.84	December Future: $980.94/(1.08)$^{.25}$ =	962.25
March Future: $976.45/(1.08)$^{.50}$ =	939.59	March Future: $980.94/(1.08)$^{.50}$ =	943.91
June Future: $976.45/(1.08)$^{.75}$ =	921.68	June Future: $980.94/(1.08)$^{.75}$ =	925.92
	3,745.04		3,728.52
		Equity:	16.52
			3,745.04

Real World Complications in Hedging

The examples in tables 6 and 7 simplify real world problems to illustrate the basic concepts of interest rate risk and hedging. In practice, a number of complicating factors will make the construction of a hedge considerably more difficult.

The first difficulty to note is that the calculation of present values for a large portfolio composed of many different assets and liabilities will require a great deal of information. Moreover, resources will be needed to estimate interest elasticities (or durations). And, unlike our examples, which are based on single-payment loans and deposits of known durations, firms face the additional problem of loans that are subject to early payment and deposits that are subject to early withdrawal.

Even with a good estimate of its exposure to interest rate risk, firms will face practical problems in implementing a hedge. Typically, liquidity is very thin in futures contracts dated for delivery more than nine months in the future. Firms also are not likely to find futures contracts for the exact dollar amount they wish to hedge or for the specific spot asset or liability being hedged. For example, money market certificates (MMCs) might be hedged with Treasury bill futures. It is possible, however, that interest rates on MMCs and Treasury bill futures will not move by identical amounts or in the same direction, an event that will reduce the effectiveness of a hedge. When the futures contract does not correspond exactly to the spot commodity, as in this case, the firm is exposed to "basis" risk.

Firms also face the possibility of changes in the slope of the yield curve; that is, unlike our examples, short- and long-term rates could change by differing amounts. If, for example, long rates increased 200 basis points but short rates increased only 100 basis points, the change in the difference between the present values of spot assets and spot liabilities would not be completely offset by a change in the difference between the present values of the futures asset and liability. True hedges, however, are implemented under the expectation of no change in the yield curve's slope. It is easy to see, therefore, that hedging does not eliminate this source of risk.

SUMMARY

Higher and more variable interest rates have increased the risk faced by financial institutions associated with attracting deposit funds and extending credit. This article presented some simple examples of techniques that can isolate and quantify sources of a financial institution's exposure to interest rate risk. The discussion also described how financial futures can be used to reduce this risk. A simple hedging example indicated that relatively conservative use of futures markets can have a potentially large impact on reducing risk exposure. The use of futures trading is a threat to the long-run performance of a financial firm only if applied in a manner inconsistent with hedging.

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GLOSSARY

Basis — The price or yield difference between a futures contract and the cash instrument being hedged

Basis point — 1/100 of 1 percent

Delivery month — A specified month within which delivery may be made under the terms of the futures contract

Discount yield — The ratio of the annualized discount to the par value

Evening up — Buying or selling to offset or liquidate an existing market position

Futures contract — A standardized contract, traded on an organized exchange, to buy or sell a fixed quantity of a defined commodity at a price agreed to now but delivered in the future

Gap analysis — A technique to measure interest rate sensitivity

Hedge — An attempt to reduce risk by taking a futures position opposite to an existing cash position

Interest rate swap — The exchange of two financial assets (liabilities) which have the same present value but which generate different streams of receipts (payments)

Long hedge — A hedge in which the futures contract is bought (long position)

Macro-hedge — A hedge designed to reduce the net portfolio risk of an organization

Micro-hedge — A hedge designed to reduce the risk of holding a particular asset or liability

Open interest — The number of open futures contracts, that is, unliquidated purchases *or* sales of futures contracts

Short hedge — A hedge that involves selling a futures contract (short position)

Spot price — The current market price of the actual physical commodity

An Early Look at the Volatility of Money and Interest Rates under CRR

Daniel L. Thornton

ON February 2, 1984, the Federal Reserve enacted a system of contemporaneous reserve requirements (CRR) to replace the system of lagged reserve requirements (LRR) that had been in effect since September 1968. The Fed made this change in response to widespread criticism that, under a reserve target operating procedure, LRR made it more difficult to control the monetary aggregates and contributed to the volatility of money and, perhaps, interest rates. Thus, critics believed a return to CRR would reduce the volatility of money and might reduce the volatility of interest rates as well.[1]

The purpose of this article is to determine whether the return to CRR has had, so far, any significant impact on the variability of money and interest rates. The article begins with a concise review of the arguments bearing on the presumed effects of the change from LRR to CRR on the volatility of money or interest rates. The actual behavior of these variables is then examined to see whether arguments in favor of the return to CRR have been supported.

WHAT CRR IS SUPPOSED TO ACCOMPLISH: THE STANDARD ANALYSIS

The rationale for returning to CRR rests primarily on the argument that LRR weakens the contemporaneous link between reserves and deposits of depository institutions. For example, it was argued that depository institutions would have no incentive to curtail their lending activities under LRR because they are not required to hold reserves against the deposits that these activities create until the following week. Consequently, an increase in loan demand would be more readily transmitted into a change in the money stock in the short run under LRR.

At a more formal level, the case for CRR was usually presented in terms of the supply of and demand for

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[1]See Thornton (1983b) and the references cited there.

Figure 1
Demand-Side Variability under CRA and LRA

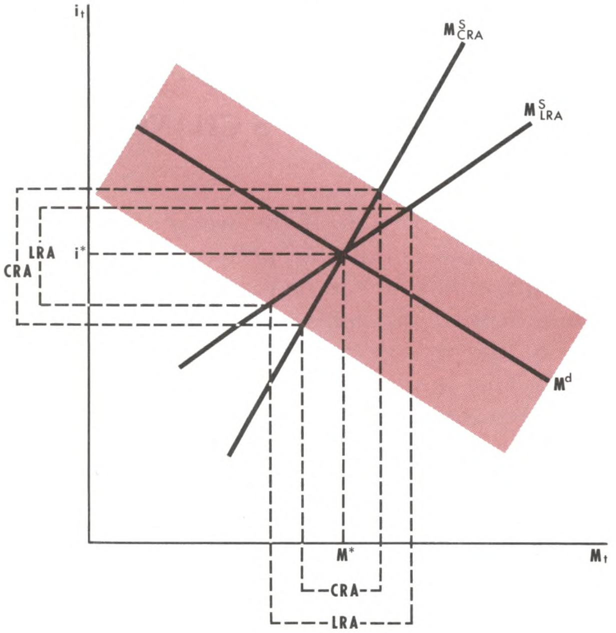
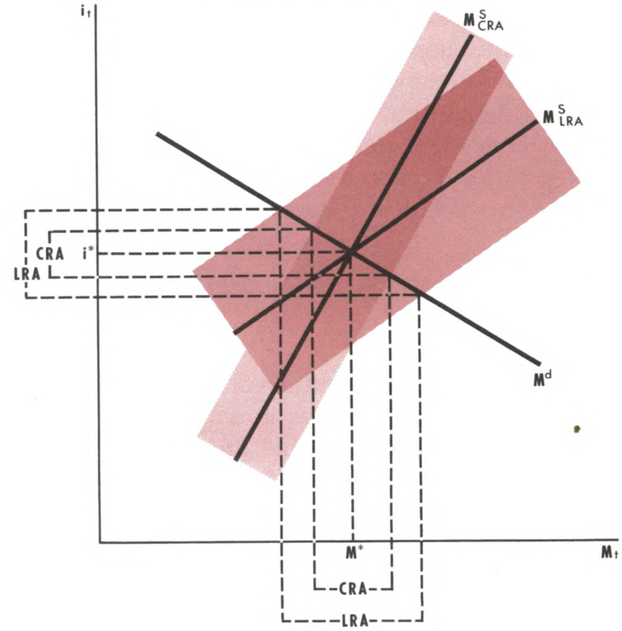


Figure 2
Supply-Side Variability under CRA and LRA



money. Within this framework, the proponents of CRR argued that the money supply schedule is flatter under LRR than under CRR. This is illustrated in figures 1 and 2. Consequently, random variation in the demand for money (represented by the shaded area in figure 1) results in more variability in the stock of money and less variability in the interest rate under LRR, as illustrated in figure 1. Also, random variation in the supply of money (represented by the shaded areas in figure 2) results in more variability in money and interest rates under LRR. Thus, compared with CRR, LRR produces greater variation in the money stock. Whether interest rates are also more variable depends on the relative magnitude of the variance of the supply-side and demand-side disturbances.[2]

An Alternative Analysis of What to Expect under CRR

There are two reasons why the result predicted above need not occur. First, depository institutions' behavior may not be as sensitive to the reserve accounting system in effect as this analysis suggests. Consequently, the switch from LRR to CRR may not significantly alter the week-to-week variability of money and interest rates, at least in the short run. Second, the suggested outcome is predicated on the assumption that the Federal Reserve is targeting on a reserve aggregate. If the Federal Reserve is not targeting explicitly on money or a reserve aggregate in the short run, the variability of money and interest rates will not necessarily be related to the reserve accounting system.

The first view argues that the short-run contemporaneous link between depository institutions' decisions to make additional loans and investments and their holdings of reserves need not be close *even under a system of CRR*.[3] In the short run, depository institutions can obtain additional reserves by borrowing from the Federal Reserve or holding temporarily fewer excess reserves than they would hold otherwise. These factors may be sufficient to accommodate most short-run, week-to-week supply- and demand-side disturbances. Consequently, the slopes of the money supply schedules under LRR or CRR may be similar. Unless the adoption of CRR fundamentally changes the way that depository institutions adjust their reserve positions, there may be no dramatic change in the volatility of money and interest rates in the short run.

[2]There are other factors, not considered here, that also affect the outcome; see Thornton (1983b) and the references cited there.

[3]See Thornton (1983b) for a more detailed explanation of the arguments presented in this section.

This conjecture is likely to be even more valid given that the new CRR system lengthened the reserve settlement period from one to two weeks.[4] Depository institutions may now make loans early in the accounting period, waiting to settle (through the discount window, the money market or changes in excess reserves) toward the end of the period. By accommodating loan demand at the first part of the period and settling later in the period, week-to-week variability in money and interest rates could be similar under the new system of CRR and the old system of LRR.[5]

The Role of Federal Reserve Operating Procedures

Expectations of differential effects in the variability of money and interest rates under CRR and LRR are based on the assumption that the Federal Reserve is attempting to hit a monetary target by manipulating a reserve aggregate. If this is not the case, there is little reason to expect differential effects associated with a change in the reserve accounting system. For example, week-to-week variability of money and interest rates are unaffected by the choice of reserve accounting system under an interest rate targeting procedure.[6]

This point is important because the Federal Reserve changed operating procedures in the fall of 1982, about a year and a half before the implementation of CRR. The Federal Open Market Committee (FOMC) followed a reserve aggregate targeting procedure that placed greater emphasis on movements in M1 as a policy guide from October 6, 1979, to early October 1982.[7] Since then, the FOMC has placed less emphasis on the behavior of M1 in the short run, aiming instead at longer-run monetary and credit aggregate objectives. This policy has been implemented in the short run through a "flexible nonborrowed-reserves path."[8] As a result of this procedural change, the variability of money and interest rates immediately before and after the implementation of CRR may reveal little change.

HAS THE VARIABILITY OF MONEY AND INTEREST RATES CHANGED SINCE CRR?

Before a comparison of the weekly variability of money and interest rates for periods before and after the adoption of CRR can be made, one must decide what measure of variability to use. The measure used here is the average absolute percentage change (AAPC).[9] This is preferable to two more commonly cited measures, the standard deviation and the coefficient of variation, as a measure of the short-run, week-to-week variability that this article is concerned with (see the insert on page 30).

Data are presented for various subperiods to reflect both the move from LRR to CRR *and* the change in Federal Reserve operating procedures. Data for the two weeks immediately before and after the implementation of CRR were excluded to guard against the possibility that they were contaminated by expectations or other problems associated with the implementation of the new procedure.

Results for the money stock, M1, are presented in table 1. The AAPC of seasonally adjusted M1 appears to have increased significantly in the 28-week period following the implementation of CRR, compared with that of the 28-week period immediately before CRR. The AAPC of seasonally adjusted M1 increased from about 0.13 percent to 0.43 percent, a difference that is significant at the 5 percent level.[10] When the most recent period is compared with a similar period in 1983, the increase is much smaller; nevertheless, it is statistically significant.[11]

These comparisons, however, are deceptive because revised seasonally adjusted data is "smoother" than preliminary seasonally adjusted data. Thus, the significant increase in the variability of seasonally ad-

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[4]For a discussion of the new system, see Gilbert and Trebing (1982). For an interesting analysis of the carryover provision of the new system of CRR, see Spindt and Tarhan (1984).

[5]Some have suggested that the Federal Reserve has no choice but to accommodate this credit expansion, since the additional reserves needed to support the new deposits can only come into the system via the discount window. This argument comes perilously close to saying that the Federal Reserve must accommodate credit demand completely under LRR. This position, however, ignores the dynamics of these long-run adjustments. For another view of this process, see Thornton (1982), p. 29.

[6]The short-run money supply schedule is completely flat (interest-elastic). Thus, the variability of money would be completely determined by the random variation in the demand for money, and this would be unaffected by the reserve accounting system.

[7]For a discussion of the issues surrounding the decision to deemphasize M1 as an intermediate target, see Thornton (1983a).

[8]Wallich (1984), p. 26. Also, see Solomon (1984).

[9]The AAPC is defined as $AAPC(X) = (1/(T-1)) \sum_{t=1}^{T} (\,|\,X_t - X_{t-1}\,|/X_{t-1})100$. It is a measure of relative variability in that AAPC (kX) = AAPC(X), where k is an arbitrary constant.

[10]The t-statistic is 5.20.

[11]The t-statistic is 3.15.

Table 1

The Variability of M1

Period	Seasonally adjusted	Not seasonally adjusted	First-published seasonally adjusted
2/27/84 — 9/03/84	0.43%	1.61%	0.44%
7/13/83 — 1/18/84	0.13	1.46	0.36
3/02/83 — 9/07/83	0.24	1.57	0.44

Table 2

The Variability of M1 and Selected Interest Rates

Period	Revised seasonally adjusted	First-published seasonally adjusted	Federal funds	Treasury[1] bill	Commercial[1] paper
10/17/79 — 9/29/82	0.22%	.50%	4.48%	3.91%	4.11%
10/06/82 — 9/28/83	0.24	.43	2.52	1.90	1.81

[1]For week ending two days later than date shown.

justed M1 with the implementation of CRR may be a statistical artifact of the seasonal adjustment revision.[12]

This is investigated by a comparison of the AAPC over the three periods using either not seasonally adjusted or first-published seasonally adjusted data. If the increased variability is primarily the result of the seasonal adjustment revision rather than the change in the reserve accounting system, then the AAPC for the first-published or not seasonally adjusted M1 should be essentially the same over these periods.[13] Likewise, a comparison of not seasonally adjusted data for the 28-week period since the implementation of CRR and the corresponding period a year earlier should reveal no change in the AAPC. The data are consistent with both of these conditions. Thus, there appears to be no change in the variability of M1 between the pre- and post-CRR periods.

It is indeterminant, however, whether this result stems from depository institutions not changing their behavior following the enactment of CRR or from a change in the operating procedure in the fall of 1982. In order to determine which explanation is more consistent with the facts, the AAPC was calculated for M1 and three interest rates — the federal funds rate, the three-month Treasury bill rate and the commercial paper rate — for the three-year period of reserve aggregate targeting (October 17, 1979, to September 29, 1982) and for the year immediately following the change in the Federal Reserve's operating procedure (October 6, 1982, to September 28, 1983). These results are presented in table 2. The data indicate a decline in the AAPC for both revised and first-published M1 after the fall of 1982; however, this decline is not statistically significant at the 5 percent level.[14] Thus, it appears there was no significant change in the week-to-week variability of M1 following the change in the operating procedures.

The AAPCs for all three interest rates, however, decrease significantly after the fall of 1982. Thus, it appears that the change in operating procedure had some impact on the behavior of interest rates. Hence,

[12]For example, see Hein and Ott (1983).

[13]A comparison of these data is perhaps more relevant because these are the figures that economic agents and policymakers use to make their decisions.

[14]The relevant t-statistics for first-published and not seasonally adjusted data are 0.91 and 0.15, respectively.

The Limitations of Two Common Measures of Variability

Both the standard deviation (SD) and the coefficient of variation (CV) measure the variability of the data relative to an average. For the SD the average is the mean of the raw data; for the CV the mean is unity, that is, the average of the raw data divided by the mean. Thus, the SD is a measure of absolute variability and the CV is a measure of relative variability.[1]

Because both of these statistics average squared deviations from their respective means, they may give relatively small weight to large weekly changes and relatively large weight to small weekly changes.

[1]The SD $= \left(\sum_{t=1}^{T} (X_t - \bar{X})^2/(T-1)\right)^{1/2}$ and the

CV $= \left(\sum_{t=1}^{T} (X_t^* - \bar{X}^*)^2/(T-1)\right)^{1/2}$,

where $\bar{X}$ is the mean of the raw series,

i.e., $\bar{X} = \sum_{t=1}^{T} X_t/T$, and $X_t^* = X_t/\bar{X}$,

so that $\bar{X}^* = \sum_{t=1}^{T} ((X_t/T)/\bar{X}) = 1$. Furthermore, while the SD depends on the scale of the data, the CV does not; i.e., the SD(kX) = kSD(X), while the CV(kX) = CV(X), where k is a constant.

This is illustrated in the accompanying charts, which show the level of seasonally adjusted M1, by itself and relative to its mean level for the 28-week period following the implementation of CRR.

Charts 1 and 2 show that the largest (in absolute and relative terms) one-week change in M1 occurred on May 7, when the money supply increased by $5.3 billion. Because the absolute and relative (i.e., mean-adjusted) levels are only slightly above their respective means for the period, their respective contributions to the SD and the CV are small. Moreover, the smallest one-week change in M1 occurred on March 19. Because the levels are further from their mean, their contribution to the SD and the CV is larger than that of the largest change.

The average absolute percentage change (AAPC) is a measure of *relative* variability that avoids the problem of inappropriate weighting. Thus, it is a better measure of the week-to-week variability with which this article is concerned.[2]

[2]Of course, if the growth rate is constant across time periods, then the AAPC will not necessarily be preferable to the SD of the growth rate. If there is variable growth or short periods of rapid growth preceded and followed by periods of approximately equal growth, as in the charts above, then the AAPC is likely to be a better measure of week-to-week variability. If the growth rates were constant over these periods, however, the CV of the growth rate might be a useful measure.

it is possible that the lack of a significant change in the variability of money after the implementation of CRR was due to the earlier change in operating procedures. Unfortunately, these results cannot rule out the possibility that the short-run reserve management behavior by depository institutions is simply insensitive to changes in the reserve accounting system.[15]

The Variability of Interest Rates

The AAPC was calculated for the federal funds, the three-month Treasury bill and the 30-day commercial paper rate for comparable 28-week periods before and after the implementation of CRR. The results, which are reported in table 3, indicate a slight increase in the AAPC for the federal funds rate for periods immediately before and after the implementation of CRR and a slight decrease for both the Treasury bill rate and the commercial paper rate; however, none of these were

Table 3

The Variability of Selected Interest Rates

Period	Federal[1] funds	Treasury bills	Commercial paper
2/24/84 — 8/31/84	2.55%	1.13%	1.13%
7/15/83 — 1/20/84	2.33	1.21	1.27
3/04/83 — 9/09/83	1.99	1.58	1.56

[1]For week ending two days earlier than date shown.

[15]Neither of these, however, rules out other potential gains from CRR. See Goodfriend (1984).

Chart 1
Levels of M1

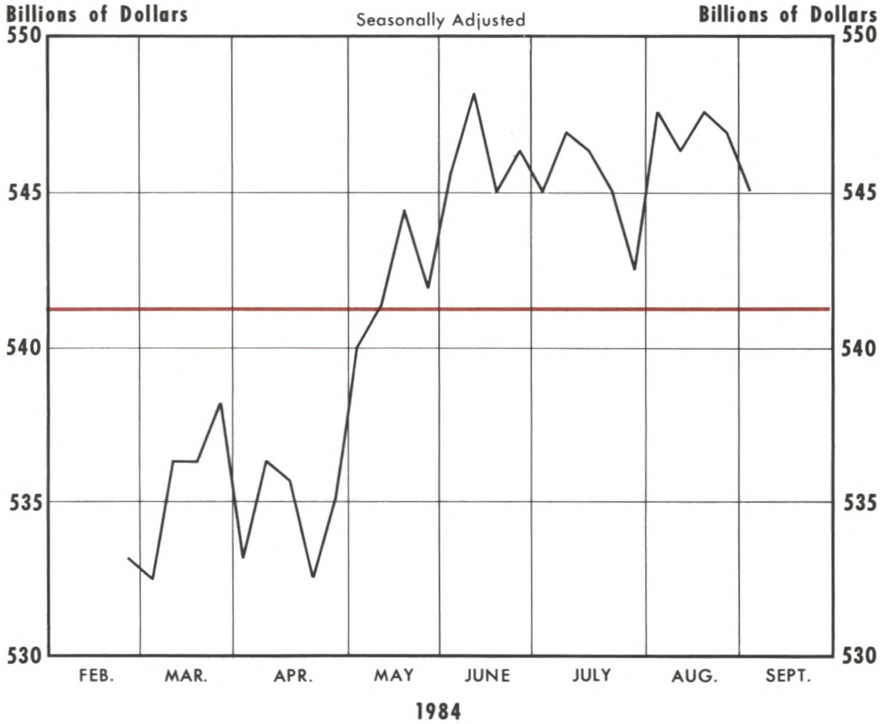
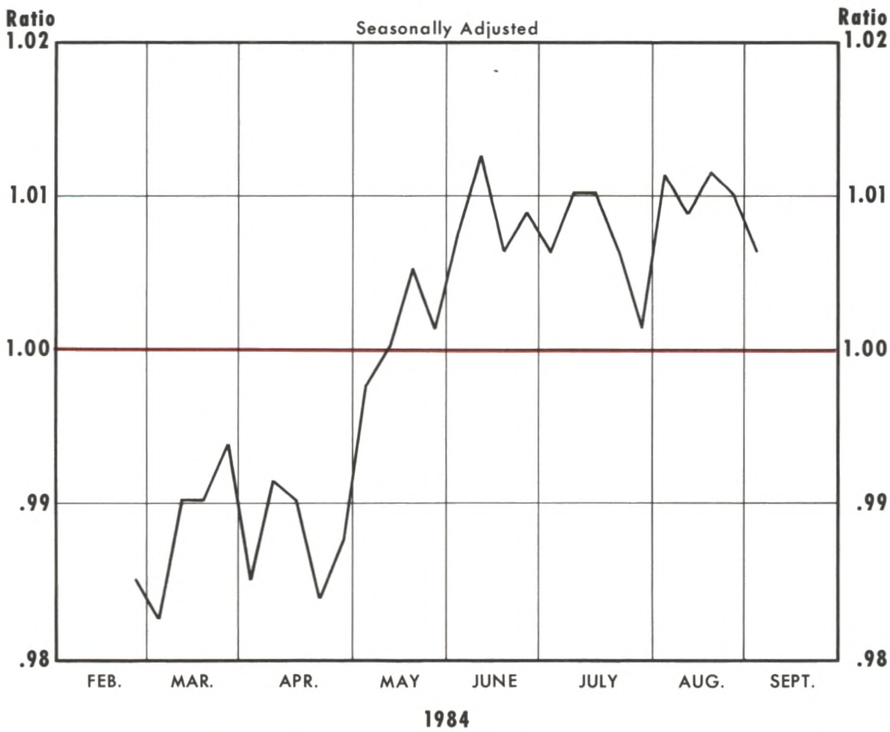


Chart 2
Ratio of M1 to Sample Mean



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significant at the 5 percent level.[16] Thus, the results suggest that the implementation of CRR had little effect on the variability of money or interest rates. The significant reduction in interest rate variability appears to correspond with the earlier change in operating procedures, not with the implementation of CRR.

CONCLUSIONS

The purpose of this article was to take an early look at the effect of the Federal Reserve's new system of contemporaneous reserve accounting on the variability of money and interest rates. Although the CRR system was adopted with the expectation that it would reduce the variability of money under a reserve targeting procedure, it may not have that effect for two reasons. First, depository institutions may behave in ways that reduce the short-run contemporaneous link between aggregate reserves and deposits even under CRR. Second, the change in operating procedures in October 1982 may have preempted any potential benefits from the switch in accounting systems.

The data for M1 indicate that there was no significant change in week-to-week variability following either the change in operating procedure in October 1982 or the adoption of CRR. The variability of short-run interest rates declined significantly after the change in operating procedures, but has been unaffected by the implementation of CRR. Thus, the change in the reserve accounting procedure had no statistically significant impact on the variability of money either because depository institutions' lending and investment decisions are insensitive to the reserve accounting system, or because of the change in operating procedures that occurred some year and a half earlier. Consequently, CRR's potential usefulness in reducing the variability of money can be determined for certain only if the Federal Reserve implements a strict reserve aggregate or monetary base target.

[16]The relevant t-statistics for a comparison of periods immediately before and after the implementation of CRR for the federal funds rate, the three-month Treasury bill rate and the commercial paper rate are 0.30, 0.39 and 0.53, respectively.

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