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1 **Central Bank Independence: An International Comparison**

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An analysis of central banks in major countries shows that institutional independence of the central bank appears to rank high among the factors explaining differences in inflation across countries. The more autonomous central banks have not accommodated inflationary pressures as much as central banks that are more closely tied to their governments. This study also finds that the Federal Reserve ranks among the world's more independent central banks, possibly behind only those of West Germany and Switzerland.

15 **A T-Bill Futures Hedging Strategy for Banks**

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Hedging with Treasury bill futures contracts can partially insulate banks' earnings from unpredictable changes in interest rates. Other things unchanged, earnings would tend to vary inversely with interest rates because banks typically hold long-term assets and short-term liabilities. As interest rates have become more volatile in recent years, banks have relied increasingly on variable-rate loans and have largely ignored futures markets. The simulation reported in this article indicates that banks making fixed-rate loans can reduce the variability of profits 80 percent by hedging with futures contracts.

Central Bank Independence: An International Comparison

*By King Banaian, Leroy O. Laney, and Thomas D. Willett**

The independence of the Federal Reserve System has once again become a major topic of debate. Over the years, critics of existing institutional arrangements have included both those who fault the Federal Reserve for being too responsive to outside pressures and those who fault it for not being responsive enough. But many observers consider the Fed to exercise more autonomy from the executive and legislative branches of the Government than is the case with central banks in most other countries, and today the criticism is heard principally from those who do not regard institutional independence as a virtue.

This debate raises basic issues about the design of institutions in a democratic society. What government activities should be responsible directly to the electorate and its representatives? In what areas should the direct operation of political forces be constrained by constitutional limitation, an independent regulatory commission, or the checks and balances of the different branches of government?

An autonomous central bank typically has several functions: it usually serves as fiscal agent to the government, as lender of last resort for private financial institutions during emergencies, and as a regulator and supervisor of the financial system. As the principal public sector agency charged with the execution of a country's monetary policy, however, the bank can encounter a number of conflicting objectives. It must weigh economic growth in the near future against control of inflation, the external balance, and long-run economic growth. It is almost always under economic and political pressure to emphasize some goals at the expense of others in the formulation and conduct of monetary policy. The extent to which the central bank accommodates this pressure can depend greatly on its institutional independence.

No judgment is made here on the relative importance of the various goals of monetary policy. The focus, however, is on a highly important goal. How

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successful has the institution of independent central banking been in countering inflationary tendencies?

The United States has not had postwar experience with monetary policy under institutional arrangements fundamentally different from those now in existence. Nevertheless, some useful information on the matter can be provided by comparison with the experiences of other industrial countries. If distinguishing independent from dependent central banks is possible, this comparison can shed light on the effects of independence in the conduct of monetary policy. This article concludes that the more independent central banks have indeed been associated with less inflationary policies. In addition, central banking arrangements appear to be more important than several other structural factors that have been put forth in explaining differences in inflation across countries.

Federal Reserve independence and a U.S. monetary constitution

Arguments for reducing the independence of the Federal Reserve are usually based on a combination of views about the most appropriate structure of democratic institutions and about how alternative institutional arrangements are likely to affect the objectives emphasized by monetary policy. Proposals range from reforms to constrain the discretionary scope of monetary policy through a return to some form of gold or other commodity standard—or at least a constitutionally mandated set of limitations on monetary growth—to the advocacy of making Federal Reserve policy more directly responsive to the Congress or the executive branch of the Government. In general, those who are more concerned with inflation have been inclined toward the former types of reform, while those more concerned with generating short-run reductions in interest rates and unemployment have tended to favor the latter approaches.[1]

A major traditional argument for the independence of the central bank is that those responsible for paying the Government's bills should not also be responsible for printing the country's money. The temptation to engage in inflationary finance is too strong. In recent years this rationale has been supplemented by concern that the direct operation of the political process, with its tendency to focus primarily on the near future, would force extensive monetary accommodation in the short run at the cost of long-run destabilization of the economy.[2] But recently, critics have argued that Fed independence actually has proved conducive to monetary accommodation because it makes determining who is responsible for such accommodation more difficult.[3]

Few argue that any central bank should be divorced completely from government. After all, a central bank is inherently a public sector institution, not only in discharging its responsibilities for monetary policy and financial supervision but also in performing its traditional function as banker to the government. But the extent to which the bank is independent within the public sector can make a great deal of difference in the conduct of monetary policy.

Advocates of closer executive branch control over the Fed contend that a more coordinated national economic policy would result and that such coordination would be desirable.[4] Others have

1. For further discussion on alternative monetary constitutions, see Thomas D. Willett, "A New Monetary Constitution: An Evaluation of the Need and the Major Alternatives," Claremont Working Papers, no. 71 (Claremont, Calif.: Claremont Graduate School, November 1982), and the references cited there. See also Leland B. Yeager, ed., *In Search of a Monetary Constitution* (Cambridge: Harvard University Press, 1962).

2. An evolving branch of the economic literature investigates the interaction of national politics and macroeconomic policy. Much of this literature does not focus explicitly on monetary policy as it relates to government or partisan politics, but see Bruno S. Frey and Friedrich Schneider, "Central Bank Behavior: A Positive Empirical Analysis," *Journal of Monetary Economics* 7 (May 1981): 291-315, and Leroy O. Laney and Thomas D. Willett, "Presidential Politics, Budget Deficits, and Monetary Policy in the United States, 1960-1976," *Public Choice* 40, no. 1 (1983): 53-70.

3. See Ira P. Kaminow, "Politics, Economics, and Procedures of U.S. Money Growth Dynamics," in *Political Economy of International and Domestic Monetary Relations*, ed. Raymond E. Lombra and Willard E. Witte (Ames: Iowa State University Press, 1982), 181-96, along with discussions by Thomas Mayer and John T. Woolley, comment by Thomas D. Willett and Leroy O. Laney ("Technical Versus Political Causes of Monetary Expansion"), and the rejoinder by Kaminow.

4. As indicated by Lester C. Thurow, for example: "Whatever its historical merit, the time has come to end the independence of the Fed. If the President is competent enough to have his finger on the nuclear button, he is competent enough to control the money supply. Presidents are elected and defeated on

argued that because the Fed is accountable by law not to the President but to the Congress, it is this body that should exercise more direct control over the central bank.[5] It might be countered that the central bank is, in fact, likely to impose more discipline upon itself than would be imposed by the diffuse goals of a legislative body or the short horizon of the President. Nevertheless, some would evidently view direct Fed accountability to either the executive or the legislative branch of the Government as more desirable than current arrangements.[6]

Those who believe that the Federal Reserve has not paid enough recent attention to interest rates and unemployment generally assume that institutional independence has insulated monetary policy from short-term political considerations, allowing greater emphasis on fighting inflation over the long run. But this assumption has been challenged by the view that Fed independence is overstated.[7] The present independence of the Fed may remain at issue, but it can be put in clearer perspective by examining central banking relationships in other countries.

Assessing central bank independence

The concept of central bank independence has practical meaning primarily for institutions in industrialized countries with deeper capital markets. Governments of most less developed countries must rely on their own central banks and foreign capital markets to finance their debt. In more developed countries, private domestic capital markets provide an additional source of government finance, so greater scope for central bank independence is at least possible. Because of these distinctions, comparisons here are limited to central banks of more developed countries. Even among those countries, however, techniques for conducting monetary policy and the depth of financial markets differ greatly.

Measuring central bank independence is not simple because independence can be ensured or undermined through a wide range of channels. Consequently, there is no single institutional characteristic by which to rank central banks from most to least independent. Several sources can provide information on this question, however. Not only can information be gathered on formal, structural relationships specified by statute, but information on informal relations between central banks and government may prove useful as well. Formal indications of independence can be gleaned from the sources of appointment of governors in the bank, their terms of office, and their methods of reaching decisions. Relevant, but sometimes misleading, information may be conveyed by whether the stock of the central bank is owned by the state or the private sector. Formal liaison or interchange of staff with the finance ministry may be indicative of ties to the executive branch of government, just as reporting requirements and other accountability to Parliament or Congress are revealing about the relationship to the legislative branch.

Statements concerning goals in the charter of a central bank may also help reveal its degree of independence. Such goals can range from a statutory duty to foster the general welfare of the country to specific requirements set by law—for example, controlling inflation, promoting full employment or production, or stabilizing the exchange rate.

But all these indicators may be misleading. A central bank that appears not to be constrained by law may be influenced strongly, and not just episodically, by other branches of government. And it is

their economic performance. They deserve both the controls and the responsibilities that this implies. No President should be able to hide his failures behind an 'erratic' money supply beyond his control. And if the charge is true, no President should have to put up with an incompetent Fed" (*Newsweek*, 1 March 1982, 29).

5. Some observers have noted that under current arrangements the Administration exercises more de facto influence over the Fed than does the Congress. See, for example, Sherman J. Maisel, *Managing the Dollar* (New York: W. W. Norton & Company, 1973), 108-13, and Robert E. Weintraub, "Congressional Supervision of Monetary Policy," *Journal of Monetary Economics* 4 (April 1978): 341-62.

6. According to Milton Friedman: "The only two alternatives that do seem to me feasible over the longer run are either to make the Federal Reserve a bureau in the Treasury under the secretary of the Treasury, or to put the Federal Reserve under direct congressional control. Either involves terminating the so-called independence of the system. But either would establish a strong incentive for the Fed to produce a stabler monetary environment than we have had" ("Monetary Policy: Theory and Practice," *Journal of Money, Credit, and Banking* 14 [February 1982]: 118).

7. For discussion, see Edward J. Kane, "External Pressure and the Operations of the Fed," in *Political Economy of International and Domestic Monetary Relations*, ed. Lombra and Witte, 211-32.

also conceivable that a central bank that seems to be constrained can establish a fair amount of autonomy over time. The relationship between the central bank and other entities of government can be strongly influenced by tradition, a result of gradual evolution rather than any well-articulated or easily observed formal linkage.

How, then, can a line be drawn between dependent and independent central banks? Economists and other observers tend to agree that countries with a traditional sentiment toward controlling the financial power of the national government—such as is generally found in federal unions like West Germany, Switzerland, and the United States—also have central banks that are the most likely candidates for being classified as independent. Most of the indicators discussed above lend support to this view.

The central banks of most developed economies do not show much independence in the determination of monetary policy. Although central banks are almost always charged with the execution of monetary policy and some scope for disagreement with government exists, they are usually subordinate to the treasury or finance ministry in the formulation of policy.

British monetary policy is subject to the direction of the U.K. Treasury, and Parliament generally holds the government responsible for the actions of the Bank of England. In Japan, too, the Finance Ministry dominates. Both the Finance Ministry and the Economic Planning Agency in Japan are represented on the Policy Board of the central bank, and this board's annual report to the Japanese Diet must be submitted through the Finance Ministry. French and Italian monetary policies are also dictated by the Treasury, even on a very short-term basis. In Canada the central bank had more formal authority before 1967, when an amendment to the Bank of Canada Act gave the Minister of Finance the power to issue directives to the bank. This general pattern of subordination to the Treasury extends to most of the world's other developed countries as well.[8]

The more independent central banks

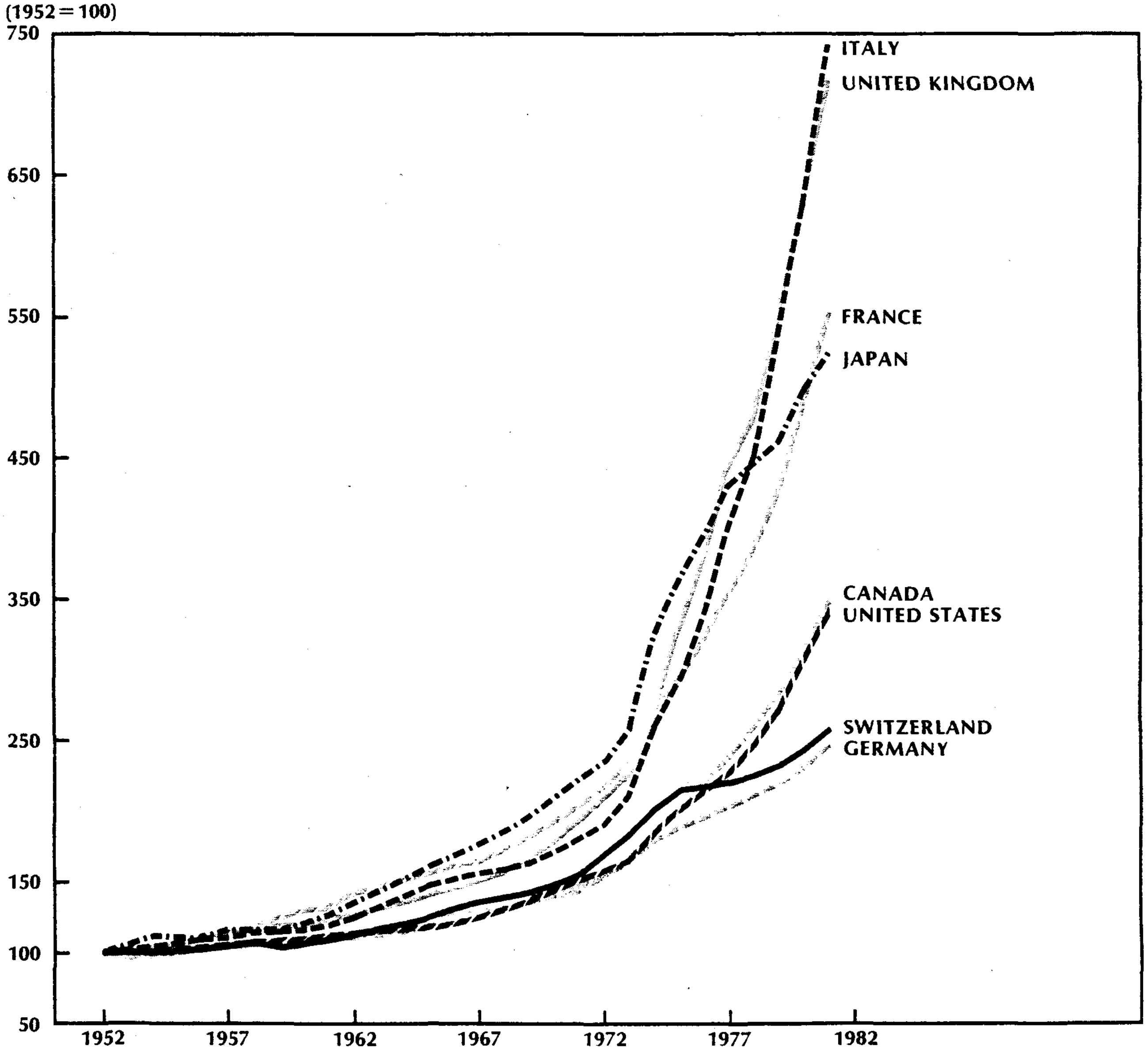
Even though its stock is owned by public authorities, the central bank of West Germany has experienced substantial independence in postwar years. The current organization of the Deutsche Bundesbank dates from 1957, when restructuring actually increased the influence of the federal government but still left the central bank one of the most independent in the world. Government authorities can attend meetings of the bank's highest deliberative body, the Central Bank Council. But they have no vote, only the power to delay a decision a maximum of two weeks.

Although the Bundesbank is charged with supporting general economic policy, this is subordinate to its responsibility for safeguarding the value of the currency. The government itself is responsible for fiscal policy, and the central bank deals with monetary policy. While the government is responsible for decisions about the exchange rate regime, subject in practice to central bank approval, the Bundesbank is responsible for discretionary foreign exchange intervention policy. This division has allowed some conflict in the past, but it has not been prolonged. The Bundesbank is not formally answerable to the Parliament, except for submission of an annual report.

The President of the Deutsche Bundesbank and not more than 10 directors are appointed to eight-year terms upon nomination by the federal government. The Central Bank Council is composed of this directorate plus the presidents of the 11 "Land" Central Banks, which are somewhat analogous to district Federal Reserve Banks in the United States. The 11 presidents provide regional representation to the decisionmaking body; they are proposed by appropriate local authorities and then nominated by

8. Comparatively few attempts have been made to classify central banks according to their independence, but the above categorization is generally supported in work done so far. See, for example, Donald R. Hodgman, *National Monetary Policies and International Monetary Cooperation* (Boston: Little, Brown and Company, 1974); Michael Parkin and Robin Bade, "Central Bank Laws and Monetary Policies: A Preliminary Investigation," University of Western Ontario, Department of Economics, Research Report no. 7804 (London, Ontario, Canada, 1978), part of which was published in Michael Parkin, "In Search of a Monetary Constitution for the European Communities," in *One Money for Europe*, ed. Michele Fratianni and Theo Peeters (New York: Praeger Publishers, Praeger Special Studies, 1978), 167–95; and "Relations Between Government and Central Bank: A Survey of Twenty Countries," by D. E. Fair for the U.K. Parliament, Committee to Review the Functioning of Financial Institutions, *Appendices*, Cmnd. 7937 (June 1980), 557–72. A summary of the last work cited is found in Don Fair, "The Independence of Central Banks," *The Banker*, October 1979, 31–41 passim.

Chart 1
Consumer Prices in Major Countries



SOURCE: Board of Governors, Federal Reserve System.

the Parliament for eight-year terms, subject to reappointment. The council, chaired by the Bundesbank President, sets monetary policy by simple majority vote. There is no formal liaison or interchange of staff with the Ministry of Finance.

Probably the only monetary agency that can be ranked with the German central bank in terms of institutional independence is that of Switzerland. Although the Swiss National Bank and the government must consult with each other on policy matters, approval before implementation by the other party is not necessary. The bank is constitutionally independent of the parliamentary body but, as in the German case, submits an annual report. Unlike West Germany, the Swiss Confederation owns no shares in its central bank. Stock is held by the cantons, cantonal banks, and the public. Shares are listed on the Swiss Stock Exchange.

The policy of the Swiss National Bank is made indirectly by the Bank Council, which consists of 40 members, 25 of whom are appointed by the government cabinet to four-year terms. The remaining 15 are elected by bank stockholders. The council selects a smaller board that directly manages monetary policy. The role of the government in the bank is explicitly limited by law to such matters as determining the size of the bank's capital, the denomination of bank notes, and the division of profits among cantons. Formal government participation in monetary policy is quite minor overall.

The U.S. Federal Reserve System is also independent when judged against most other central banks. But the Federal Reserve has a formal responsibility to the legislative branch of the Government that is greater than in the two foregoing cases. It must report in testimony to the Congress twice yearly on the conduct of monetary policy, and it submits an annual report. The Chairman and the six other members of the Board of Governors of the Federal Reserve System are frequently called upon to testify before Congress on monetary policy and various other subjects.

Although the Board does not report formally to the executive branch, there is frequent contact with the Treasury and other Government agencies. Board members are appointed by the President, subject to Senate approval, to 14-year, nonrenewable terms. (A Board member may serve more than 14 years if a full term follows an incomplete term created by a vacancy.) The Chairman and Vice Chairman of the Board are appointed similarly to four-year, renewable terms.

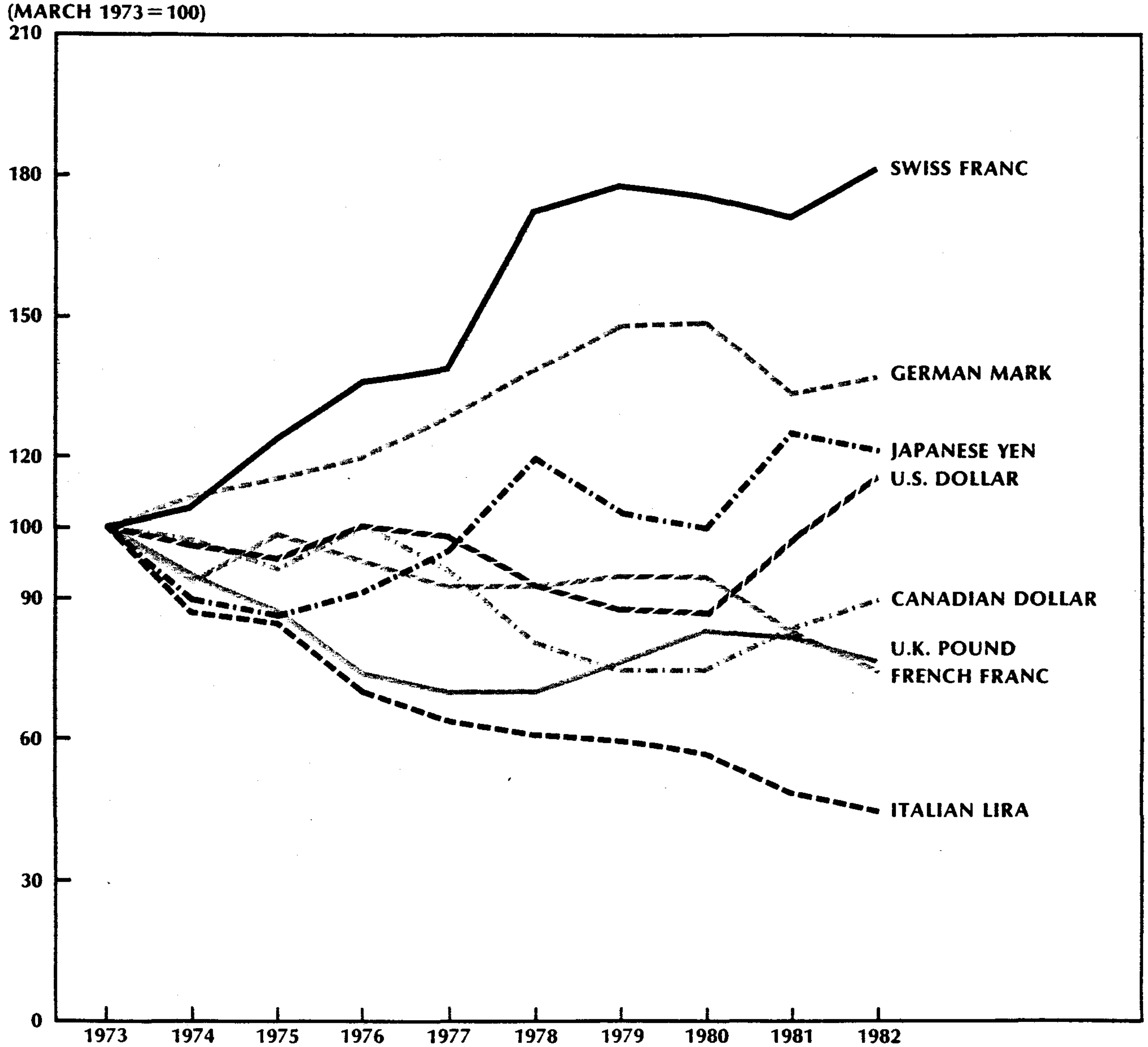
Monetary policy in the United States is actually decided by the 12-member Federal Open Market Committee, on which 5 district Reserve Bank presidents sit. And since these presidents are appointed by the boards of directors of the district Reserve Banks (two-thirds of the directors are elected by district member banks and one-third by the Board of Governors), subject to approval by the Board of Governors, there is at least some formal scope for non-Government-approved representation.

Independent banks and inflation

How have these more independent central banks measured up with respect to the rates of inflation their societies have experienced? A number of indicators of inflationary performance have been suggested—for example, different price indexes, exchange rates (a reflection of the external value of the currency), and growth rates of monetary aggregates. Price indexes are subject to various biases, especially when compared internationally, while exchange rates are often subject to important nonmonetary influences. For money growth rates, simple comparisons across countries can be misleading because of substantial differences in velocity trends. Consequently, it is useful to examine several different indicators.

Chart 1 shows clearly that since the early 1950's, national price levels in the world's larger economies have diverged markedly. But overall, prices in West Germany, Switzerland, and the United States have increased at the slowest rates. (Inflation in Canada over the long haul has been quite close to that in the United States.) And since the advent of more flexible exchange rates in the early 1970's, overall movements in the external values of national moneys have reflected inflation differences also. Chart 2 depicts effective (trade-weighted) exchange rates for the currencies of the eight major countries. The Swiss franc and the German mark have been the strongest currencies, at times challenging the U.S. dollar's role as the world's primary international reserve currency. The U.S. dollar retains that status, however, and dollar inflows in recent years have been reflected in the observed weakness in the Swiss and German trade-weighted rates. (The strength of the Japanese currency over the period

Chart 2
Trade-Weighted Exchange Rates of Major Currencies



SOURCE: Board of Governors, Federal Reserve System.

Table 1
PRICE LEVEL, MONEY SUPPLY, AND NOMINAL GNP GROWTH IN EIGHT MAJOR COUNTRIES

Country	Implicit deflator inflation	Consumer price inflation	Narrow money supply growth[1]	Broad money supply growth[2]	Nominal GNP growth
	Average annual rates of change, 1960–80 (Percent)				
Germany	4.4	3.9	12.6	13.6	8.3
Switzerland	4.8	4.2	11.4	8.5	8.1
United States	4.9	5.3	5.5	9.6	8.6
Canada	5.8	5.3	7.2	12.2	10.6
Japan	6.3	7.4	18.1	19.3	14.6
France	6.9	6.8	10.9	14.3	12.4
United Kingdom	8.9	8.8	7.9	10.6	11.4
Italy	9.5	8.8	14.6	14.0	14.7

1. Based on M1.
2. Based on M1 plus quasi money.
SOURCES OF PRIMARY DATA:
International Monetary Fund.
Organization for Economic Cooperation and Development.

has been partly due to the rising international role of the yen, as well as Japan's economic growth and international trade performance.)

Further comparisons for the eight countries over the past two decades are presented in Table 1. Both measures of the price level, the GDP implicit price deflator and the consumer price index, show lower inflation in the countries with the more independent central banks. The ranking according to inflation is not borne out in the figures for growth rates of the narrow and broader money supplies. However, the inflationary stance of the monetary authority cannot always be judged on the basis of money supply growth alone, although there is often some tendency to do so, as this growth does not account for changes in money demand.

The last column is probably more indicative of monetary accommodation. Nominal gross national product growth rates do reflect the relative accommodative stance of monetary policy over the longer run, even if they do not show the extent to which money growth is translated into real output growth versus inflation. (Viewed in the familiar quantity equation context, nominal GNP equals the product of the money stock times velocity. Thus, nominal GNP growth rates measure rates of money growth adjusted for changes in velocity.) By this gauge, it is again the countries with more independent central banks that emerge as less accommodative.

Central bank reaction functions

Although the above comparisons are interesting, they leave much to be desired in investigating the underlying importance of central banks' independence. A further step is to consider the various sources of pressure to which a central bank is subject. This step can open the discussion to a wide range of economic and social forces that frame the context within which monetary policy is made. The basic premise is that monetary authorities react to a number of different influences in attempting to deliver an acceptable set of economic conditions. Policy targets, such as interest rates and money supply growth rates, are presumed to be manipulated in response to underlying economic, sociological, or political pressures. In this spirit, many economic researchers in recent years have attempted to estimate central bank "reaction functions."[9] These attempts have been aimed at identifying the forces to which particular central banks have responded and at quantifying the magnitude of the responses.

Monetary policy may be influenced by outside forces, but the authorities can still control their operating and intermediate monetary targets with a reasonable degree of accuracy. A monetary policy that resists pressures entering the relevant reaction function simply requires accepting the consequences—for example, higher unemployment or lower economic growth in the short run—if the pressures are not accommodated. The extent to which such pressures are accommodated, however, can depend significantly on the independence of the central bank.

Although cataloging all plausible pressures is not possible, several are frequently mentioned. Commonly cited is the pressure that government fiscal deficits place on interest rates and money growth. If the central bank counteracts alleged "crowding out" of private investment, resulting from higher interest rates because of government financing needs, it monetizes the public debt. One would expect this option of taxing through inflation, rather than conventionally, to be exercised more the less the independence of the central bank from government.

Central banks also may react to other inflationary pressures. Wage increases may call for monetary validation if unemployment results from wage gains in excess of productivity. And international sources of inflationary pressure may call for accommodation. Typical foreign sources are import price pressure (due to a depreciating exchange rate or rising world prices in general) and unsterilized international reserve flows in the balance of payments.

The response of the monetary authority may not be inflationary, on the other hand. The central bank's reaction may be to combat inflationary pressures by being more restrictive. And any discretionary monetary policy responds to real economic activity, either procyclically to foster an expansion or countercyclically in a fashion that stimulates real growth.

In assessing the importance of factors entering these monetary reaction functions, it is possible to draw upon other work to some extent. One of the relatively few formal studies of central bank independence concluded that the Federal Reserve should be considered a subservient central bank rather than an independent one.[10] That study surveyed 10 industrial countries—Australia, Belgium, Canada, France, Germany, Italy, Japan, Sweden, the United Kingdom, and the United States—on the basis of available reaction function studies. Among the central banks of these countries, only the German bank was found to behave independently as measured by the response to included pressures. This outcome was reinforced by other conclusions on relative central bank inflationary-deflationary stance and observations concerning appointment of bank governors.[11]

Another investigation, some results from which are presented as Table 2, partly supports this finding but yields somewhat different conclusions regarding

9. Early examples are G. L. Reuber, "The Objectives of Canadian Monetary Policy, 1949-61: Empirical 'Trade-offs' and the Reaction Function of the Authorities," *Journal of Political Economy* 72 (April 1964): 109-32, and John H. Wood, "A Model of Federal Reserve Behavior," in *Monetary Process and Policy: A Symposium*, ed. George Horwich (Homewood, Ill.: Richard D. Irwin, 1967), 135-66. For comparative international evidence, see also Robert J. Gordon, "World Inflation and Monetary Accommodation in Eight Countries," *Brookings Papers on Economic Activity*, 1977, no. 2:409-68, and T. D. Willett and L. O. Laney, "Monetarism, Budget Deficits, and Wage Push Inflation: The Cases of Italy and the U.K.," *Banca Nazionale del Lavoro Quarterly Review* 31 (December 1978): 315-31.

10. Parkin, "In Search of a Monetary Constitution for the European Communities," 180-84.

11. The conclusion for the United States, however, was influenced by at least two aspects of Parkin's analysis that should be noted. First, as his indicator of secular inflationary-deflationary stance, Parkin uses the average rate of change in the exchange rate for the currency of each country in his sample against the U.S. dollar over the 1951-75 period. He finds that the two most institutionally independent central banks—in Germany and Switzerland—rank one and two, respectively, and the United States ranks number nine (that is, eight currencies appreciated against the dollar, while only three—those of France, Italy, and the United Kingdom—depreciated). But use of exchange rate changes as a measure of inflationary trends is questionable, because exchange rates are often influenced substantially by real factors that can cause large deviations from purchasing power parity, both in the short run and in the long run. (For discussion and references, see the articles by Richard J. Sweeney and Thomas D. Willett in *The International Monetary System: A Time of Turbulence*, ed. Jacob S. Dreyer, Gottfried Haberler, and Thomas D. Willett [Washington, D.C.: American Enterprise Institute for Public Policy Research, 1982].) Also, while simple comparisons may be misleading, Parkin observes that 100 percent of the Fed's Board of Governors is Government-appointed (compared with fractions in the German and Swiss cases), but he does not account at all for the fact that only a fraction of the policymaking Federal Open Market Committee is composed of that Board.

Table 2
SIGNIFICANCE OF FOUR PRESSURES FOR MONETARY ACCOMMODATION IN 12 INDUSTRIAL COUNTRIES

Area	Domestic: Fiscal deficit	Domestic: Wage increases	Foreign: Reserve changes	Foreign: Import prices	Total number of cases
	Cases in which variables were significant at the 5-percent confidence level, using a one-tail test that the sign was as hypothesized				
Australia	11	7	6	0	24
Belgium	10	9	3	1	23
Canada	5	3	0	0	8
France	4	8	2	1	15
Germany	6	1	0	0	7
Italy	9	5	6	2	22
Japan	7	10	11	0	28
Netherlands	11	9	10	1	31
Sweden	9	0	3	2	14
Switzerland	1	0	8	1	10
United Kingdom	6	10	4	2	22
United States	6	4	0	2	12
12 countries	85	66	53	12	216

SOURCE: Leroy O. Laney and Thomas D. Willett, "The Political Economy of Global Inflation: The Causes of Monetary Expansion in the Major Industrial Countries" (U.S. Department of the Treasury, Office of International Monetary Research, Washington, D.C., 1977, Mimeographed).

REACTION FUNCTION SPECIFICATIONS USED FOR THE 11 ESTIMATED EQUATIONS

Equation	Specification
	Annual observations (starting with the earliest available year in International Monetary Fund data)
1	Changes in M1 as the dependent variable; the fiscal deficit cyclically adjusted; percentage changes in nominal wages specified as the wage increase term; changes in monetary authority foreign assets as the reserves term; differences in import price inflation and consumer price inflation as the import price pressure term.
2	Same as (1), with changes in the broad money supply as the dependent variable.
3	Same as (1) except the fiscal deficit cyclically unadjusted.
4	Same as (3), with changes in the broad money supply as the dependent variable.
5	Same as (1) but modified to abstract from multicollinearity in annual data (independent variables were regressed on each other; then the residual of this regression was substituted for the basic variable).
6	Same as (5), with changes in the broad money supply as the dependent variable.
7	Same as (1) except percentage changes in import prices only were substituted as the import price term.
	Quarterly observations (starting with the earliest available quarter in International Monetary Fund data)
8	Changes in seasonally adjusted M1 as the dependent variable; the fiscal deficit cyclically and seasonally adjusted; other quarterly variables computed the same as in (1).
9	Same as (8), with the fiscal deficit seasonally (but not cyclically) adjusted.
10	Same as (8), with percentage changes in M1 substituted for first-difference changes as the dependent variable.
11	Same as (8) except distributed lags were estimated on the independent variables.

NOTE: An example of this general specification is found in T. D. Willett and L. O. Laney, "Monetarism, Budget Deficits, and Wage Push Inflation: The Cases of Italy and the U.K.," *Banca Nazionale del Lavoro Quarterly Review* 31 (December 1978): 315-31.

the United States. The responses of monetary policy to four pressures—the fiscal deficit, wage increases, international reserve influences, and import price increases—were examined across a sample of 12 industrial countries. Initial results were sensitive to alternative econometric specifications testing these four factors, so 11 different regressions (described below the table) were estimated for each country. The figures in the table indicate the number of equations in which the respective variables were significant statistically at the 5-percent confidence level.

The outcomes provide two interesting observations. First, the monetary authorities were more responsive to the two domestic pressures than to the two pressures of foreign origin. This suggests that sources of inflation may originate more often at home than abroad even in an open economy and that domestic monetary and fiscal policies must bear most of the responsibility. Balance-of-payments surpluses and deficits may influence monetary expansion when sterilization is not complete. Recent empirical research suggests, however, that even though such developments may have been important for certain countries in particular episodes, the industrial countries have generally been able to sterilize a high proportion of international reserve flows. Thus, secular rates of monetary expansion are primarily a function of domestic considerations, rather than international ones.[12] Likewise, while international commodity price shocks and exchange rate changes can exert independent influences on domestic price levels in the short run, long-run price trends are largely due to domestic macroeconomic policies.

But perhaps more noteworthy, monetary policy was less accommodative overall in the countries in which the central bank has been characterized as more independent. The four countries showing the fewest total cases of significant monetary validation of the pressures covered were Germany, Canada, Switzerland, and the United States. While Sweden and France fell fairly close to the United States, the remaining countries had considerably higher totals.

A structural approach

Beyond the typical economic reaction function arguments is an array of social and political arguments. Considering some of these is appropriate because an examination of central bank independence leads inevitably into this broader realm. Sociopolitical factors are usually more strongly linked to the structure of an individual society than are the behavioral economic variables that are often hypothesized. Is it possible to identify structural aspects that make some societies exhibit greater inflationary tendencies than others? Is the central bank less independent in these more inflationary societies simply because it evolved as part of the underlying social structure, or does the relationship of the monetary authority to government make any separately identifiable contribution?

Again, complete identification of inflationary factors is not possible, but several explanations have been suggested. A frequently mentioned aspect is the growth of government.[13] Some work has even found significant explanatory power from the extent of unionization in the economy.[14] The role of an "aspirations gap," both within countries and among countries, has also been hypothesized. According to this reasoning, many attempts to improve real income per capita relative to that in other countries, as well as make income distribution more equal within a country, may be well-intentioned but ultimately result mainly in inflation.[15] And the openness of an economy can be important for internationally transmitted inflation.[16]

12. For supporting evidence, see Leroy O. Laney and Thomas D. Willett, "The International Liquidity Explosion and Worldwide Inflation: The Evidence from Sterilization Coefficient Estimates," *Journal of International Money and Finance* 1 (August 1982): 141-52.

13. For one analysis, see Alan T. Peacock and Martin Ricketts, "The Growth of the Public Sector and Inflation," in *The Political Economy of Inflation*, ed. Fred Hirsch and John H. Goldthorpe (Cambridge: Harvard University Press, 1978), 117-36.

14. See Robert E. McCormick, "Why Are Inflation Rates Different Across Countries?" (Paper prepared for the Liberty Fund Conference, Long Island, New York, 25-27 September 1980).

15. For investigation, see M. Panic, "The Origin of Increasing Inflationary Tendencies in Contemporary Society," in *The Political Economy of Inflation*, ed. Hirsch and Goldthorpe, 137-60.

16. For discussion, see Richard J. Sweeney and Thomas D. Willett, "The International Transmission of Inflation," *Kredit und Kapital* 9, special supplement (1976): 441-517.

Institutional Independence, Monetary Accommodation, and Inflation

Even when other often-cited structural factors are taken into account, central bank independence appears to be important in explaining monetary accommodation and inflation in developed countries. Using cross-sectional data for 17 industrial countries—Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States—central bank institutional independence and several other structural aspects that have been set forth in explaining why inflation rates differ across countries were investigated for the 1960-80 period.

Fiscal deficits relative to savings (*DS*) can be an important variable, as countries with a low savings ratio are less able to finance deficits privately than are those with a high savings ratio. The percentage of the labor force unionized (*U*) was also included, perhaps not so much because labor unions cause inflation directly as because they affect political behavior through lobbying and voting. If the aspirations gap hypothesis is valid, variables such as the percentage change in real income per capita (*YC*) can be important across countries, as well as a Gini coefficient (*G*) measuring income inequality within countries. Foreign inflationary pressures were proxied by the ratio of imports to gross domestic product (*IY*). Finally, to capture the influence of probable central bank independence, a dummy variable (*CBI*) set equal to 1 for Germany, Switzerland, and the United States—zero otherwise—was added.[1]

These variables were regressed as independent variables to explain three different gauges of monetary accommodation: two inflation measures—rates of change in implicit price deflators (*DI*) and consumer prices (*CI*)—and the growth of nominal gross national products (*NGNP*). Because price levels over the 1960-80 period rose substantially worldwide and, at the same time, diverged and possibly crossed internationally, cross-sectional data were divided into three subperiods—1960-67, 1967-73, and 1973-80—and then pooled for the actual regressions. This was not done for the unionization or Gini coefficient variables, which are not likely to have exhibited much variation over time. Sources yielded these for the years 1977 and 1970, respectively.

The central bank independence variable was always quite significant, while the other variables generally performed poorly. Real per capita income and the deficit-savings ratio entered significantly in the inflation regressions, the former more strongly than the latter, but not in the regression using nominal income growth as the dependent variable. The coefficients indicate that inflation could be about 4 percent less, on average, in countries with an independent central bank; of course, any such estimate should be regarded with caution.[2]

1. For the 1960-67 period the independence dummy was also set equal to 1 for Canada, because the Bank of Canada was accorded final authority over monetary policy during this period.

2. Several variations on the reported regressions were investigated. Regressions were estimated with separate dummies for each country with an independent central bank. Germany and the United States were significant here but Switzerland usually was not, possibly because other variables captured the independence effect for the Swiss National Bank. (For example, the Swiss fiscal balance was in substantial surplus in each period.) In addition, in one set of regressions, the mean global rate for the variables was subtracted in each subperiod to abstract from any trend biasing upward the significance of those independent variables that were so divided. The independence dummy still was dominant, and the results reported here are biased against the relative importance of the bank independence term. Finally, a separate set of regressions was computed substituting fiscal deficits relative to GNP for deficits relative to savings. Results were generally the same but not quite as robust as those reported.

REGRESSION RESULTS

$$DI = 8.41 + 5.96\,DS - .02\,U - .88\,YC + 9.40\,G - .03\,IY - 4.01\,CBI.$$
$$(1.80)\quad(1.51)^{*}\quad(-.66)\quad(-3.30)^{***}\quad(.81)\quad(-.79)\quad(-3.32)^{***}$$
$$\bar{R}^2 = .31;\ F = 4.69.$$

$$CI = 9.38 + 7.00\,DS - .01\,U - .98\,YC + 7.72\,G - .05\,IY - 4.03\,CBI.$$
$$(1.97)\quad(1.73)^{**}\quad(-.50)\quad(-3.57)^{***}\quad(.65)\quad(-1.15)\quad(-3.26)^{***}$$
$$\bar{R}^2 = .33;\ F = 5.15.$$

$$NGNP = 13.14 + 5.67\,DS - .04\,U + .14\,YC + 3.55\,G - .04\,IY - 4.58\,CBI.$$
$$(2.46)\quad(1.25)\quad(-1.47)\quad(.47)\quad(.27)\quad(-.94)\quad(-3.31)^{***}$$
$$\bar{R}^2 = .22;\ F = 3.33.$$

NOTE: Figures in parentheses are *t* statistics; * indicates significance of the independent variable at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level, using a one-tail test that the variable is signed as hypothesized.
$\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom.
F is a test statistic for regression significance; here, all are significant at the 5-percent level.

The results of an attempt to explain inflation across countries by using several of these structural factors are presented in the accompanying box. There, most of the proxies for the factors investigated are only weakly significant statistically or not significant at all. But a variable intended to capture central bank independence is always strongly significant. The implication is that even after several frequently mentioned structural forces are accounted for, the relationship of the central bank to government appears to play an important separate role.

Conclusion

These results suggest that independent central banks have conducted monetary policies over the postwar years that have been less accommodative to outside pressures than the policies of their less autonomous counterparts; consequently, their countries have experienced substantially lower rates of inflation. This article has not evaluated monetary policy with respect to other objectives, such as maximization of real growth rates or reduction of unemployment. Even though other segments of society, in the political arena or the policymaking establishment, can be depended on to emphasize the importance of these other goals, often only the monetary authority can be depended on to defend the value of the currency. And most would judge this to be the principal responsibility of a central bank.

Central bankers, therefore, may be doing their best job when they are least popular. Once an inflation-conscious credibility has been established by a central bank, its occasional departure from noninflationary monetary policy may be overlooked as a factor in the formation of inflationary expectations. But it is questionable whether making the bank more answerable to the political process would enhance such credibility.

Because examples of independent central banks are few—only the banks in Germany, Switzerland, and the United States were considered to be so here—and because such categorization is somewhat subjective, these generalizations remain more tentative than might be deemed desirable. Societies with low inflation rates have more independent central banks, but causation may run more from the former to the latter than vice versa. Evidence presented here, however, suggests that central banking arrangements are likely to have made an independent contribution to the lower rate of inflation. The evidence also suggests, contrary to conclusions by some analysts that the U.S. central bank fits better with the dependent central banks, that the Federal Reserve should at least be classified in an intermediate position, between the German and Swiss cases on the one hand and the dependent central banks on the other.

A T-Bill Futures Hedging Strategy for Banks

By G. D. Koppenhaver*

Recent economic conditions have been accompanied by increased variation in interest rates. Typically, banks borrow short-term funds and extend long-term loans. In today's environment, this balance sheet structure exposes banks to considerable uncertainty about net income. Rapid changes in interest rates produce larger changes in the cost of funds than in the revenue generated by assets, thereby creating planning problems for management.

In response, banks have sought to achieve a closer match of interest-sensitive assets with interest-sensitive liabilities. This article focuses on an alternative solution to the problem. Futures contracts in financial assets can be used to hedge the gap between the volume of assets whose interest rates do not vary with the market and the volume of liabilities whose interest rates do vary with market rates. A bank could, for example, sell a futures contract calling for the future delivery of U.S. Treasury bills (T-bills) in an amount sufficient to balance the term to maturity of assets and liabilities.[1] This transaction would insulate the bank's income from the effect of changes in interest rates.

Trading in futures markets in this manner is called hedging. Futures contracts allow banks to respond quickly and inexpensively to changes in the business environment and to continue making long-term, fixed-rate loans. Nevertheless, the existing evidence indicates that the percentage of banks currently using financial futures is small.[2] Financial futures markets are relatively new and regulatory restrictions on futures trading are quite general, so bankers may be unfamiliar with the advantages of

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1. The T-bill futures contract traded at the International Monetary Market of the Chicago Mercantile Exchange calls for delivery of T-bills with 90 days to maturity. Contract size is $1 million in T-bill face value. Interest rates on the T-bill futures contract are quoted on a discount basis.

2. See Mark Drabenstott and Anne O'Mara McDonley, "The Impact of Financial Futures on Agricultural Banks," *Economic Review*, Federal Reserve Bank of Kansas City, May 1982, 19-30. They report that of 330 agricultural banks responding to a financial futures survey nationwide, 7 percent were using

futures markets and the manner in which they may be used.

This article addresses the following questions. How should a bank trade 90-day T-bill futures in an asset management strategy including T-bill investment and loan decisions? To what extent can bank profits be stabilized by trading T-bill futures, and is the stabilization potential similar across banks of various sizes? How much margin investment (a cost of hedging) is required to initiate a T-bill futures trading program for banks of various sizes? Lastly, what are the effects on bank profitability if futures positions are restricted to bona fide hedges of specific financial investments?

These issues are pursued through a mathematical model of optimal futures trading by a risk-averse banking firm. A simulation based on the model is then conducted, using T-bill futures prices over the 1976–81 period and balance sheet profiles of banks of various sizes in the Eleventh Federal Reserve District. To keep the analysis tractable, the bank analyzed in the model has no freedom to reduce its exposure to interest rate risk without using futures markets. The solution of the model shows how the optimal futures position depends on the bank's asset structure, market interest rates prevailing at the time decisions are made, and forecasts of interest rates over the planning horizon.

The solution implies that the bank will tend to hedge its full exposure to interest rate risk unless (1) management expects interest rates at the end of the planning period to be lower than the interest rate forecast implicit in the current T-bill futures price and (2) management is willing to accept some risk. The simulation shows that for the hypothetical banks, this strategy would have reduced the variance of unhedged profits by 80 percent from 1976 through 1981. The margins required to initiate the indicated futures market transactions range from about $4 million for banks with assets greater than $1 billion to $25,000 for banks with assets under $100 million.

futures to hedge interest rate risk as of January 1982. Also see Donald L. Koch, Delores W. Steinhauser, and Pamela Whigham, "Financial Futures as a Risk Management Tool for Banks and S&Ls," *Economic Review*, Federal Reserve Bank of Atlanta, September 1982, 4–14. It is reported there that of 230 financial institutions responding to a survey in the Sixth Federal Reserve District, 10 percent were using financial futures as of May 1982.

A simple model of banking

The simulation is based on a mathematical model of bank decisionmaking. To focus attention on the potential of futures trading, a hypothetical bank has been modeled with a much simpler balance sheet than that for an actual commercial bank.[3] The bank's assets are limited to loans and T-bills having six-month maturities and the margin deposited with a commodity broker to initiate a T-bill futures market position.[4] The liabilities are limited to a position in three-month T-bill futures, purchased funds with a three-month maturity at unregulated interest rates, and deposits earning interest that is fixed by Federal Reserve Regulation Q.[5] Thus, sources of funds roll over more frequently than uses of funds, and the bank faces a "negative gap." The assumptions preclude closing this gap with cash market transactions.

3. Another paper that systematically addresses the use of interest rate futures in restructuring bank balance sheets is Jack W. Parker and Robert T. Daigler, "Hedging Money Market CDs with Treasury-Bill Futures," *Journal of Futures Markets* 1 (Winter 1981): 597–606. Unfortunately, the hedging strategy employed is not based on a complete theory of bank behavior. For excellent reviews of the literature on the theory of the banking firm without futures trading, see David H. Pyle, "Descriptive Theories of Financial Institutions Under Uncertainty," *Journal of Financial and Quantitative Analysis* 7 (December 1972): 2009–29, and Ernst Baltensperger, "Alternative Approaches to the Theory of the Banking Firm," *Journal of Monetary Economics* 6 (January 1980): 1–37.

4. This margin is not applied against the value of the futures contract, as in a stock purchase, but is held by the brokerage house as a performance bond. To exit the futures market, the trader need only take an equal and opposite position at a later date to offset the initial position. After this contract offset, all margin deposited with the broker is returned, less a fixed commission. The commissions amount to approximately $100 per contract per round-turn transaction. Commissions are ignored here. A margin deposit is required to initiate either a buy or a sell position.

5. This framework draws heavily on the model used by C. W. Sealey, Jr., "Deposit Rate-Setting, Risk Aversion, and the Theory of Depository Financial Intermediaries," *Journal of Finance* 35 (December 1980): 1139–54. Sealey ignores T-bill investments and T-bill futures trading as uses of bank funds while allowing the bank to set deposit rates. The model here incorporates these uses of funds and ignores the pricing of deposits, assuming instead that Regulation Q interest rate ceilings determine deposit rates.

The bank's portfolio is reviewed once every three months. At that time, management adjusts the portfolio with the objective of maximizing the expected utility of bank profits at the end of the three-month planning period. Maximization of expected utility, rather than simply expected profits, is assumed in order to incorporate the effect of risk on decisions made by the bank's management. Its preferences in this respect are assumed to be characterized by risk aversion, which implies that favorable odds are required before a risky gamble is accepted. Loans are assumed to be free of default risk, so the only sources of uncertainty are the volume of fixed-rate deposits and the negative gap.[6]

Information is received and decisions are made in the following sequence. At the beginning of the period, current interest rates are known, and forecasts of interest rates three months in the future are available. With this information, management determines the size of the loan portfolio, the holdings in six-month Treasury bills, and the futures position in three-month Treasury bills. Subsequently, management learns the amount of fixed-rate deposits the bank will have available. At that point, the bank acquires or disposes of a sufficient volume of 90-day funds to balance assets and liabilities. At the end of the period, a new set of market interest rates is revealed, and the process is repeated.

The role of futures trading in this model is to reduce the uncertainty arising from the negative gap. Without futures contracts, the bank's net income will be sensitive to unpredicted changes in interest rates. If interest rates at the close of the planning period are higher than had been expected, the return from holding assets—and, consequently, profits—will be lower than had been predicted three months before. The reverse is true if interest rates at the close of the planning period are lower than expected.

Trading in futures markets can make bank profits less dependent on unpredictable changes in interest rates. When interest rates are higher than predicted, the profit from a short T-bill futures position will approximately offset the fall in the value of the bank's assets. The reverse will be true when interest rates are lower than expected. An illustration of these points is presented in the accompanying box.[7]

Any bank's strategy for participation in futures markets must take account of banking regulations. The Board of Governors of the Federal Reserve System, the Comptroller of the Currency, and the Federal Deposit Insurance Corporation set the guidelines for banks' use of financial futures contracts.[8] Although these regulations are quite general in allowing individual banks to apply their own futures trading strategy to specific conditions, use of financial futures must be pursued in accordance with prudent and sound banking practices.

Regulatory policy explicitly disapproves of futures trading that increases the market risk of the bank's portfolio. Therefore, financial futures market positions must be bona fide hedges of the net interest

6. Since the bank possesses 13-week T-bills at the end of the period, the uncertain interest rate on T-bills at that time is also the uncertain interest rate on the T-bill futures contract. Using regression techniques, one could not reject the hypothesis that spot 13-week T-bill interest rates and T-bill futures market interest rates on the first day of contract maturity are equal from June 1976 to December 1981. As a result, basis risk at contract maturity is ignored.

7. The two examples illustrate an important aspect of futures trading not dealt with in the text—basis risk. All futures market participants are subject to basis risk, defined as the risk of nonparallel interest rate changes in the cash and futures markets. In both examples, basis risk works in favor of the bank, although the opposite could have occurred. In the first example the T-bill futures rate increases 160 basis points, while in the cash market, T-bill interest rates rise 156 basis points and prime loan rates rise 75 basis points. Futures trading profits exceed the decline in asset value by $300,000 because the increase in futures rates is greater than in either loan or T-bill rates. In the second example the rate on a T-bill futures contract remains virtually unchanged, while in the cash market, T-bill interest rates fall 23 basis points and prime loan rates rise 25 basis points. If the futures rate had fallen with the cash T-bill rate, the bank would have suffered futures trading losses in addition to the decrease in the value of its loan portfolio. The hedging strategy developed here ignores the presence of basis risk. One point of these examples is to show that basis risk is important in determining futures trading profits or losses at a given time.

8. These guidelines were issued simultaneously by all three regulatory agencies in November 1979 and revised in March 1980. For national banks, see Banking Circular No. 79 issued by the Comptroller of the Currency. For Eleventh District state member banks, see Circular No. 80-61 issued by the Federal Reserve Bank of Dallas. For insured state nonmember banks, see Banking Letter No. 17-80 issued by the Federal Deposit Insurance Corporation. The article by Drabenstott and McDonley, "The Impact of Financial Futures on Agricultural Banks," contains an excellent overview and discussion of the guidelines and the regulatory issues.

Illustrations of the Hedging Strategy

On December 1, 1981, a hypothetical bank (described in the text) in the Eleventh Federal Reserve District has assets between \$100 million and \$500 million and knows the data in Table A. All variables are defined as in the text. By assumption, both assets L and T have term to maturity of 26 weeks, which is greater than the planning horizon. Therefore, the interest rate exposure faced by the bank is \$122 million. Also on that date, futures contracts for delivery of \$1 million in T-bills (face value), per contract in March 1982, are trading at an annual rate of 10.81 percent. The management of the bank is uncertain about the value of its loans and T-bills three months forward. To hedge against this risk, management decides to sell March T-bill futures.

Assuming a risk aversion index of 1×10^{-6} and a forecast that 13-week T-bill rates will be 12.49 percent three months forward (ER_T = an annual yield of 12.49 percent), equation 2 in the text and the data in Table A imply

$$X = -7{,}000{,}000 + \frac{(.1081 - .1249).25 - .0025(.1250)}{.000001(.00099)} - \frac{115{,}000{,}000(.00128) + .1100(237{,}000)}{.00099} = -\$187{,}000{,}000.$$

That is, the desired T-bill futures position is a liability position of value \$187 million. This position represents a hedge of approximately 153 percent of the bank's total interest rate risk. Unfortunately, a liability position of this size involves some short speculation, which violates current bank regulations for futures trading. Management would then implement the best strategy possible, given the regulatory constraint that the futures position represent a bona fide hedge—a 100-percent hedge of the bank's interest rate exposure. Initial margin of approximately \$300,000 would be required to sell 137 March T-bill futures contracts valued at \$122 million on December 1, 1981.

On March 1, 1982, the hypothetical bank's situation has changed as shown in Table A. Loan and T-bill assets with 13 weeks to maturity now have values of approximately \$119,142,000 and \$7,173,000, respectively. However, if interest rates had remained the same as on December 1, 1981, the current values of the assets would be \$119,360,000 and \$7,203,000. The interest rate rise over the three-month period lowered the value of bank loans and T-bills by \$248,000 altogether. This loss in asset value is more than offset by a gain of \$548,000 [= (.1241 − .1081) .25(\$137,000,000)] from the T-bill futures position, before return of the margin deposit. The bank's profits increase \$300,000 as a result of T-bill hedging.

For an example of a hedge of less than 100 percent

Table A
BANK DATA FOR FIRST EXAMPLE

Variable	Values: Dec. 1, 1981	Values: March 1, 1982	Variable	Values, Dec. 1, 1981
L	\$115,000,000	\$119,142,000	$cov(R_T,R_L)$ . . .	.00128
R_L . . .	15.75% *	16.50% *	$var(R_T)$	.00099
T	\$7,000,000	\$7,173,000	R_B	12.50%
R_T . . .	10.93% *	12.49% *	$(R_B - R_D)$ . . .	11.00%
R_X . . .	10.81% *	12.41% *	$cov(R_T,D)$ . . .	\$237,000

* Annualized yield.

of a hypothetical bank's interest rate exposure, take the following situation from the simulation. On December 1, 1977, an Eleventh District bank with assets of less than $100 million knows the data in Table B. The interest rate exposure faced by the bank is $14 million.

Again, assuming a risk aversion index of 1×10^{-6} and a forecast that 13-week T-bill rates will be 6.15 percent three months forward (ER_T = an annual yield of 6.15 percent), equation 2 in the text and the data in Table B imply

$$X = -1{,}000{,}000 + \frac{(.0648 - .0615).25 - .0025(.0686)}{.000001(.00017)} - \frac{13{,}000{,}000(.00020) - .0526(1{,}000)}{.00017} = -\$12{,}000{,}000.$$

That is, the desired T-bill futures position is a hedge of value $12 million. In this case the futures position represents a hedge of approximately 86 percent of the bank's total interest rate risk. Initial margin of approximately $30,000 would be required to open this futures position.

On March 1, 1978, the bank's situation has changed as shown in Table B. Loan and T-bill assets with 13 weeks to maturity now have values of approximately $13,239,000 and $1,016,300, respectively. If interest rates had remained the same as on December 1, 1977, the current values of the assets would be $13,247,000 and $1,015,700. The rise in the prime lending rate over the three-month period lowered the value of bank loans by $8,000, while the fall in the T-bill rate raised the value of T-bill securities by $600. The net effect is a decrease of $7,400 in asset value. In this case the loss in asset value is not offset by a gain from the futures hedging strategy. The T-bill futures position returns $300 [= (.0649 − .0648).25($12,000,000)], excluding the margin deposit. Bank profits decrease $7,100 over the period. Hence, the hedging strategy did not protect the bank from contrasting movements in the prime and T-bill interest rates.

These results, it should be noted, are dependent on the specific nature of the bank's hypothesized balance sheet and interest rate exposure. An alternative mechanism for forecasting interest rates, a different risk aversion index, or a different mix of loan and T-bill assets would give different results.

Table B
BANK DATA FOR SECOND EXAMPLE

Variable	Values: Dec. 1, 1977	Values: March 1, 1978	Variable	Values, Dec. 1, 1977
L	$13,000,000	$13,239,000	$cov(R_T, R_L)$	.00020
R_L	7.75%*	8.00%*	$var(R_T)$	.00017
T	$1,000,000	$1,016,300	R_B	6.86%
R_T	6.38%*	6.15%*	$(R_B - R_D)$	5.26%
R_X	6.48%*	6.49%*	$cov(R_T, D)$	$1,000

* Annualized yield.

rate exposure of the overall balance sheet. In the model, this governmental restriction can be captured by limiting the position in the T-bill futures market to be no greater in absolute value than the interest rate exposure of the bank. This is called macro hedging and does not preclude the possibility that the T-bill futures position is a partial hedge (less than 100 percent) of the bank's interest rate exposure.

The banker's problem is to choose the optimal portfolio of loans and T-bills and the optimal futures market position. Solving the constrained optimization problem outlined in this section provides the solution for the hypothetical bank. The solution requires some additional, technical assumptions and some mathematical manipulations, both of which are described in the Appendix.

The optimal portfolio

The model produces explicit solutions for the optimal values of the three decision variables: loans (L), T-bills (T), and the futures market position (X). The third variable will be negative when the bank takes a short position in the futures market (agrees to sell T-bills for delivery three months hence) and positive when the bank takes a long position (agrees to buy T-bills for delivery three months hence). Because the end-of-period value of the bank's liabilities is independent of changes in interest rates, the exposure to interest rate risk is $(T + L)$. Thus, the regulators' rule that futures trading reduce exposure to interest rate risk requires that the bank take a short position no larger than the sum of T-bill holdings and loans outstanding; or

$$(1a) \qquad -(T + L) \leqslant X,$$

and

$$(1b) \qquad X \leqslant 0.$$

The optimal amount of Treasury bills can be shown to be independent of the other two choice variables.[9] In general, the T-bill investment decision depends on the 26-week T-bill interest rate, the T-bill futures contract interest rate, the interest rate on sold or purchased funds, and the marginal resource cost of making T-bill investments. The sizes of the optimal T-bill futures position and the optimal loan portfolio are interdependent. They can be expressed as

$$(2) \qquad X^* = -T^* - \frac{L^* \operatorname{cov}(R_T,R_L)}{\operatorname{var}(R_T)} + \frac{(R_B - R_D)\operatorname{cov}(R_T,D)}{\operatorname{var}(R_T)} + \frac{R_X - ER_T - hR_B}{c \operatorname{var}(R_T)}$$

and

$$(3) \qquad L^* = \frac{-(T^* + X^*)\operatorname{cov}(R_T,R_L)}{\operatorname{var}(R_L)} + \frac{(R_B - R_D)\operatorname{cov}(R_L,D)}{\operatorname{var}(R_L)} + \frac{R_L - ER_L - R_B - f_L'}{c \operatorname{var}(R_L)}.$$

A glossary of the symbols is provided in Table 1. After the optimal investment in T-bills, T^*, is determined, equations 2 and 3 must be solved simultaneously to determine X^* and L^*.

Equation 2 indicates the conditions under which the regulatory constraint in expression 1a is binding. The hypothetical bank will fully hedge its interest rate exposure if, first, $[\operatorname{cov}(R_T,R_L)/\operatorname{var}(R_T)] \geqslant 1$; second, $\operatorname{cov}(R_T,D) \leqslant 0$ and $(R_B - R_D) > 0$; and third, $(R_X - ER_T) \leqslant 0$. Empirically, the first two conditions are usually met. The third condition depends on interest rate expectations. The first condition implies that the bank would choose to hedge more than 100 percent of its interest rate exposure, $[-X^* \geqslant (T^* + L^*)]$, if the last two terms in equation 2 were negative and the regulators allowed short speculation. The second and third conditions reinforce the pressure to increase the short position (recall that X must be negative).

Only if the banker expects lower interest rates than the T-bill futures market expects ($R_X - ER_T >$ 0) will he be inclined to hedge less than his entire interest rate exposure. If such expectations were realized, hedging in the futures market would result in trading losses that would offset the rise in the value of bank loans and T-bill investments. The extent to which expectations about future interest rates affect the strategy depends heavily on the banker's taste for risk. If he is highly risk-averse (c is large), the last term in equation 2 will be small in

9. The mathematics of the banking model used here is outlined in the appendix to this article. A more detailed derivation of the T-bill investment decision is found there.

Table 1
VARIABLES USED IN THE MODEL OF THE BANKING FIRM

X^* =	dollar value of the optimal T-bill futures position.
T^* =	dollar value of the optimal investment in 26-week T-bills.
L^* =	dollar value of optimal loans made.
$cov(R_T,R_L)$ =	covariance between the interest rate on T-bill securities and the interest rate on loans.
$var(R_T)$ =	variance of the interest rate on 13-week T-bills.
R_B =	interest rate on sold or purchased funds.
R_D =	interest rate payable on deposits.
$cov(R_T,D)$ =	covariance between the interest rate on T-bill securities and the level of deposits.
R_X =	interest rate on the T-bill futures contract three months before maturity.
ER_T =	three-month forecast of the interest rate on 13-week T-bills.
h =	per-dollar margin requirement, $0 > h > 1$.
c =	constant absolute risk aversion (CARA) parameter, $c > 0$.
$var(R_L)$ =	variance of the interest rate on 13-week prime bank loans.
$cov(R_L,D)$ =	covariance between the interest rate on loans and the level of deposits.
R_L =	interest rate on 26-week prime bank loans.
ER_L =	three-month forecast of the interest rate on 13-week prime bank loans.
f_L' =	marginal resource cost of servicing bank loans.

absolute value, and the forecast will have little influence. On the other hand, if c is small and ER_T is sufficiently below R_X, then the banker might refrain entirely from hedging and, in the absence of the constraint imposed by expression 1b, even wish to engage in some long speculation.

The tendency to be at or near the point where $[X^* = -(T^* + L^*)]$ implies that the hedge will vary directly with the exposure to interest rate risk. From the first two terms on the right side of equation 2, greater T-bill investments, ΔT^*, increase the futures hedge by $(\Delta X^* = -\Delta T^*)$, but greater loans, ΔL^*, increase the hedge by $[-\Delta X^* = \Delta L^* \, cov(R_T,R_L)/var(R_T) > \Delta L^*]$ if equality does not hold in expression 1a. When the covariance-variance ratio exceeds 1, T-bill interest rate changes are associated with changes in loan rates in the same direction and of greater magnitude. If equality does hold in (1a), $-\Delta X^*$ equals ΔL^*.

The third term on the right side of equation 2 shows that if the bank is susceptible to disintermediation, its futures strategy also depends on the current level of interest rates. As market rates rise, D declines by an amount indicated by $cov(R_T,D)$, and the bank must then purchase relatively high cost funds (at rate R_B) to support its assets. The bank can protect against this squeeze on profits by increasing its short position in the futures market, locking in the known interest rate on assets. The greater the sensitivity of deposit flows to market rates, $cov(R_T,D)$, the stronger the pressure to hedge.

Turn next to the optimal loan decision, described by equation 3. The first term on the right side of equation 3 shows that the optimal loan portfolio depends on $(T^* + X^*)$. If X^* is less than $-T^*$ (if the T-bill futures position hedges more than 100 percent of the bank's T-bill investments), optimal bank loans are larger than either the situation of no futures trading $(X^* = 0)$ or 100-percent hedging of T-bill investments $(X^* = -T^*)$. When no futures trading is undertaken, T-bills serve as a substitute for loans since their interest rates are positively correlated. A short T-bill futures position greater in absolute value than T-bill investments allows more loans to be made because the futures position covers the extra interest rate exposure.

Table 2
SIMULATION PARAMETERS FOR THE HEDGING STRATEGY, BY BANK ASSET SIZE
Eleventh Federal Reserve District

Parameter	Bank asset sizes (Total assets, *millions* of dollars)			
	$1,000 and over	$500 to $1,000	$100 to $500	Less than $100
	Means for June 1976–December 1981 period			
$T/(T + L)$	.038	.064	.059	.061
$cov(R_T, R_L)$	.00128	.00128	.00128	.00128
$var(R_T)$	.00099	.00099	.00099	.00099
$SD/(SD + DD)$	.107	.176	.206	.236
R_D	.006	.011	.013	.016
$cov(R_T, D)$	-$1,499,000	-$1,018,000	-$237,000	$77,000

Definitions

$T/(T + L)$ = T-bill investments as a percentage of T-bill investments and loans.

$cov(R_T, R_L)$ = covariance between the monthly average prime rate for short-term loans and the monthly average auction rate for 13-week T-bills. Recalculated for each hedging period, using only past data.

$var(R_T)$ = variance of the monthly average auction rate for 13-week T-bills. Recalculated for each hedging period, using only past data.

$SD/(SD + DD)$ = savings deposits as a percentage of savings and demand deposits.

R_D = interest rate on savings deposits multiplied by $SD/(SD + DD)$. (Because of Regulation Q restrictions, demand deposits paid zero interest over the sample period.)

$cov(R_T, D)$ = covariance between the monthly average auction rate for 13-week T-bills and the level of savings and demand deposits. Recalculated for each hedging period, using only past data.

SOURCE OF PRIMARY DATA: Board of Governors, Federal Reserve System.

The second term on the right side of equation 3 reveals that disintermediation, in addition to its effect on the futures position, exerts downward pressure on lending. A negative correlation between deposit flows and interest rates on loans implies that as interest rates rise and deposits flow out, the bank must turn to the purchase of more expensive funds to finance its assets. This action only exacerbates the negative gap problem. The model indicates that to compensate, the bank should make fewer long-term loans, narrowing the gap between interest-insensitive assets and interest-sensitive liabilities. The more severe the disintermediation, the greater the downward pressure on lending.

Finally, the third term on the right side of equation 3 captures the role of expectations and risk aversion in the optimal loan portfolio decision. This term illustrates that the lower the expected interest rate on 13-week prime bank loans, ER_L, the greater the value of loans made at the beginning of the planning horizon. As with the T-bill futures position, the greater is the aversion to interest rate risk, c, the less important is the ability to forecast loan interest rates in the loan decision.

The hedging simulation

To simulate the T-bill hedging strategy suggested by the model of the banking firm, observations for each of the elements on the right side of equation 2 must be collected. The purpose here is not to perform a complete simulation of all bank decisions in the model but to calculate the optimal T-bill futures position, assuming the other decisions are given.

In the preceding section, it is contended that the T-bill investment decision can be separated from the other portfolio decisions. Theoretically, the T-bill futures and loan decisions cannot be separated unless $\mathrm{cov}(R_T,R_L)$ equals zero, which is implausible. However, in the interest of simplicity, the simulation assumes the optimal loan level is predetermined. This assumption allows the calculation of an optimal T-bill futures position based on existing data for bank loans and investments, although the resulting X^* may not be sufficient for maximizing the expected utility of bank profits.

The simulation covers the period from June 1976 to December 1981. Trading in T-bill futures contracts began in January 1976 at the International Monetary Market of the Chicago Mercantile Exchange. Currently, contracts mature in the months of March, June, September, and December. Since the model here assumes a three-month planning horizon and futures contract maturity at the end of the planning period, futures market interest rates were collected for the first day of contract maturity and for the first day of the month 90 days before maturity. The latter quotes are used for establishing the interest rates at which futures trading is initiated (R_X in equation 2), and the former are used for computing actual trading returns when the position is closed out. As a result, the sample period contains 23 nonoverlapping opportunities for hedging.

The dollar values of loans, T-bill investments, and deposits over the period for banks in the Eleventh Federal Reserve District were taken from report-of-condition data gathered by the Federal Reserve Bank of Dallas and published by the Board of Governors of the Federal Reserve System. All member banks in the District were sorted according to the size of their total assets: (1) $1 billion and over, (2) $500 million to $1 billion, (3) $100 million to $500 million, or (4) less than $100 million. The limits of the four categories were determined arbitrarily and were not set to equalize the numbers of banks in the subsets.[10] Bank averages for T-bill investments, loans, and Regulation Q deposits were then computed at each of the 23 simulation points to capture representative aspects of firms in each subset. Table 2 presents the distinguishing characteristics of the average bank in each size category.

Risk aversion and expectations

Two elements of equation 2 remain to be specified. The first is the index of constant absolute risk aversion, c. This parameter influences the size and type (buy or sell) of futures position calculated at each decision point. For the entire simulation period and for each category of bank size, the index of constant absolute risk aversion is arbitrarily given as 1×10^{-6}. This number was chosen after performing a sensitivity analysis of the simulation results, using values of c between 1×10^{-1} and 1×10^{-8}. The parameter value 1×10^{-6} was selected because larger values yielded uninteresting differences across bank sizes and smaller values led to improbable simulation results.

10. The number of banks in each subset varied over the simulation because of asset-size changes and changes in reporting procedures.

Table 3
SIMULATION RESULTS FOR MACRO HEDGING
$[0 \geqslant X^* \geqslant -(T^* + L^*)]$
Eleventh Federal Reserve District

Bank asset size (total assets, millions of dollars) and type of T-bill forecast	Hedging ratio	Hedging effec-tiveness	Futures market return	Margin require-ment
			Millions of dollars	
	Means for June 1976–December 1981 period			
$1,000 and over				
Futures forecast . . .	-.998	.808	$3.652*	$3.756
	(.007)	(.054)	(36.655)	(.536)
Perfect forecast . . .	-.999	.808	3.664*	3.759
	(.005)	(.054)	(36.659)	(.537)
$500 to $1,000				
Futures forecast . . .	-.849	.746	.136*	.770
	(.155)	(.104)	(6.359)	(.144)
Perfect forecast . . .	-.873	.729	.915*	.791
	(.135)	(.115)	(5.767)	(.124)
$100 to $500				
Futures forecast . . .	-.977	.826	.241*	.287
	(.040)	(.059)	(2.401)	(.015)
Perfect forecast . . .	-.910	.768	.743*	.268
	(.212)	(.163)	(1.725)	(.064)
Less than $100				
Futures forecast . . .	-1.000	.715	.069*	.045
	(.000)	(.043)	(.432)	(.011)
Perfect forecast . . .	-.772	.546	.177*	.036
	(.374)	(.261)	(.255)	(.020)

* Not significantly different from zero at the 5-percent level.
NOTE: Figures in parentheses are standard deviations of the sample.
SOURCES OF PRIMARY DATA: Board of Governors, Federal Reserve System.
International Monetary Market Yearbook.

The last variable to be specified is ER_T, the three-month forecast of the 13-week T-bill rate. Two alternative forecasts are studied.[11] It is first assumed that bank decisionmakers consider no interest rate forecast other than the interest rate expected by the T-bill futures market. That is, at the initiation of the trading program, the interest rate in the current T-bill futures quote is taken to be the current expected rate. Banks without economic research or forecasting units may be able to use the T-bill futures market as an expectations-generating mechanism; therefore, T-bill futures interest rates merit consideration as forecasts in a futures hedging strategy.

The second type of forecast used in the hedging simulation is the actual T-bill rate at the end of the planning period. This amounts to assuming that bank management can forecast T-bill interest rates perfectly. The hedging simulation results using a perfect interest rate forecast will serve as a performance standard for evaluating the futures market forecast. Furthermore, using a perfect forecast in the simulation serves as a proxy for all possible regression and time series models capable of predicting three-month T-bill interest rates.

Simulation results

Table 3 shows the simulation results for the macro hedging strategy. Sample means and standard deviations are calculated for the 23 futures positions taken from June 1976 to December 1981 for each bank size and type of T-bill forecast used. The hedging ratio is defined as $X^*/(T^* + L^*)$ and indicates the percentage of total interest rate exposure hedged in the T-bill futures market. Hedging effectiveness is calculated as the percentage reduction in the variance of unhedged profits resulting from implementation of the T-bill hedging strategy. The gross T-bill futures market return, excluding the repayment of initial margin at the end of the decision period, has been computed for each hedging strategy. In the last column of the table is an indication of the costs of implementing the strategies. Initial margins may tend to understate hedging costs because actual margin requirements over the hedging period usually include maintenance margin deposits. Initial margins are set at 0.25 percent of position value, which is approximately the Chicago Mercantile Exchange minimum.

Table 3 shows the average hedging ratios to be between 75 and 99 percent, depending on bank size. But for virtually all banks with less than $1 billion in assets and for both types of forecasts, the ratios are significantly different from -1 at the 5-percent level. This implies that, on average, such banks seek only a partial hedge of their interest rate exposure. They prefer to bear part of the interest rate risk themselves when T-bill interest rates are expected to fall during the planning period or when the current T-bill rate is low and intermediation is expected. The extent to which the former causes different partial hedges across bank sizes also depends on the amount of interest rate exposure facing the bank relative to the common risk aversion index assumed for all banks.

Turning to the results within each bank size category, a hedging strategy using a futures market forecast yields greater hedging effectiveness than hedging with the other forecast. When a futures market forecast is used, the futures position tends toward a 100-percent hedge of interest rate exposure because R_X less ER_T equals zero in equation 2. This tendency is reinforced the greater the aversion to interest rate risk. Hedging with a perfect forecast yields more selective position taking, which is more profitable but also reduces the variance of profits less.

Finally, for the largest banks the hedging ratio and hedging effectiveness measures seem to be independent of the type of forecast used, while the results for the smallest banks are quite dependent on the type of forecast used. The explanation lies in the assumption of equal risk aversion across all bank sizes. For the largest banks, interest rate exposure $(T^* + L^*)$ is too large to be affected by different forecasts, given a common risk aversion index of 1×10^{-6}. Hedging results would be less independent of the type of forecast used at smaller values

11. The simulation was also conducted using forward T-bill interest rates as expected rates. The results with forward rates as forecasts were more similar to the results with perfect forecasts than the results with futures rates as forecasts. For further discussion on a comparison between forward and futures interest rates as expectations, see William Poole, "Using T-Bill Futures to Gauge Interest-Rate Expectations," *Economic Review*, Federal Reserve Bank of San Francisco, Spring 1978, 7–19, and Richard W. Lang and Robert H. Rasche, "A Comparison of Yields on Futures Contracts and Implied Forward Rates," *Review*, Federal Reserve Bank of St. Louis, December 1978, 21–30

Table 4
SIMULATION RESULTS FOR MICRO HEDGING
$(0 > X^* > -T^*)$
Eleventh Federal Reserve District

Bank asset size (total assets, millions of dollars) and type of T-bill forecast	Hedging ratio	Hedging effectiveness	Futures market return	Margin requirement
			Millions of dollars	
	Means for June 1976–December 1981 period			
$1,000 and over				
Futures forecast . . .	–.038	.055	$0.026*	$0.139
	(.022)	(.030)	(1.176)	(.072)
Perfect forecast . . .	–.038	.055	.026*	.139
	(.022)	(.030)	(1.176)	(.072)
$500 to $1,000				
Futures forecast . . .	–.065	.106	.033*	.059
	(.022)	(.027)	(.397)	(.020)
Perfect forecast . . .	–.065	.106	.033*	.059
	(.022)	(.027)	(.397)	(.020)
$100 to $500				
Futures forecast . . .	–.059	.093	.013*	.017
	(.011)	(.012)	(.129)	(.003)
Perfect forecast . . .	–.058	.092	.020*	.017
	(.013)	(.015)	(.116)	(.004)
Less than $100				
Futures forecast . . .	–.066	.071	.005*	.003
	(.009)	(.018)	(.030)	(.001)
Perfect forecast . . .	–.051	.052	.012	.002
	(.025)	(.030)	(.019)	(.001)

* Not significantly different from zero at the 5-percent level.
NOTE: Figures in parentheses are standard deviations of the sample.
SOURCES OF PRIMARY DATA: Board of Governors, Federal Reserve System.
International Monetary Market Yearbook.

of the risk aversion index, indicating less risk aversion. For the smallest banks the interest rate exposure is small enough to yield widely varying results depending on the forecast used. Modeling differential aversion to risk, such that small banks are more risk-averse and large banks are less risk-averse, could help equalize hedging effectiveness across bank sizes, given an interest rate forecast.

Table 4 shows the simulation results for the micro hedging strategy. All variables are defined the same as in Table 3. The largest category of banks has the smallest hedging ratios and the smallest hedging effectiveness of the four bank sizes considered. This result can be explained by realizing that a micro hedging strategy restricts the largest banks to a futures position proportionately smaller than for the other banks because T-bill investments are a proportionately smaller part of their assets. Furthermore, these results may overestimate the benefits of micro hedging by the largest banks because they may make more variable-rate loans than smaller banks, contrary to the simulation assumption that $(T^* + L^*)$ is the measure of interest rate exposure for all banks. Another result from Table 4 is that the futures positions for the three largest bank sizes are virtually independent of the type of forecast used in micro hedging. For these banks, management of the total gap calls for futures positions greater than the constraint imposed by micro hedging at this level of risk aversion, regardless of the forecast.

Conclusions

The practical applicability of the results here depends on the assumptions of the underlying model, as well as several assumptions specific to the simulation itself. Bank investments certainly include Government securities other than 26-week T-bills, creating an opportunity for futures trading in T-notes and T-bonds, along with T-bills. For simplicity, however, these alternative investments were not modeled into the bank's decision problem. To do so would lead to an integrated micro hedging strategy with possibly differing results. Also, to the extent that bank loans may have a term to maturity of less than six months or carry variable interest rates, using the sum of T-bill investments and loans as a measure of interest rate exposure overstates the true gap requiring management. As a result, hedging ratios and hedging effectiveness in the simulation would be biased upward. Finally, this investigation could have focused on futures hedging to extend the maturity of the liability side of the balance sheet, instead of hedging to shorten the maturity of assets.

As for the simulation itself, one objectionable assumption concerns equal risk aversion indexes across all four sizes of banks. It is likely that smaller banks are more risk-averse than larger ones. Assuming equal risk aversion across bank sizes understates the results for smaller banks or overstates the results for larger banks.

Another qualification to the simulation results is that cash market transactions to balance the term to maturity of assets and liabilities are ignored. In the model of bank behavior, an optimal solution to the problem requires that decisions on lending and the T-bill futures position be made simultaneously. A change in risk aversion or expected interest rates will cause a change in the bank's interest rate exposure by changing the quantity of loans made as well as changing the T-bill futures position. Cash market alternatives to futures hedging do exist, and to ignore them tends to bias the hedging ratios upward. To the extent that the gap between asset and liability maturities does vary across different bank sizes, smaller banks with more illiquid loan portfolios may, in practice, gain more from futures trading than other banks, even though the simulation suggests the opposite.

In summary, this paper estimates that simulated banks are capable of reducing up to 80 percent of the variability of stylized profits by using the macro T-bill hedging strategy discussed above, without adjusting bank assets through cash market transactions. A micro hedging strategy was shown to be even less expensive at the cost of achieving a reduction of only 10 percent in the variability of profits. These results depend on the quality of the interest rate forecast used, as well as management's willingness to accept interest rate risk. The hedging strategy presented here need not reduce the variability of profits if the bank's interest rate forecasts are systematically wrong or management has a low aversion to risk.

Since margin requirements are not extensive and the benefits from futures trading appear to be substantial, why are banks staying out of interest rate futures markets? The answer must be found in either a lack of knowledge about the elements of a futures hedging strategy or the relative cost-effectiveness of alternative methods of restructuring bank balance sheets. This research can only help alleviate the former problem.

Appendix

The Mathematics of the Bank Model

Let the bank's balance sheet constraint be given by

(A.1) $$L + T - hX = B + D,$$

where L, T, h, and X are defined as in Table 1 and

B = the purchase ($B > 0$) or sale ($B < 0$) of funds with a term to maturity of 90 days

D = Regulation Q demand and savings deposits.

Uses of funds are on the right side of equation A.1, and sources of funds are on the left side.

At the end of the 90-day planning horizon, the profits of the bank, W, are given by

(A.2) $$W = \Delta R_L L + \Delta R_T T + \Delta R_X X - R_B B - R_D D - f(L,T),$$

where the variables not previously defined are:

ΔR_L = change in the interest rate on loans over the planning period

ΔR_T = change in the interest rate on T-bill securities over the planning period

ΔR_X = change in the interest rate on the T-bill futures contract over the planning period

$f(L,T)$ = resource cost of servicing loan and T-bill assets, $f_1 > 0$, $f_2 > 0$, $f_{1,1} > 0$, $f_{2,2} > 0$, $f_{1,2} = f_{2,1} = 0$.

The bank's objective is

(A.3) $$\underset{L,T,X}{\text{maximize}}\ E\left[\underset{B}{\text{maximize}}\ U(W)\right], \quad L>0,\ T>0,\ X<0,$$

subject to equation A.1, with E being the expectations operator and $U(W)$ being the risk-averse utility function of bank management ($U' > 0$, $U'' < 0$).

The bank's problem is to choose L, T, and X before the random deposit flow, D, is known. After L, T, and X are set, D is revealed and no decisions are made until the end of the planning period. Funds are purchased or sold, B, to balance assets and liabilities.

After substituting for B in W from the balance sheet constraint, the problem can be rewritten in terms of three decision variables: L, T, and X. The first-order conditions for the rewritten problem are:

(A.4) $$EU'(W)(\Delta R_L - R_B - f_1) = 0.$$

(A.5) $$EU'(W)(\Delta R_T - R_B - f_2) = 0.$$

(A.6) $$EU'(W)(\Delta R_X - hR_B) = 0.$$

Together, equations A.5 and A.6 imply

(A.7) $$R_T - R_X - R_B + hR_B = f_2.$$

Since ΔR_T is the 26-week T-bill rate less the 13-week T-bill rate and ΔR_X is the T-bill futures rate three months before maturity less the 13-week T-bill rate, equation A.7 determines the optimal T-bill securities investment independent of the other two variables, L and X.

To obtain the result in equation 2 in the text, suppose bank management is constant absolute risk-averse and that the random variables are jointly distributed as multivariate normal random variables. Note that (1) $E(AZ)$ equals $[EAEZ + \text{cov}(A,Z)]$; (2) $\text{cov}[U'(A),Z]$ equals $EU''\ \text{cov}(A,Z)$ if A and Z are multivariate normal; and (3) the constant absolute risk aversion index, c, equals $-U''/U'$. Constant absolute risk aversion implies that favorable odds are required before accepting a risky gamble of fixed absolute size and that those favorable odds do not change as wealth changes. The only known function exhibiting the CARA property is the negative exponential, $-\exp[-c(W)]$, where c is the index of constant absolute risk aversion. Using the three relations just enumerated, equations A.6 and A.4 can be rewritten as equations 2 and 3, respectively.

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