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row money or, alternatively, to lend money (make deposits). If local deposit-market competition is the dominant influence, then internal characteristics of the credit union won't matter at all. This study tests the sponsor-control, the member-control, and the market-control hypotheses against each other using a large sample of occupational credit unions observed in 1997. Our results suggest that sponsors exercise effective control over occupational credit unions.

Erratum

The article, "The Information Content of Treasury Inflation-Indexed Securities," published in the November/December 2000 issue of *Review* contained an error regarding the tax treatment of adjustments to the principal of the Treasury inflation-indexed securities (TIIS). The article incorrectly stated (on pp. 29 and 36 and in Tables 3 and 4, pp. 31-32) that adjustments to principal of TIIS are taxable at capital-gains rates. Instead, these adjustments are taxable at ordinary-income rates. Thus, all of the income in the examples used in Tables 3 and 4 is taxed as ordinary income. A corrected version of the article can be found on our Web site, < http://www.stls.frb.org/publications/review/review00.html#NOV > .

The Rise and Fall of a Policy Rule: Monetarism at the St. Louis Fed, 1968-1986

R. W. Hafer and David C. Wheelock

> "Once the quantity theory regained academic respectability, it was obliged to resume responsibility for the short-run forecasting of aggregate movements of prices and quantities . . . This it has begun to do, most importantly through the research work of the Federal Reserve Bank of St. Louis, and with appreciable success; but it has been lured into playing in a new ballpark, and playing according to a different set of rules than it initially established for itself . . . [I]ts own success is likely to be transitory, precisely because it has relied on the same mechanisms of intellectual conquest as the [Keynesian] revolution itself . . . and has also espoused a methodology that has put it in conflict with long-run trends in the development of the subject."—Harry Johnson (1971, pp. 12-13)

Macroeconomists today generally agree that monetary policy cannot permanently increase the rate of economic growth above its potential or decrease the rate of unemployment below its market clearing, or "natural," level (e.g., De Long, 2000; Woodford, forthcoming). In the long run, monetary policy affects only the rate of inflation, and many economists argue that monetary policy can best promote maximum sustainable economic growth by ensuring price level stability (e.g., Barro, 1996). Monetary policymaking, however, both in the United States and elsewhere, is often concerned with the *short-run*. Policymakers meet frequently: the Federal Reserve's Open Market Committee (FOMC) meets eight times a year, for example, and a vote is taken at each meeting on whether to maintain or change the current stance of policy. While price stability is widely acknowledged as the appropriate long-run objective of monetary policy, many economists argue that policymakers should respond to fluctuations in real output or employment as part of their strategy to achieve price stability and, ultimately, to support maximum sustainable economic growth.[1]

To help guide them in their deliberations, policymakers and their economic advisors rely on both complex economic and econometric models and on simple rules-of-thumb based on empirical regularities observed in macroeconomic data. Indeed, simple rules, such as the so-called Taylor rule (Taylor, 1993), which describes the response of the federal funds rate to past deviations of inflation and output from target values, often appear to explain well how policymakers set policy in the short-run. Economists generally conclude that rules-based policies are preferable to those relying solely on the discretion of policymakers. The transparency of rules reduces uncertainty about the responsiveness of policy to economic change and can enhance the accountability of policymakers.

Monetarists have long advocated the use of rules to guide monetary policy, with Friedman's (1960) proposal for a constant money stock growth rate being the most famous example. At the time it was made, Friedman's proposal was sharply at odds with the prevailing mainstream view that monetary policy was best conducted by manipulating interest rates to strike a balance between inflation and unemployment. At the time, economists widely believed in the power of activist monetary and, especially, fiscal policy to limit fluctuations in economic activity and to ensure sufficient demand to provide full employment economic growth over extended periods. Friedman's "monetarist" policy rule thus attracted considerable attention. Moreover, a growing body of empirical work by Friedman and others showing the potential for money supply shocks to have large short-run impacts on output and employ-

R. W. Hafer is a professor of economics and finance, and Director, Office of Economic Education and Business Research, Southern Illinois University Edwardsville. David C. Wheelock is an assistant vice president and economist at the Federal Reserve Bank of St. Louis. Heidi L. Beyer provided research assistance. The authors thank Anatol Balbach, Rachel Balbach, Michael Bordo, Keith Carlson, Brad DeLong, Bill Dewald, Jerry Dwyer, Milton Friedman, Gail Heyne Hafer, Joe Haslag, Bob Hetzel, Ali Kutan, Thomas Mayer, and Anna Schwartz for comments on an earlier draft. The authors also thank Gloria Valentine of the Hoover Institution for her assistance with the Friedman papers.

[1] For a recent argument along these lines, see Mishkin (2000) and the references cited therein.

ment led to the development of an alternative framework for conducting stabilization policy based on targeting growth of the money stock.

The Federal Reserve Bank of St. Louis played an important and highly visible role in the development and advocacy of stabilization policy based on the targeting of monetary aggregates. This article examines the development of the monetarist-based stabilization policy framework advocated by the St. Louis Bank between the late 1960s and the 1980s, with an eye toward identifying lessons from that experience for the conduct of stabilization policy in general.[2]

This article also illustrates how the Federal Reserve System's decentralized structure fosters a climate of internal debate. Beginning in the 1960s, the monetary policy actions advocated by the St. Louis Bank in its research publications, in public forums, and in the participation of the Bank's presidents in policy meetings often were sharply at odds with the policies adopted by the Federal Reserve System. The Fed's decentralized structure permitted the development of alternative policy views and the exploration of new ideas within the System (Wheelock, 2000). Policy debates often took place within System publications. We describe the public debate as we trace the evolution of the St. Louis Fed's monetarist policy, and the criticism of that policy by other Fed officials, in the Federal Reserve Bank of St. Louis *Review*, other System publications, and in the public speeches of Darryl Francis, President of the Federal Reserve Bank of St. Louis from 1966 to 1976.

To provide a backdrop to our discussion, the next section summarizes the dominant policy positions taken by economists during the 1960s and early 1970s about the causes of inflation and the role of monetary policy. We point out key issues where monetarists disagreed with the conventional wisdom. In the subsequent two sections we review the research and policy positions taken by St. Louis Fed economists and officials from the 1960s through the early 1980s. We limit our discussion mainly to the period 1968-86. In 1968, the Federal Reserve Bank of St. Louis published an econometric analysis of the relative impacts of monetary and fiscal policy on economic activity. That article, by Andersen and Jordan (1968), became one of the most cited papers in economics in the past 40 years. In 1970, the Bank published the first version of its monetarist model for gauging the impact of monetary policy actions on economic activity (Andersen and Carlson, 1970). The year 1986 marked the appearance of the final version of that model (Carlson, 1986). We show how research conducted at the Federal Reserve Bank of St. Louis extended earlier monetarist analysis that had focused on the role of money in explaining economic activity in the long run. Their success in finding apparently robust, stable relationships in both long- and short-run data led monetarists to apply long-run propositions to short-run policy questions, effectively competing with alternative views of the time. When the short-run correlation between money and economic activity went astray in the early 1980s, however, the efficacy of the monetarist rule and appeals for targeting monetary aggregates to achieve economic stabilization quickly lost credibility.

THE SETTING: FINE-TUNING THE ECONOMY

The 1960s were the glory days of activist, short-run stabilization policy. Policymakers had confidence in their ability to achieve full employment using fiscal and monetary policy to "fine tune" or manage aggregate demand. For a time, their confidence seemed justified: Before the present expansion, the 1960s witnessed the longest uninterrupted expansion in U.S. history, with the economy operating at full employment (defined then as a civilian unemployment rate of 4 percent or less) from 1966 to 1969.

Beginning in 1965, however, rising inflation and an increasing balance of payments deficit reflected the cost of expansionary macroeconomic policies. Policymakers felt increasing pressure to control inflation but were hesitant to take actions that might reduce employment and real output growth. Because policymaking was viewed as striking a balance between inflation and unemployment, disagreements about policy, according to one Fed governor, boiled down to one's preferences between the two outcomes.[3] Because unemployment frequently was viewed as a more

[2] The defining characteristics, technical aspects, and legacy of monetarism in general have been explored elsewhere, e.g., DeLong (2000), Melzter (1998), Rasche (1993), and Woodford (forthcoming).

[3] Governor Sherman Maisel argued at an FOMC meeting on October 20, 1970, "that at least some of the Committee's differences on policy reflected difference in basic value judgments regarding the relative importance of various conflicting goals—for example, regarding the appropriate trade-off between employment and price stability" (FOMC *Minutes*, October 20, 1970, p. 41).

serious concern than inflation, for many years the Fed opted for maintaining an inflationary bias in monetary policy to avoid higher rates of unemployment. Fed officials, like other government officials, argued that the inflation-unemployment tradeoff could be improved only through the cooperation of business and labor in the setting of prices and wages or, if necessary, by the use of anti-trust and other polices to make price setting more competitive. Alternatively, inflation could be controlled through explicit regulation of wages and prices

Juxtaposed against this mainstream view was an alternative associated with the work of Milton Friedman, Anna Schwartz, Karl Brunner, Allan Meltzer, and other so-called monetarists. Monetarism was rooted in the Quantity Theory of Money. The core of the Quantity Theory is that, in the long run, inflation reflects excessive growth of the money stock relative to real output growth, the latter determined fundamentally by non-monetary forces such as population growth and productivity. An important component of this position is the stability of the public's demand for money. Monetarists amassed empirical evidence showing the demand for money to be more stable than money supply or, equivalently, that velocity is stable.[4] Stability of velocity supported monetarists' view that short-run fluctuations in economic activity often are caused by fluctuations in money supply growth—fluctuations brought about by central bank policy actions.[5] Monetarists concluded that central bank attempts to manipulate interest rates had led to destabilizing fluctuations in money supply growth and, therefore, in economic activity. Hence, monetarists argued that monetary policymakers should minimize the variation of the growth rate of the money stock both in the short-run and over time. Lags in assessing economic conditions and in the effects of policy actions on economic activity, they argued, made attempts at "fine tuning" a balance between inflation and unemployment futile. Instead, monetarists argued for a policy that maintained growth of the money stock at a low, fixed rate, irrespective of the business cycle.

The Federal Reserve Bank of St. Louis was the center of monetarism within the Federal Reserve System from the 1960s into the 1980s.[6] Darryl Francis, who became president of the St. Louis Bank in 1966, was an especially strong advocate of monetarist policy prescriptions. At FOMC meetings, he argued frequently for a policy of minimizing variability in money stock growth around a moderate trend. In public forums, Francis made the case that growth of the money stock was the most accurate reflection of monetary policy and that excessive monetary growth was the fundamental cause of inflation. Francis was supported in his policy views by St. Louis Fed economists, whose research findings were largely in accord with those of other monetarists but sharply at odds with the conventional wisdom of the times, including the views about monetary policy held in most quarters of the Federal Reserve System.

Mainstream Views About Monetary Policy in the 1960s

A review of monetarism and all of its differences with mainstream Keynesian macroeconomics of the 1960s is beyond the scope of this article. Sharp theoretical differences about the cause or causes of inflation and economic fluctuations, as well as methodological differences about the empirical analysis of the effects of policy actions on economic activity, however, are fundamental to understanding why St. Louis Fed research and policy positions were controversial. These differences include whether a tradeoff exists between inflation and unemployment, either in the short or the long run, and whether such a tradeoff is exploitable by policymakers. A related question is whether monetary policy can, or should, be used to fight inflation when the economy is at less-than-full employment. Monetarists and non-monetarists divided also over the measures that best reflect the impact of monetary policy actions—monetary aggregates or interest rates and credit aggregates. Finally, monetarists and non-monetarists debated the tools and methods for identifying the impact of monetary policy on the economy.

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[4] Velocity was stable not as an arithmetic constant, but in the sense that its behavior was related predictably to changes in the opportunity cost of holding money and to changes in income or wealth of individuals.

[5] Perhaps the most famous statement and evidence of this proposition is Friedman and Schwartz (1963).

[6] Consider Friedman's (1992) appraisal: "The interesting thing to me has always been that the most important contributions to understanding of monetary theory and monetary institutions have not come from Washington during the decades in which I've been active. The Federal Reserve Bank of St. Louis in the 1950s, '60s and '70s was by far and away the pre-eminent producer of significant monetary research within the System."

Inflation and the Phillips Curve

The Phillips curve—the inverse relationship between unemployment and wage growth in British historical data observed by Phillips (1958)—was a key empirical regularity at the heart of macroeconomic policy discussions in the 1960s. The Phillips curve was viewed as a constraint on stabilization policy; policymakers with both unemployment and inflation goals had to choose a feasible combination of the two because policies that, say, reduced inflation would invariably slow economic activity and increase unemployment. Perry (1966, p. 3) noted that

> a fairly general consensus exists among economists . . . [that s]uccessively higher levels of activity are associated, roughly at least, with correspondingly larger rates of price increase. In this situation, the more traditional problem of adjusting aggregate demand so as to reach full employment without overshooting into the area of inflation must be replaced with the dual problems of deciding what combination of unemployment and inflation to aim at and then adjusting aggregate demand to reach this point.

Fed governor Sherman Maisel (1973, p. 14) observed succinctly: "There is a trade-off between idle men and a more stable value for the dollar. A conscious decision must be made as to how much unemployment and loss of output is acceptable in order to get smaller price rises."

Although many influential economists believed that the hyperbolic shape and negative slope of the Phillips curve were fixed, it was clear that the position of the Phillips curve could move over time. The U.S. experience of 1955-58 was widely discussed: In 1955-57, the unemployment rate hardly changed when the inflation rate increased sharply; in 1958, when inflation abated, the increase in the unemployment rate seemed disproportionately high. Concern arose that the U.S. economy had an "inflation bias," meaning that inflation, perhaps accelerating inflation, was necessary to achieve and maintain full employment (Wheelock, 1998).

The experience of 1955-58 gave prominence to the notions of "cost-push" inflation and "wage-price spirals." The term cost-push inflation was used to define an ongoing increase in the general level of prices caused by firms passing along increases in production costs, in contrast to "demand-pull" inflation caused by increases in aggregate demand. Cost-push forces were thought to explain how inflation could occur at less than full employment. The "essence of the problem," according to Samuelson and Solow (1960, p. 181), stems from the absence of perfect competition in factor and product markets and was, Bronfenbrenner and Holzman (1963) noted, associated with the power of "economic pressure groups," such as labor unions and monopolistic firms. If a powerful union extracts a real wage increase, the quantity of labor demanded falls. If affected firms have pricing power, they pass along a portion of the increase in wages to consumers in the form of higher prices. If perfect competition exists in other industries and labor markets, prices and wages fall to offset the increases in the first industry. If wages are downwardly rigid throughout the economy, however, the aggregate price level might rise alongside an increase in unemployment.

Throughout the 1960s, the *Economic Report of the President* blamed inflation on "excessive" wage and price increases. The clear implication was that monetary and fiscal policies were not responsible for inflation when the economy was at less than full employment. The *Economic Report* for 1965 explained that "in a world where large firms and large unions play an essential role, the cost-price record will depend heavily upon the responsibility with which they exercise the market power that society entrusts to them" (1966, p. 179). Hence, President Johnson urged, "in the strongest terms I know—that unions and business firms exercise the most rigorous restraint in their wage and price determinations" (*Economic Report of the President* for 1967, p. 20). Throughout the 1960s the *Economic Report* published detailed wage and price "guideposts" defining the extent to which wage and price increases were "justifiable."

Monetarists dismissed the notion of cost-push inflation, arguing that inflation is "always and everywhere a monetary phenomenon." Non-monetarists generally accepted that "cost-push may involve increases in money supply, money income, and money expenditures, particularly if decreases in output and employment are to be avoided" (Bronfenbrenner and Holzman, 1963, p. 614). Nonetheless, many economists found monetary explanations of inflation wanting, claiming that inflation can arise through wage and price setting independent of shocks to aggregate

demand. The short-run linkages from money to inflation were considered to be tenuous at best.[7]

Economists generally did acknowledge the potential for restrictive monetary policy to eliminate cost-induced inflation. The apparent downward rigidity of prices and wages, however, convinced many that using monetary policy to arrest even a moderate inflation would entail a substantial and unacceptable increase in unemployment. The *Economic Report of the President* for 1961 (p. 47) claimed that "an attempt to restrict aggregate demand so severely as to eliminate all risk of an increase in the general price level might well involve keeping the economy far below full employment."[8] High unemployment was simply an unacceptable cost of reducing inflation. In his introduction to the 1967 *Report* (p. 20), President Johnson argued, "Dealing with inflation by creating a recession or persistent slack is succumbing to the disease—not curing it. The experience of 1957 and 1958—when the unemployment rate reached 7 $\frac{1}{2}$ percent and consumer prices still rose 5 percent—is a clear reminder of the large costs of such a policy and of its limited effectiveness in halting a spiral in motion. This is a course which I reject."

To fight inflation, some mainstream economists advocated incomes policies; others favored policies aimed at enhancing the competitiveness of product and labor markets and policies aimed at raising productivity. Monetary policy, many argued, should focus on maintaining full employment by keeping interest rates low.

Many Federal Reserve officials expressed similar qualms about using monetary policy to control inflation. For example, Charles Partee, a Fed staff economist who later became a Fed governor, argued in 1970 that "The question is whether monetary policy could or should do anything to combat a persistent residual rate of inflation . . . The answer, I think, is negative." He added that "Product markets generally are substantially underutilized and labor appears to be readily available . . . It seems to me that we should regard continuing increases [in the price level] as a structural problem not amenable to macro-economic measures" (FOMC *Minutes*, April 1970, pp. 385-86, 379, 396 [quoted in Mayer (1999), p. 99]). Federal Reserve Board Chairman Arthur Burns also argued that "Monetary policy could do very little to arrest an inflation that rested so heavily on wage-cost pressures . . . A much higher rate of unemployment produced by monetary policy would not moderate such pressures appreciably" (FOMC *Minutes*, June 8, 1971, p. 51).

The Long-Run Phillips Curve

Wage and price rigidity and the possibility of cost-induced inflation suggested to many observers that using monetary policy to contain inflation would invariably cause higher unemployment. Monetarists did not deny this, but argued that the tightening of monetary policy would have merely a temporary adverse impact on unemployment. Andersen (1973), for example, argued that "our economic system is such that disturbing forces, including even changes in money growth, are rather rapidly absorbed and . . . output will naturally revert to its long-run growth path following a disturbance" (p. 7).

Some economists, however, argued that using monetary or fiscal policy to achieve price stability might cause unemployment to increase *permanently*. Keynesians frequently interpreted the Great Depression as indicating that private demand might be insufficient to generate full employment output in the face of downwardly rigid wages and prices, thereby leaving the economy mired permanently at less than full employment. Thus, many economists believed that monetary and fiscal policy should ensure that aggregate demand is sufficient to generate full employment, even if that requires some inflation. Samuelson (1960, p. 265), for example, argued that "With important cost-push forces assumed to be operating, there are many models in which it can be shown that some sacrifice in the requirement for price stability is needed if short- and long-term growth are to be maximized, if average long-run unemployment is to be minimized, if optimal allocation of resources as between different occupations is to be facilitated."

The Fed often was accused of paying "excessive" attention to price stability. In summarizing a symposium on recent monetary policy, Harris (1960, p. 245) wrote, "In general the disagree-

[7] Ackley (in Perlman, 1965, p. 47), for example, wrote that "I do not consider the change in money supply of much short-run importance." Weintraub (1960, p. 280) contended that "contrary to the widespread belief that there is a direct tie of money supplies to price levels, the *modus operandi* of monetary policy is different: its immediate effect is upon consumption and investment demands, thereby upon employment levels, and *only indirectly affecting the general level of money wages"* (emphasis in the original).

[8] The Council of Economic Advisors at this time consisted of Walter Heller, Kermit Gordon, and James Tobin.

ments of [participating] economists with Federal Reserve policy have stemmed primarily from a fear that the interest in the stability of the currency has been at the expense of growth and employment."[9] Not only was the tradeoff between inflation and unemployment widely viewed as persistent, but some economists argued that policies to achieve price stability in the short-run might make the tradeoff less favorable over time. Samuelson and Solow (1960), for example, believed that policies directed at limiting inflation in the short-run might increase structural unemployment. The long-run tradeoff between inflation and unemployment would worsen because an increase in structural unemployment would raise the size of the increase in inflation that would be needed to achieve a given reduction in the unemployment rate. Perry (1966, p. 119) even suggested that policies aimed at maintaining low unemployment and minimizing short-run cyclical variation in output could moderate wage and price increases.[10]

The Impact of Monetary Policy

Economists' conviction that policymakers could manipulate aggregate demand to stabilize the growth of real output reached its zenith in the 1960s and early 1970s. The apparent failure of low interest rates to revive the economy during the Great Depression, however, was taken as evidence that monetary policy is less potent than fiscal policy. The 1950s witnessed the development of new theories about the impact of monetary policy, with the dominant view being that policy is effective through its influence on both the cost and availability of credit.[11] Still, even in the 1960s, the mainstream view was that monetary policy, though capable of having some impact, was less powerful than fiscal policy.[12]

Monetarists, by contrast, argued that changes in the quantity of money exert a powerful influence on economic activity. Friedman's work during the 1950s helped establish the foundation for later studies of the link between monetary policy and the economy (e.g., Friedman, 1956). His examination of monetary policy and the business cycle is reflected in his testimony to the Joint Economic Committee in March 1958.[13] At that time, most Fed officials believed that short-term interest rates and the quantity of bank credit were the appropriate instruments of monetary policy. Minutes of FOMC meetings reveal that policymakers generally rejected the notion that movements in the money supply affect economic activity, much less that the Fed can control the money stock. Although one or two FOMC members warned persistently that fluctuations in money growth could cause undue fluctuations in the real economy, these concerns largely were ignored.[14]

Outside the Fed, by contrast, monetarist views about the impact of fluctuations in money stock growth were receiving considerable attention. Friedman and Meiselman's (1963) "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958," for example, stirred much debate. Associated with the Commission on Money and Credit's inquiry into the structure of the financial system, this paper was controversial because it rejected a core ingredient in the Keynesian theoretical structure—the validity of the expenditure multiplier. Friedman

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[9] Angell (1960, p. 248) argued similarly, stating that "As to aggregate growth, a good many students feel—as do I —not only that monetary policy has not done much to promote it, but that the intermittent restrictions imposed to fight instability and inflation have probably retarded it substantially." Hansen (1960, pp. 255-56) proposed that "Monetary policy should seek to achieve a low long-run rate of interest" to raise permanently the ratio of investment to output and thus real growth, while fiscal policy could "offset . . . the inflationary pressures caused by the increase in investment incident to rapid technological advance and low interest rates."

[10] Policymakers often agreed with such assessments. The Economic Report of the President for 1965 concluded "Rising prices that originate from such a [cost-push] process can affect expectations, jeopardize the stability and balance of an expansion, and create inequities and distortions just as readily as demand inflation. But measures to restrain these price increases by reducing over-all demand will enlarge unemployment and impair the productivity record so important to cost-price stability over the longer run" (p. 179). The Council of Economic Advisors at this time consisted of Gardner Ackley, Otto Eckstein, and Arthur Okun.

[11] The "Availability Doctrine" posits that small changes in interest rates can have large economic effects by affecting banks' willingness to supply loans. The theory was developed by New York Fed economist Robert Roosa (1956) and was the dominant view of the transmission mechanism within the Fed at the time. See Johnson (1962) for a survey of current thinking on monetary theory and policy effectiveness as of the early 1960s.

[12] The consensus view is perhaps well represented by Ando et al. (1963, p. 2), who concluded "the effect of monetary policy on the flow of expenditures is far from overwhelming, though it exists and is of a magnitude worth exploiting in the interests of economic stability . . . Our findings on fiscal policy are primarily that variations in disposable income, either through transfer payments or personal income tax changes, can operate as a powerful short-run stabilizer."

[13] This testimony was based on on-going research with Anna J. Schwartz at the National Bureau of Economic Research. This research was subsequently published in three volumes: see Friedman and Schwartz (1963, 1970, 1982).

[14] In the late 1950s and early 1960s, Malcolm Bryan, President of the Federal Reserve Bank of Atlanta, argued that the Fed should target the growth rate of total reserves, and minimize fluctuations in the money stock. See Meigs (1976) and Hafer (1999).

and Meiselman's empirical analysis also found money demand to be relatively more stable than money supply, suggesting that observed movements in the money stock and economic activity are dominated by Fed policy actions rather than by volatility in the public's demand for money.

The debate that ensued was so important that the *American Economic Review* devoted an entire issue to critical appraisals of the Friedman-Meiselman (1963) study by Ando and Modigliani (1965) and DePrano and Mayer (1965) and a response by Friedman and Meiselman (1965).[15] Two issues were key to the attacks and rejoinder. One was Friedman and Meiselman's finding that velocity is relatively more stable than the Keynesian expenditure multiplier. In other words, output appeared to be related more to movements in money than to other measures of autonomous expenditure.

The other issue, one that is more important for what would later be the attack on the St. Louis approach, was the procedure Friedman and Meiselman used to produce that finding. The debate displayed a fundamental difference in views about how to estimate economic relationships for policy purposes. Friedman and Meiselman, whose work was grounded in the tradition of the Quantity Theory of Money, based their conclusions on simple reduced-form relations observed in the data. Ando and Modigliani (1965) argued that such simple regressions, not much more than correlations, were inferior to the output of the large-scale, structural models then coming into vogue to evaluate policy. In other words, though different approaches may produce different results, only the most sophisticated is useful for policy analysis.[16]

Many Federal Reserve officials embraced the use of large-scale econometric models then being developed. Board staff participated with economists from the Massachusetts Institute of Technology in constructing the FRB-MIT model, which was used for policy analysis and evaluation at the Board. Such models were widely judged superior to single-equation or small-model systems for studying the effects of policy actions on economic activity. An official of the Federal Reserve Bank of New York argued that large-scale models produced "quantitative estimates of the timing and magnitude of the effects of central bank actions on the money supply and other financial magnitudes and the subsequent effects, in turn, of these variables on each of the various major components of aggregate demand" (Davis, 1968, p. 73). Thus, large structural models appeared to give policymakers the information they needed to make short-term, fine-tuning policy adjustments to stabilize economic activity.

Monetary Policy Target

Alongside large-scale macroeconometric models, the 1960s witnessed the development of increasingly complex analyses of the effects of monetary policy actions, interacting with financial regulatory policies, on financial flows and interest rates. With the exception of monetarists, many macroeconomists believed that monetary policy was not represented accurately by the behavior of any single variable, such as the rate of interest, the quantity of bank credit, or the stock of money. This view was reflected in the *Economic Report of the President* for 1968:

> In the formulation of monetary policy, careful attention should be paid to interest rates and credit availability as influenced by and associated with the flows of deposits and credit to different types of financial institutions and spending units. Among the financial flows generally considered to be relevant are: the total of funds raised by nonfinancial sectors of the economy, the credit supplied by commercial banks, the net amount of new mortgage credit, the net changes in the public's holdings of liquid assets, changes in time deposits at banks and other thrift institutions, and changes in the money supply. Some consideration should be given to all of these financial flows as well as to related interest rates in formulating any comprehensive policy program or analysis of financial conditions. (p. 89)

The *Report* also dismissed monetarist appeals for focusing on money stock growth. In response to calls for setting monetary policy according to a

[15] This is the so-called AM-FM or "radio" debate. Hester (1964) was also critical of the Friedman-Meiselman approach.

[16] Brunner (1986) provides an excellent and wide-ranging overview of this debate. He defends the Friedman-Meiselman (1963) approach, arguing that "the use of a single equation with a single independent variable should now be clear. It was the appropriate choice for an assessment of the core class [of hypotheses]. It did not represent a single equation *model* or a [direct] disposition to favor simple, as against sophistical models" (p. 41, emphasis in original). Rather, Brunner suggests (p. 40) that "the strong assertions conveyed by the basic core of the income-expenditure approach, which frequently spilled over into categorical policy statements, were thus shown to have little substantive foundation."

fixed-growth rule for the money stock, the *Report* argued (p. 92) that "given the complex role of interest rates in affecting various demand categories and the likely variations in so many other factors, any such simple policy guide could prove to be quite unreliable." Similar reasoning was reflected in the analysis of Federal Reserve Board economists. In a paper published in the *Federal Reserve Bulletin*, Gramley and Chase (1965, pp. 1403-04) wrote that "the money stock [is] an untrustworthy indicator of the effects of policy actions on financial asset prices and yields . . . Financial market behavior is too complex for simple monetary rules to work."[17]

Monetarists, of course, disagreed that the complexity of financial markets made targeting a monetary aggregate infeasible. In an article in the *Journal of Political Economy*, Federal Reserve Bank of St. Louis economist Leonall Andersen (1968) presented evidence that the Fed could use open market operations to smooth fluctuations in total and free (i.e., excess less borrowed) reserves and, by implication, in the monetary base.[18] Albert Burger (1971), another St. Louis Fed economist, presented a detailed analysis of how the monetary base can be manipulated so as to control the money stock.

The Fed's ability to control monetary aggregates and the efficacy of monetary control for economic stabilization remained hotly debated issues. They also were central research themes at the Federal Reserve Bank of St. Louis throughout the 1960s and 1970s.

ST. LOUIS—THE LONG-RUN VIEW

Under the leadership of its director of research, Homer Jones, the Federal Reserve Bank of St. Louis emerged as the center of monetarist economics within the Federal Reserve System in the early 1960s.[19] The Bank's *Review*, which then appeared monthly, tracked the behavior of the economy and the money stock in nearly every issue. *Review* articles often described the recent behavior of the money stock and related it to monetary growth during previous expansions. For example, the June 1962 article, "Monetary Developments," compared graphically the recent behavior of bank reserves and the money stock (M1) with their patterns during the 1953-57 and 1957-60 cycles. This type of chart, used by Friedman in his 1958 Senate testimony and in Friedman and Schwartz (1963), provided a visual analysis of expansionary and contractionary movements of the money stock.

A companion article in the June 1962 *Review* provided one of the first monetarist explanations from the St. Louis Fed of how monetary policy actions are transmitted to changes in nominal income and prices. The article, "Changes in the Velocity of Money: 1951-1962," addressed one of the more difficult questions monetarists faced in attempting to use the Quantity Theory to explain how monetary policy affects the economy in the short-run. If velocity is highly variable, then the connection between changes in the money supply and nominal income is uncertain at best. The article provided a "tentative and exploratory analysis" of the behavior of velocity. The analysis showed that a "rapid change in money [is] to be matched temporarily by an opposite change in velocity" (p. 13). Over time, however, "as the public recognized the change in its [money] balances . . . there was an increase in spending, and velocity moved upward" (p. 13). Using this pattern to explain the effects of past policies, the article noted that "Within a few months after money began expanding at a rapid rate in 1954, 1958, and 1961, spending and the velocity of money began rising" (p. 13).

The article is an early example of the research coming out of St. Louis in support of the monetarist position that changes in nominal income largely reflect prior movements in the money supply. Even though velocity might vary, its variability appeared to be less than that of money supply. Hence, monetarists argued, observed cycles in

[17] It was a long-standing view among Board officials that monetary policy should not focus on any one variable. For example, as early as 1932, Governor Eugene Meyer stated: "Our credit machinery is entirely too delicate and responsive to too many influences to make it desirable to have any one indicator, whether it be the price level or the level of member bank reserves, be the sole guide in determining credit policy" (quoted by A. James Meigs in a letter to Milton Friedman: Friedman Papers, Hoover Library, Stanford University, Box 30, Folder 17).

[18] See also Meigs (1966), who reviews the debate about whether financial innovation had made control of the money stock infeasible or inefficacious.

[19] Jones was hired by the St. Louis Fed in 1958. At that time, the Bank's research staff consisted of one Ph.D. economist, two graduate students, an agricultural economist, a geographer and several junior staff members. During 1958, Jones corresponded regularly with Friedman concerning potential hires for the department (Friedman Papers, Hoover Library, Stanford University, Box 28, Folder 36). In recognition of Jones' accomplishments, in 1976 a special issue of the *Journal of Monetary Economics* was devoted to papers in his honor.

nominal income growth are caused mainly by changes in the money supply—over which the Fed has some control—rather than by changes in velocity.

As inflation worsened over the 1960s, *Review* articles reflected an increasingly aggressive application of monetarist arguments by St. Louis Fed economists, as critical reviews of policy replaced tentative and exploratory studies. For example, a July 1966 article, titled "Total Demand and Inflation," stated that "Excessively stimulative Government policies lead to marked increases in the price level. Rapid monetary expansion is regarded by many as a means of stimulating total demand" (p. 1). In the same issue, Keran (1966) studied the relationship between nominal and real output in eight countries. He concluded that inflation results when total demand—nominal income—rises faster than the economy's potential rate of real output growth, suggesting that "If the recent acceleration in total demand is continued at a time of high-level resource utilization, prices will probably begin to rise even faster" (p. 12). In addition, Keran hinted at the possibility of using monetary policy for short-run stabilization, noting that "To the extent that policy tools control the growth in total demand they are useful in achieving cyclical stability in the economy *because year-to-year movements in real output can be influenced by changes in total demand*" (p. 12, emphasis added). These and other *Review* articles, many of which were written anonymously, reflect clearly the monetarist-oriented research and policy analysis carried out by St. Louis Fed economists in the early-to-mid 1960s.

The St. Louis Bank's visibility increased significantly, however, with the publication of articles by Andersen and Jordan (1968) and by Andersen and Carlson (1970). These articles provided two of monetarism's most challenging attacks on policy orthodoxy and mainstream Keynesian macroeconomics. The former presented an econometric evaluation of the relative impacts of monetary and fiscal policy on economic activity. The latter offered a small monetarist econometric model that the authors proposed as an alternative tool to simulate alternative policy scenarios. Both papers concluded that changes in the growth of nominal income and inflation are linked closely to changes in the growth rates of monetary aggregates. Although such relationships had been demonstrated over relatively long time-horizons, these two articles suggested that they hold over even the short time horizons of concern to policymakers. The articles were instrumental in developing the monetarist policy rule as an alternative to the conventional interest rate and fiscal-policy oriented ideas of the time.

The Andersen-Jordan Equation

Andersen-Jordan (1968) (hereafter, AJ) is an intellectual and analytical descendant of Friedman-Meiselman (1963).[20] Andersen and Jordan, like Friedman and Meiselman, were interested in isolating statistically the impact of money on nominal income. AJ went further, however. They provided a straightforward empirical test of a related and critical policy issue—the relative impacts of monetary and fiscal impulses on nominal income. Rather than building a complex econometric model like those in vogue at the time, AJ took a relatively simple approach to assessing alternative policies. They estimated a single empirical relation—a "reduced-form" model—between income and different measures of monetary and fiscal policy actions. Their equation can be written as:

$$(1) \qquad \Delta Y_t = \sum_{i=0}^{3} \beta_i \Delta M_{t-i} + \sum_{j=0}^{3} \delta_j \Delta E_{t-j} + \varepsilon_t$$

where Y represents nominal gross national product, M is the money stock (M1 or the monetary base), and E is a measure of fiscal policy actions. The variables were measured as changes in their levels. In their estimation, AJ accounted for lags in the effect of policy actions on economic activity using a new econometric technique that constrained the estimated parameters to lie along a predetermined polynomial. This was thought to provide more precise estimation of the effects of changes in the policy variables.[21]

[20] Jordan (1986) refers to it as a "sequel" to Friedman-Meiselman (1963), though it clearly is linked to earlier work by Karl Brunner. This is evident in the statement by AJ that their purpose is not to "test rival economic theories [i.e., Keynesian vs. Monetarist] of the mechanism by which monetary and fiscal actions influence economic activity" (AJ, 1986, p. 29). A decade earlier Brunner was examining the logical structure of empirically testing between Keynesian models, in which money played a very minor role, and monetary models, in which "money matters." For example, Brunner and Balbach (1959) present a structure of models in which they test empirically the relative roles of money and fiscal policy actions.

[21] See Batten and Thornton (1986) and the articles cited therein for a discussion of this and other technical issues regarding the estimation of equation (1).

Using quarterly data covering the period 1952 to mid-1968, AJ estimated equation (1) to test three hypotheses. By comparing the sizes of the estimated impacts of fiscal and monetary policy on GNP, AJ rejected the hypothesis that output responds more to fiscal policy actions than to changes in the money stock. Comparison of the statistical significance of the coefficient estimates for monetary and fiscal policy actions led AJ to reject the hypothesis that fiscal actions have a more "reliable" impact on GNP than monetary actions. Finally, comparison of coefficient estimates on lagged monetary and fiscal policy actions, led AJ to reject the hypothesis that fiscal actions affect GNP faster than do monetary policy actions. They succinctly summed up their evidence: "The response of economic activity to monetary actions compared with that of fiscal actions is (I) larger, (II) more predictable, and (III) faster" (p. 22).

Early Criticism of Andersen-Jordan (1968)

Andersen-Jordan (1968) was subject to immediate and critical analysis by economists inside and outside of the Federal Reserve System. Technical criticisms have been dealt with at length elsewhere.[22] Of interest here is the fact that much of the early debate over the usefulness and the conclusions of the article took place among Fed economists within the pages of System publications. For example, the first published criticism of the AJ approach and findings was by DeLeeuw and Kalchbrenner (1969), both of whom were or had been with the Board of Governors.[23] Their comment was published in the Federal Reserve Bank of St. Louis *Review,* along with a response by AJ. DeLeeuw and Kalchbrenner (hereafter, DK) raised several technical issues, but focused on AJ's use of the monetary base as the appropriate measure of monetary policy. DK argued that the Fed controls neither the borrowed reserves of member banks nor the currency stock. Hence, they argued, the base is not statistically independent of the model's dependent variable—changes in GNP. DK reestimated the AJ equation, using the base less borrowed reserves and currency as the monetary policy variable, and found that, although monetary policy appeared "to exert a powerful influence" on GNP, money was not as dominant as AJ's results had suggested. DK noted also that their results were more consistent with the output from large-scale econometric models, suggesting that their results were more plausible than those of AJ.

Another early criticism of AJ appeared in the *Monthly Review* of the Federal Reserve Bank of New York (Davis, 1969). That study defended the view that monetary policy affects income through interest rates, not the money stock or monetary base, with its author noting that the St. Louis equation "portrays a world in several respects [that is] sharply at variance with the expectations of most of us" (p. 121). Like DK, Davis reestimated the AJ equation using different measures of monetary policy, as well as different polynomial lag specifications and different sample periods. Davis's analysis led him to conclude that "we can't accept the St. Louis equations at face value because neither money nor the total reserve base may be sufficiently exogenous" (p. 126). The only recourse, he suggested, is to build a structural model (like the FRB-MIT model) and reject the reduced-form approach used by AJ. The onus for monetarists, he implied, was to put their ideas into a structural model that details the transmission mechanism of monetary policy.

The controversy generated by the appearance of AJ marked an abrupt change in the "monetary versus fiscal policy" debate. Despite criticism of the AJ study, the earlier view that business cycle evidence relating money and income was "the province of an obscure sect with headquarters in Chicago" (Davis, 1969, p. 119) was changed by their results. Monetary aggregates now were considered plausible alternatives to interest rates and fiscal policy as tools for short-run economic stabilization.

Darryl Francis and the Andersen-Jordan Results

While the technical analysis, criticism, and responses of the AJ equation took place in both System and academic publications, its policy implications were being disseminated in public forums. Darryl Francis, the president of the St. Louis Bank, used the AJ results to promote the role

[22] Reviews include Meyer and Rasche (1980), Batten and Thornton (1986), McCallum (1986), and Brunner (1986).

[23] DeLeeuw, then a Senior Staff Member at the Urban Institute, had been the Chief of the Special Studies Section, Division of Research and Statistics at the Board of Governors and a principal in the design and development of the FRB-MIT model. Kalchbrenner was an economist in the Special Studies Section.

of monetary aggregates in setting stabilization policy. Francis (1968, p. 8) rejected the use of fiscal actions as a tool for stabilization, arguing that "monetary actions are a major determinant of short-run movements in total spending." He also rejected the common view that interest rates and bank credit reflect accurately the stance of monetary policy. Francis (1968) argued that "movements in interest rates should be viewed no differently than movements in commodity prices" (p. 8). Instead, Francis pushed for the "primary and consistent use of monetary aggregates" in setting policy, noting that "all of these aggregates can be rather precisely controlled by monetary authorities" (p. 8). This approach would serve the dual purpose of holding the authorities accountable for their actions and instituting "scientific methodology and modern quantitative analysis" to monetary policy (p. 7).

At an FOMC meeting on February 4, 1969, Francis reviewed how the Committee had been misled by the behavior of interest rates and bank credit:

> For about four years . . . the Committee had been led into unintended inflationary monetary expansion while following interest rate, net [free] reserves, and bank credit objectives . . . If the Committee meant business now, it should try some other guides. Not only could the old guides lead to further inflation as long as demands for credit continued to rise, but when and if contrary trends set in they could lead to an undue contraction of total spending.

Francis also made clear his preferred policy guides: "He urged the Committee to give some evidence that it was exercising restraint by limiting the growth of bank reserves, the monetary base, and the narrow measure of money supply" (FOMC *Minutes*, February 4, 1969, p. 47).

Francis believed strongly that inflation was the consequence of excessive monetary growth, and that the Fed had erred in pursuing policies that resulted in accelerating growth of the monetary aggregates. In essence, Francis attacked the dominant view that policy should be aimed at stabilizing short-run variation in economic activity, as reflected in the unemployment rate, at the expense of higher inflation. At an FOMC meeting on May 11, 1971, Francis reviewed the course of monetary policy and inflation over the previous 20 years:

> During the ten-year period ending in late 1962, money grew at an average annual rate of 1.5 per cent . . . With the economic sluggishness of the early 1960's . . . monetary stimulation was increased, and money rose at a 3.5 per cent average annual rate from late 1962 to the end of 1966 . . . [T]hat rate of monetary expansion resulted in a gradual increase in inflation to a 3 per cent rate. Following the credit crunch of 1966 money growth was again accelerated, producing a 6.3 per cent average annual rate from early 1967 to the present . . . [A] 6 per cent trend rate of monetary expansion implied a sustained 4 per cent rate of inflation. In each case . . . the rate of growth in money was accelerated in order to overcome weakness in the economy. Despite those progressively more stimulative monetary actions, the rate of unemployment had averaged about the same whether the trend growth of money was 6 per cent, 3.5 per cent, or 1.5 per cent. The trend growth had had its chief impact on prices, whereas fluctuations around the trend had had the greatest impact on production and employment. (FOMC *Minutes*, May 11, 1971, pp. 57-58)

Francis's perspective reflected his monetarist outlook: He argued that inflation is primarily determined by the rate of growth of the money stock and that, in the long run, real output growth and the unemployment rate are unaffected by monetary policy. In other words, the long run Phillips curve is vertical.[24] Francis also argued that while monetary policy has no effect on real growth or employment in the long run, fluctuations in monetary growth could have substantial effects on these variables in the short-run. He used the Andersen and Jordan (1968) results, and those of other Bank economists, to support his claim.

[24] The distinction between short- and long-run Phillips curves was formalized by Friedman (1968) and Phelps (1967).

Although some members of the Committee shared Francis's views, the chairman and a majority of others did not. In one of the most frank declarations of the opposing view, Chairman William McChesney Martin stated at the October 7, 1969, FOMC meeting that he "did not accept the monetarist's position regarding the critical importance of the specific rate of change in the money supply. In particular, he did not agree that the consequences of deviating significantly from some preferred rate for a period of time would be as disastrous as the monetarists believed" (1969, p. 1100). Board economists Gramley and Chase (1965, p. 1403) went even farther, arguing, "there is little doubt that such a simple rule [based on changes in the money stock] for appraisal of central bank operations is no longer appropriate."[25]

Francis cited Federal Reserve Bank of St. Louis research often and at least once entered St. Louis staff forecasts of real output and inflation under alternative money stock growth rates into the formal record of FOMC deliberations. His first recorded reference came at the December 17, 1968, meeting when he discussed "a recent study done at the St. Louis Reserve Bank [which] indicated that with the existing stance of fiscal policy, if money continued to grow at a 6 per cent annual rate throughout the coming year, gross national product would rise at an excessive 8 per cent annual rate" (FOMC *Minutes*, December 17, 1968, p. 54).

Francis's discussion illustrates that St. Louis Fed officials (and monetarists in general) had begun to actively engage the prevailing wisdom on its own short-run grounds. The AJ results, in effect, provided a platform by which monetarist policy prescriptions, oriented to the behavior of the monetary aggregates, could be discussed in terms of short-run stabilization issues. With one eye cocked to the longer-term inflationary effects of policy, something that the conventional view did not provide, monetarists could also discuss the short-run effects of monetary policy.

Francis's use in FOMC meetings of research conducted by St. Louis Fed economists illustrates how the Fed's decentralized organizational structure can affect policy deliberations. The participation of Federal Reserve Bank presidents in monetary policymaking provides an outlet for alternative perspectives to be heard, including direct criticism of System policy. In addition to bringing the research findings of his staff to FOMC deliberations, Francis also promoted St. Louis Fed research in his numerous public appearances. Citing "forthcoming articles," Francis often talked about lags in the impact of monetary policy and how they made attempts to "fine tune" a balance between inflation and unemployment difficult, if not impossible.[26] Even so, the behavior of the economy in the late 1960s gave credence to the claim that nominal spending responded, albeit with a lag, more to changes in money supply growth than to fiscal policy. The "mini-recession" of 1966 and the failure of tax increases in 1968 to halt the upward march of inflation seemed to support the efficacy of monetary over fiscal policy. While some of his FOMC colleagues had urged tighter fiscal policy to stem inflation in 1968, and supported the temporary tax increase that had been enacted, Francis contended that the tax increase was unlikely to have a significant effect on economic activity.[27] As Francis predicted, the temporary fiscal measures adopted in 1968 had minimal impact on economic activity.

THE ST. LOUIS MODEL: MONETARISM FOR THE SHORT-RUN

The predictive success of the St. Louis (AJ) equation and the apparent failure of fiscal policy to stem the inflation of the late 1960s gave monetarists credibility in policy discussions. The behavior of the money stock began to get more consid-

[25] Gramley recalls the policy debates this way: ". . . if the Federal Reserve had appreciated how serious the inflationary problem was going to become, they would have paid more attention to the growth of the monetary aggregates and relied less on money market conditions . . . if you weren't worried too much about long-run inflation you were inclined therefore not to pay sufficient attention to what was happening to those aggregates" (quoted in Mayer, 1995, pp. 7-8).

[26] For example, at an FOMC meeting on March 9, 1971, he noted that "In the past the System had, on occasion, persisted in a policy course too long. Knowledge of current developments in the economy was available only with a delay, and the effects of monetary actions on spending, production, prices and employment continued for months" (FOMC *Minutes*, March 9, 1971, p. 66).

[27] As Francis summarized his position before the FOMC, "Over the past year the System had aggressively advocated fiscal restraint as a necessity to rational stabilization policy. Yet now that such restraint appeared likely, there seemed to be growing fear of its destabilizing impact. [He] did not share those views . . . Those fiscal measures were generally expected to be temporary, and thus much of the tax burden on consumers would probably come from reduced saving and much of the burden on corporations would probably come from increased borrowing . . . The tax measure, because of its temporary nature, might actually cause some acceleration of investment spending" (FOMC Minutes, June 18, 1968, pp. 87-88).

eration in the setting of stabilization policy.[28] But some observers, even Homer Jones, the St. Louis Bank's research director when the St. Louis model was developed, sounded a note of caution:

> Our own econometric studies at St. Louis have long indicated strong, roughly predictable, relations between monetary action, intentional or unintentional, and the course of the economy . . . does this mean we can expect to engage usefully in active monetary management in the future? . . . *I . . . conclude that we cannot in the near future engage intelligently in short-run manipulative monetary management*. (1970, p.15, emphasis added)

Darryl Francis also warned against using monetary policy to fine-tune economic activity. The success of the AJ equation and the building empirical evidence in support of monetarist views, however, led to a greater focus on the short-run. In his retrospective of the equation's development and use, Jordan (1986, p. 8) notes that "The [AJ] article's impact on economic policymaking would have been more favorable had it not led to an increased reliance on monetary over fiscal policy, but had it instead contributed to a general deemphasis of fine-tuning attempts by policymakers."

The increasingly short-run emphasis undoubtedly reflected, in part, the natural focus of policymaking at the central bank. Dewey Daane, a Federal Reserve governor, noted that the FOMC was "always concentrating on what's the immediate problem over the next four to six weeks and not really thinking in terms of long-run forecasts and inflation" (quoted in Mayer, 1995, p. 16). Governor Andrew Brimmer's recollection corroborates this view, noting that there was "clearly a short-term horizon. [Chairman] Martin put a lot of emphasis on the long run, but that was unusual" (quoted in Mayer, 1995, p. 4).

In April 1970, the Federal Reserve Bank of St. Louis published "A Monetarist Model for Economic Stabilization," by Andersen and Carlson (hereafter, AC). The AC, or "St. Louis" model as it has become known, reflected the latest stage in the development of an empirical model of monetarist propositions and expanded the on-going debate over the role of money in determining aggregate spending and inflation in an important way. Unlike the large-scale macroeconometric models being developed elsewhere, the St. Louis model built upon previous research at the Bank in which the money stock is the central focus of stabilization policy.

The original St. Louis model consisted of eight equations, only four of which were estimated: the total spending equation—the AJ equation, a price equation, an equation for the long-term interest rate, and an unemployment equation. The remaining equations are definitions.[29] The interest rate equation, based on earlier work by Yohe and Karnosky (1969), reflected the view that interest rates are determined by past inflation and past changes in money growth. The unemployment equation was essentially that developed by Okun (1962). The price equation rejected the typical wage-price markup approach popular at the time. Instead, AC specified the change in the price level as a function of demand pressures and anticipated price changes.

The St. Louis model is "monetarist" in that the money stock is treated as exogenous and its effect on total spending is central to the workings of the model.[30] As AC state:

> The change in total spending is combined with potential (full employment) output to provide a measure of demand pressure. Anticipated price change, which depends on past price changes, is combined with demand pressure to determine the change in the price level. The total spending identity enables the change in output to be determined, given the change in total spending and the change in prices. (p.10)

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[28] In reviewing the discussion of monetary policy at a recent conference, Friedman wrote to Homer Jones in July 1969 that "I, too, have been very much impressed with the evidence that a new day has dawned . . . I almost fell over when he [Board Governor Dewey Daane] started talking about the importance of paying attention to monetary aggregates" (Friedman Papers, Box 28, Folder 36).

[29] The original model is summarized in the Appendix. Carlson (1986) provides a comparison of the original version and the then "current" version which reflects modifications over the intervening years.

[30] AC determine real output as a residual; that is, output is determined as the difference between total spending and the price level. As they note, "This method of determining the change in total spending and its division between output change and price change differs from most econometric models. A standard practice in econometric model building is to determine output and prices separately, then combine them to determine total spending" (p.10).

The structure of the model meant that for a given change in the money supply or government expenditures, one could solve for changes in total spending, prices, real output, the unemployment rate, and interest rates. The model was simple in comparison with the complex structural models used by the Board staff and elsewhere. For example, whereas the Wharton model, a representative Keynesian structural model, had 43 exogenous variables, the St. Louis model had just three. The model also omitted details about specific sectors for the simplicity of determining the impact of a change in money growth on the economy broadly. This development fit nicely with the view of many monetarists that "the Federal Reserve should be concerned with the aggregate effects of policy, and should leave the allocative details to the operation of the market" (Francis 1973, p. 9).[31] As Carlson (1986, p. 18) recollects the development of the model,

> we wanted a model that was small enough that the interrelationships among the varables could be understood easily . . . We were not concerned about respecifying behavioral equations . . . [and] we wanted to capture empirical relationships between a relatively few key macroeconomic variables that were implicitly grounded in economic theory.

AC state explicitly that their statistical analysis is used "to estimate the response of output and prices to monetary and fiscal actions, not to test a hypothesized structure" (pp. 10-11).[32] The original estimates appeared to support the monetarist view of the world: an increase in the money supply leads first to an immediate increase in nominal spending and real output, and only after prices adjust to the higher demand pressure does the price level rise to stifle the increase in real output.

Using the Model for Short-Run Analysis

Andersen and Carlson used the St. Louis model to simulate nominal spending, real output, inflation, and the unemployment rate for different hypothesized growth paths for money. They also compared their monetarist model's forecasting ability with that of the Wharton model during 1963-64, a period that included a major fiscal action—the tax cut of 1964. How would the St. Louis model, in which fiscal policy plays a minor role, fare in comparison with the Wharton model in which fiscal policy has a much larger role than money? The St. Louis model's simulations were better (i.e., produced lower root-mean-squared errors) than the Wharton model for nominal GNP and the unemployment rate, about the same for real GNP, and worse for the price level. The upshot was that this small, monetarist-oriented model could prove as valuable to policymakers as the large-scale Keynesian models then in use. Importantly, it seemed to demonstrate the usefulness of a small monetarist model for current analysis. As AC state, "The purpose of the following statistical section is to estimate the response of output and prices to monetary and fiscal actions, not to test a hypothesized structure. *The focus is on the response in the short run—periods of two or three years—but the long-run properties also are examined"* (1970, pp. 10-11, emphasis added).

The success of the St. Louis model was important to monetarism's growing impact on policy discussions. It also appeared soon after Friedman (1968) and Phelps (1967) provided theoretical models in which the popular Phillips curve tradeoff between inflation and unemployment (and, hence, real output growth) was shown to be transitory. The Phillips curve, a version of which appears in the St. Louis model, was a critical component of most Keynesian macro-models of the time. The results of AC provided an empirical demonstration that although expansionary monetary policy might produce a short-run increase in real output growth and a dip in the unemployment rate, these effects would vanish over time as inflation increased and unemployment and output growth returned to their "natural" or trend rates.

The St. Louis model enabled monetarists to produce short-run forecasts of alternative policy scenarios, thereby putting them on similar footing

[31] A recurrent theme in discussions about the role of policy was the recognition that policy actions sometimes affected certain industries—most notably housing—more than others. Such attention was disruptive to the working of market forces, Francis believed. He noted that "Regulation of interest rates paid by commercial banks and thrift institutions unduly disrupts the allocation function of markets. Furthermore, excessive concern for the well-being of these institutions and the housing industry has caused monetary authorities to expand the money stock at a rapid rate during much of the current inflationary period" (1968, p. 9).

[32] Francis (1973, p. 8) makes the point that "The bewildering struggles that occur between model builders over specification errors, structural versus reduced-form models, recursive versus non-recursive systems, etc., are meaningless to most policymakers."

with other mainstream economists, both in and outside of the Federal Reserve System. Dewald (1988, p. 6) contends that with the development of the St. Louis model, "monetarism was widely interpreted as providing an alternative to short-run Keynesian model forecasts." The St. Louis model, though grounded in the long-run conditions of the Quantity Theory, increasingly was used to counter the short-run policy prescriptions coming from the larger structural models in use at the Board. The St. Louis model, estimated using quarterly observations and with the money stock—not interest rates—as the policy instrument, led many observers to conclude that the money stock could be an effective tool for economic stabilization.

The shifting emphasis at the St. Louis Bank toward short-run policy analysis can be found in comments of participants in the model's development. Carlson (1972, p. 25) warned against using the model for anything but interpreting the "general time path" of important macroeconomic variables. Even so, analysis of the short-run impact of alternative policies is precisely what the model came to be used for. His own admonition aside, Carlson (1972, p. 20) noted that the model "presents a set of simulations using alternative steady growth rates which can aid in assessing the economic impact *over several quarters* of different trend growth rates of money" (emphasis added). In keeping with this view, his analysis of the model's performance was based on a six-quarter horizon, hardly the long run used by early monetarist studies. But such a use for the model appeared justified by the empirical results: "the model succeeded in roughing out the average time paths of total spending, real product, prices, unemployment, and interest rates during the period *from late 1969 to mid-1971"* (Carlson, 1972, p. 26, emphasis added).

The model's success as a forecast tool gave support to monetarist calls for a policy aimed at stable money growth. In reviewing the debate over stabilization policy, Andersen (1973, p. 3) summarized the model's success at forecasting real output and inflation, stating that "The key proposition is that changes in money dominate *other short-run* influences on output and other long-run influences on the price level and nominal aggregate demand" (emphasis added). The St. Louis model suggested that stable money growth would lessen any monetary-induced instability in the real economy while promoting price stability in the long run.

Research from St. Louis continued to provide a long-term, inflation-oriented perspective on monetary policy actions, reflecting rising inflation of the early 1970s. At the same time, the *Review* contained numerous studies, often authored by Andersen or Keran, of the short-run response of the economy to changes in the growth of the monetary aggregates. The allure of short-run analysis perhaps is best illustrated by Carlson's (1975) estimation of the St. Louis equation using monthly data. Replacing nominal GNP with personal income, Carlson found that the lag from changes in the growth of money to nominal income was completed in about one year, similar to that found by AJ, though slower than reported in other studies.[33] The implication of this finding was clear: Carlson (1975, p. 17) suggests that the "Use of monthly data thus appears to carry the potential for evaluating the thrust of monetary and fiscal actions before quarterly data on GNP become available."

In the late 1960s, public interest in monetarism rose as inflation continued to increase. Monetarists were called upon by the incoming Nixon administration for advice. Milton Friedman wrote a regular column for *Newsweek* alongside one by Paul Samuelson, who had been a leading advisor to the previous two administrations and a leading architect of the so-called New Economics. Increased attention, however, brought more strident criticism. By 1972 there already were claims that monetarism had "failed." For example, in his *Newsweek* column of August 2, 1971, Samuelson objected to the monetarist claim that rapid money growth in 1971 would subsequently lead to faster nominal GNP growth. He suggested that "the forecasting ability of monetarism is selling at a huge discount on the markets of informed opinion" (Samuelson 1971, p. 70) and that the "pseudopositivism which prevails among monetarists. . . [is] still another reason why the peculiar tenets of monetarism have to be rejected" (quoted in Francis, 1972, p. 32).

Members of the Board of Governors also criticized the policy advice of monetarists. For example, Andrew Brimmer, echoing arguments made during the previous two decades, rejected any policy based on control of the monetary aggregates: "I am convinced that it would be a disastrous

[33] Another example of attempts to model the short-run effects of money on the economy is Laffer and Ransom (1971). Unlike the St. Louis results, Laffer and Ransom report that monetary actions lead to an immediate and permanent effect on the level of GNP.

error for the Federal Reserve to try to conduct monetary policy on the basis of a few simple rules governing the rate of expansion of the money supply" (1972, p. 351).

Francis (1972, p. 32) considered such attacks "strident," "doctrinaire," and "no more precise than in the past." He answered these criticisms by pointing to the St. Louis model's ability to forecast economic activity over the short-run. He compared income, inflation, and unemployment predictions for 1969, 1970, and 1971 derived from the St. Louis model to those of the consensus Livingston forecasts. The overall forecasting ability of the St. Louis model compared favorably with the consensus forecasts. Although Francis maintained that policy should take a longer-term view to be effective, he focused on a few years of forecasting results to justify applying the model to shorter time horizons.

Refining the Model

As the 1970s progressed, neither Keynesian models based on the Phillips curve and interest rates, nor simple monetarist models based on growth of the money stock, successfully forecast the rapid inflation and higher unemployment that actually occurred. Monetarists faced the task of explaining why inflation had increased so dramatically without a similar-sized increase in money stock growth. Monetarists, including St. Louis Fed officials, responded that their critics had confused changes in the aggregate price level, which are caused by monetary policy, with changes in relative prices brought on by special factors. Francis presented the Bank's position in a series of speeches in 1974. He pointed out that the increase in inflation was due largely to an increase in money growth over the preceding few years. Any inflation over and above the underlying monetary growth rate was caused by the removal of wage and price controls and the increase in oil prices by the OPEC nations.[34]

St. Louis Fed economists soon integrated such special factors in their studies. Karnosky (1976) demonstrated that money growth continued to explain longer-term movements of inflation once the oil price shock effects were accounted for. Rasche and Tatom (1977) extended this idea in their examination of the effects of supply shocks on the economy and how they could distort the statistical relationship between money and income in the short-run. Although aspects of these works were criticized, they suggested that the money supply remained useful for stabilization purposes.

The Breakdown of the Monetarist Rule

Kane (1990) observes that as the rate of inflation continued to increase over the 1970s, the growing weight of evidence supporting the monetarist position pushed the FOMC to incorporate money stock growth into their policy deliberations and evaluations. This was quite a change from their position of a decade earlier when "they treated monetarism as an eccentric and quasi-religious belief system that no responsible macroeconomist or public official could possibly take seriously"(p. 292).

Monetarism as a policy approach, however, had a relatively short stay in the limelight. In October 1979, the Federal Reserve adopted new operating procedures that it claimed would enhance its control of the money stock. Highly restrictive policies also were enacted to reduce inflation, which had reached double-digit levels. Although inflation eventually declined significantly, the more immediate effect was to send the economy into the deepest recession of the postwar period. Critics associated the policy with monetarism, referring to the policy as the Fed's "monetarist experiment," and this perception contributed to the widespread discounting of monetarism as a viable policy option. Monetarists protested that the Fed had not, in fact, adopted their preferred policy of slow and steady money growth. Rather, they noted, the variability of money growth actually increased after 1979 and gave rise to increased fluctuations in real economic activity without any appreciable short-run effect on inflation.[35]

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[34] Francis argued similarly in FOMC deliberations. At a meeting on January 22, 1974, for example, Francis contended that "the actual and prospective slowdown in economic activity resulted wholly from capacity, supply, and price-distorting constraints and not from a weakening in demand. Therefore, to ease [monetary] policy and allow a faster rate of monetary growth would be to increase inflationary pressures without expanding real output or reducing unemployment" (FOMC *Minutes*, January 22, 1974, p. 102).

[35] Batten and Stone (1983) provide an overview of the issues and evidence in support of the monetarist position. For contrasting assessments of this episode, see B. Friedman (1984) and M. Friedman (1984). Charles Schultz, Chairman of the Council of Economic Advisors from 1977-81, considered the monetarist experiment in this light: "What monetarism really is for the Fed (and I'm morally certain this is what Volcker thinks, too) a political cover. They're not monetarists, but it allowed them to do what they could never have done . . . They could never have done what needed to be done if it looked as if they were the ones raising interest rates, when they were targeting interest rates, per se. But with fixed monetary targets they could just say, 'Who, us?'" (quoted in Hargrove and Morely, 1984, p. 486).

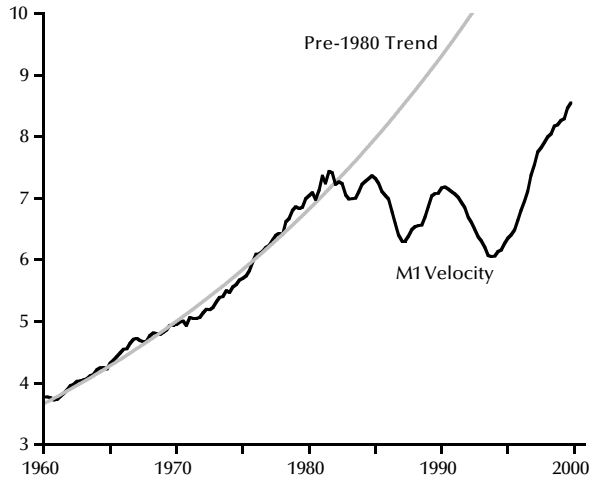
Regardless of whether the Fed had in fact adopted a monetarist policy in 1979, large, volatile movements in velocity began to erode professional support for monetarist policies. Inflation and attendant increases in market interest rates encouraged financial innovations that gave consumers more options for holding liquid balances. This, in turn, spurred regulatory changes that produced sharp changes in the relative demands for liquid financial assets. At the same time, the Fed's abrupt tightening brought a sharp decline in the rate of inflation, which probably contributed to a reversal of the upward trend in velocity that had characterized the previous three decades.[36] Asset demand shifts and uncertainty about the Fed's commitment to a new path for inflation probably explain why the velocity of traditional measures of the money stock, especially the narrow measures, such as M1, favored by officials of the Federal Reserve Bank of St. Louis, began to move erratically. Stable velocity was crucial for the reduced-form models used at St. Louis to hold. If the path of velocity changed unpredictably, then the predictions of the St. Louis equation and model could be unreliable.[37] As velocity began to deviate seriously and continuously from its previously stable path, monetarist policy prescriptions became increasingly suspect.

As shown in Figure 1, the velocity of M1—the monetary aggregate used in the St. Louis model—maintained a fairly steady upward climb during the 1960s and 1970s. During the 1980s, however, M1 velocity deviated considerably from its previous path. M1 velocity appeared to become "unstable," thus justifying critics' opposition to monetary targeting.[38]

As M1 velocity deviated further from its historic trend, St. Louis Fed researchers devoted increasing effort to understanding velocity and modifying their forecasting model. Meyer and Varvares (1981), for example, made two modifications: one modification was to model the rate of inflation as a direct outcome of money growth and oil price shocks; the other modification incorporated a new Phillips curve relation. Other St. Louis Fed studies researched the lag between money and prices (Carlson, 1980), the effects of fiscal policy (Hafer, 1982), and the longer-run consequences of policy (Carlson and Hein, 1983). These studies all concluded that the reduced-form approach continued to be a reasonable way of modeling the impact of monetary policy on the economy, and early success at improving model forecasts encouraged further research along the same lines. But, because the shift in velocity had occurred only recently, and therefore affected only a limited number of observations used in the estimation of the model, these papers largely ignored the potential effects of the shift. Indeed, even Carlson's (1986) version of the model, one that made minor revisions that recognized the

Figure 1

Velocity of Money (M1)
Quarterly Data, 1960 Through 1999



[36] Gavin and Dewald (1989) show that disinflation leads to a reduction in velocity once the public comes to expect that a new trend growth rate of money and the price level have been established.

[37] This potential problem was already known. For example, Rasche (1972) noted that the successful forecasting ability of the St. Louis equation was, in part, based on the small interest elasticity of the money demand function. As he states (p. 31): "if the *short-run* interest elasticity of the money demand function is very small, then an estimated equation omitting this term [the interest rate] would most likely produce a credible forecasting record" (emphasis in original). In some sense, the constant term in equation (1) is the empirical representation of velocity. Financial innovations altered the underlying short-run interest elasticity of money demand and adversely affected the equation's forecasting ability. Because no changes along these lines were made to the model, its forecasts began to stray. More recent investigations of the behavior of velocity include Stone and Thornton (1987), Rasche (1993), Hoffman and Rasche (1996), and Laurent (1999).

[38] Monetarists had long divided over whether a narrow aggregate, such as the monetary base or M1, or a broader aggregate, such as M2 or M3, was a preferable target for monetary policy. St. Louis Fed officials advocated M1, while Milton Friedman favored M2. When M1 velocity began to deviate from its trend in the early 1980s, M2 velocity remained relatively stable. By the early 1990s, however, M2 velocity also had deviated substantially from its long-run trend.

impact of energy prices, wage and price controls, and several other technical changes, continued to fit the data reasonably well. Thus, for a time, monetarists continued to argue that nominal income growth reflected changes in money growth over short periods and that inflation reflected money growth over longer periods, even during this turbulent time. As the 1980s progressed, however, continued instability of velocity caused all but the most diehard supporters to abandon short-run monetary aggregate targets.

LESSONS FROM THE ST. LOUIS EXPERIENCE

The development and decline of the St. Louis monetarist model as a guide to short-run stabilization policy is not unlike the evolution of stabilization policies designed to exploit a tradeoff between inflation and unemployment. Policies based on the Phillips curve arose from an apparently robust empirical relationship between inflation and unemployment observed in macroeconomic data. As discussed in King and Watson (1994), the negative correlation between the variables in the short-run suggested the presence of a long-run structural relationship that could be exploited for policy purposes. Attempts to manipulate interest rates to increase the growth of real output and employment above potential, however, gave rise to what has been called "the great inflation" in the United States, a period encompassing the 1960s and 1970s.[39]

Over the 1970s, as inflation and unemployment rose simultaneously, monetarists gained a stronger voice in monetary policy debates as the long-run relations among money, prices, and nominal income seemed to hold even in the short-run. Due in part to work at the Federal Reserve Bank of St. Louis, Woodford (forthcoming, p. 18) suggests that "the monetarist viewpoint had become the new orthodoxy by the mid-1970s."

The St. Louis Bank and its officials had special prominence because they provided an avenue for monetarist research and views to potentially influence policy deliberations. To be influential, however, monetarists had to offer a viable policy for the short-run—a policy that could be discussed and voted on at meetings some six weeks apart. The success of the St. Louis model at forecasting output, nominal income, and prices over such short horizons during the 1970s convinced St. Louis Fed officials that they could credibly advocate a monetarist stabilization policy for the short-run.

The Federal Reserve took a step toward monetary aggregate targeting in October 1979, when new procedures were implemented to better control the money stock with the goal of reducing inflation. The targeting of monetary aggregates was largely abandoned in 1982, however, when velocity, particularly of M1—the narrow aggregate favored by St. Louis Fed officials—proved too erratic.

Deregulation, other institutional changes, and uncertainty about the Fed's commitment to disinflation probably explain much of the unstable behavior of velocity in the 1980s. The Depository Institution Deregulation and Monetary Control Act of 1980 (DIDMCA) instituted a six-year process ending the prohibition of interest payments on transaction accounts at commercial banks and deregulating rates on other accounts. These changes, and various financial innovations, were followed by volatile flows between classes of financial assets that altered the empirical relationships between national income and monetary aggregates. Monetary aggregates quickly lost favor as short-run policy targets when movements in velocity became difficult to explain or predict. In essence, changes in the structure of the economy altered the short-run relationships between traditional monetary aggregates and policy objectives. Monetarist models, including the St. Louis model, were not equipped to handle such changes, and their forecasting performance suffered as a result.

Typical macroeconomic models of the 1970s, including the St. Louis model, also were not equipped to deal with the so-called "Lucas Critique." Lucas (1976) demonstrated that coefficient estimates of typical forecasting models are unlikely to be stable across policy regimes. As individuals learn about and modify their behavior in response to a change in regime, empirical relationships among macroeconomic variables may change. Consequently, economic projections based on estimation of a model over one regime may not be valid for a different regime. For example, the close short-run correlations among money, output, and prices observed during the 1960s and 1970s under a regime characterized by interest rate targeting would not necessarily have been so close in a regime of monetary aggregate

[39] For alternative views of this period, see DeLong (1997), Mayer (1999), Sargent (1999), Taylor (1999), or Wheelock (1998).

targeting.[40]

The search for robust empirical relationships across different regimes has shown that money, nominal income, and inflation remain closely linked in the long run (Dewald, 1998; Dwyer and Hafer, 1999; Lucas, 1996; Rolnick and Weber, 1997). There also is some evidence that the linkages between money and economic activity are robust even at relatively short-run frequencies.[41] Monetary aggregates again may prove useful for economic forecasting or as guides for conducting monetary policy. Experience has shown, however, that empirical relationships between policy variables and goals can change, sometimes unpredictably. The experience with the monetarist rule as developed at the St. Louis Fed councils against overconfidence in our ability to identify infallible rules for conducting short-run stabilization policy.

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[40] The monetarist experience, in which proponents sought to replace one regime with another, contrasts with Taylor's (1993) proposal for the Fed to continue the policy rule that he found described recent policy well. Researchers have, however, questioned how well the Taylor rule actually represents Fed policy. Orphanides (1997), for example, shows that a Taylor rule derived from real-time data produces a federal funds rate path over the past decade that is quite different from that found using revised data. Kozicki (1999) shows that Taylor rule predictions are not robust to differences in measures of inflation, the output gap, the real interest rate, and to different parameterizations. Finally, Hetzel (2000) argues that use of the Taylor rule within an activist model of monetary policy will mislead policymakers as they attempt to control inflation.

[41] Dwyer and Hafer (1988, 1999) find that for a large cross-section of countries the correlation between money growth and nominal income is close to unity even over short time horizons. Similarly, based on estimates of a small VAR model with quarterly U.S. data, Dwyer (1998) concludes that the link between money and nominal income may be much closer than some have claimed. Finally, using a recursive estimate of equilibrium M2 velocity, Orphanides and Porter (2000) find that monetary aggregate-based forecasts of inflation for the 1990s are quite accurate.

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Appendix

The first version of the St. Louis monetarist model appeared in Andersen and Carlson (1970), Exhibit 1. It is summarized below. For a comparison of the original and last versions of the model, see Carlson (1986).

Total Spending Equation

1) $\Delta Y_t = f_1(\Delta M_t ... \Delta M_{t-n}, \Delta E_t ... \Delta E_{t-n})$

Price Equation

2) $\Delta P_t = f_2(D_t ... D_{t-n}, \Delta P^A)$

Demand Pressure Identity

3) $D_t = \Delta Y_t - (X_t^F - X_{t-1})$

Total Spending Identity

4) $\Delta Y_t = \Delta P_t + \Delta X_t$

Interest Rate Equation

5) $R_t = f_3(\Delta M_t, \Delta X_t ... \Delta X_{t-n}, \Delta P_t, \Delta P_t^A)$

Anticipated Price Equation

6) $\Delta P_t^A = f_4(\Delta P_{t-1} ... \Delta P_{t-n})$

Unemployment Rate Equation

7) $U_t = f_5(G_t, G_{t-1})$

GNP Gap Identity

8) $G_t = (X_t^F - X_t) / X_t^F$

Exogenous Variables:
ΔM_t = change in money stock
ΔE_t = change in high-employment Federal expenditures
X_t^F = potential output

Endogenous Variables:
ΔY_t = change in total spending (nominal GNP)
ΔP_t = change in price level (GNP deflator)
D_t = demand pressure
ΔX_t = change in output (real GNP)
R_t = market interest rate
ΔP_t^A = anticipated change in price level
U_t = unemployment rate
G_t = GNP gap

Comparing Manufacturing Export Growth Across States: What Accounts for the Differences?

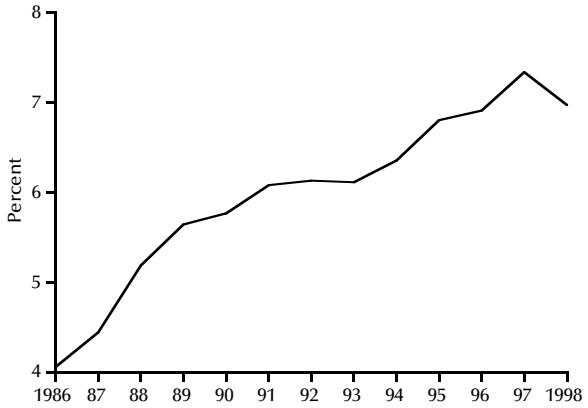
Cletus C. Coughlin and
Patricia S. Pollard

Until the reduction in manufacturing exports caused by the Asian crisis, U.S. manufacturing exports as a share of gross domestic product had trended upward since the mid-1980s. As shown in Figure 1, this share increased from 4.1 percent in 1986 to 7.3 percent in 1997, before decreasing to 7.0 percent in 1998. This feature of the internationalization of the U.S. economy has spread unevenly across regions and states. As shown in Table 1, from 1988 through 1998 the annual rate of change of manufacturing exports ranged from a low of –10.9 percent in Alaska to a high of 28.2 percent in New Mexico.[1] In this paper we examine the differences in the growth of manufacturing exports across states. Using a technique called shift-share analysis, we isolate the effects that account for the difference between a state's manufacturing export growth and U.S. manufacturing export growth between 1988 and 1998.

Applying the shift-share method generates a measure of each state's *net relative change* over the period. States in which manufacturing exports grew more (less) rapidly than the national average between 1988 and 1998 have a positive (negative) net relative change. In classic shift-share models a state's net relative change is separated into an industry mix effect and a competitive effect. The industry mix effect is the change due to differences in the initial industry makeup of the state relative to the nation. A positive (negative) industry mix effect indicates that a state's exports were relatively more concentrated in industries whose exports expanded faster (slower) than the overall national average. Meanwhile, the competitive effect in these models is the change in exports due to differences between the export growth of a state's industries and export growth at the national level, assuming the state's industry mix was the same as the nation's.

Figure 1

Manufacturing Exports as a Share of GDP
1986-98



Source: U.S. Department of Commerce, Bureau of Economic Analysis and Bureau of the Census; U. S. Department of Labor, Bureau of Labor Statistics

Recent work by Gazel and Schwer (1998) extended the classic shift-share model to incorporate the destination of a state's exports. This is potentially important because the geographic distribution of exports differs a great deal across states, a fact stressed by Erickson and Hayward (1991) and Cronovich and Gazel (1998) in general studies and by Coughlin and Pollard (2000) in a recent study of the impact of the Asian crisis on individual states. These studies highlight the importance of developments in foreign markets as a source of differential export performance across states. In the present context, a positive (negative) destination effect indicates that a state's manufacturing exports were initially relatively more concentrated in export markets that subsequently expanded faster (slower) than the overall national average.

In the following section we provide details on the data used in our study and the differences in export behavior across states. We also highlight the differences in the overall growth of manufacturing exports across states as well as the differences in the industrial compositions and geographic destinations of these exports. In the sub-

Cletus C. Coughlin is a vice president and associate director of research and Patricia S. Pollard is an economist and research officer at the Federal Reserve Bank of St. Louis. Heidi L. Beyer provided research assistance.

[1] Alaska was the only state with a decline in manufacturing exports. Between 1988 and 1998 these exports declined $1.4 billion, primarily as a result of a decline in exports of food products to Japan.

sequent section we discuss shift-share analysis and the two models we calculate—a classic shift-share model and Gazel and Schwer's (1998) model. Next, we examine our results to assess the importance of the industry mix, competitive, and destination effects. A summary of the key findings completes the paper.

EXPORT DATA DETAILS

The data on state manufacturing exports used in this study were prepared by the Massachusetts Institute for Social and Economic Research (MISER) at the University of Massachusetts. These data are export shipments by state of origin of movement at the two-digit Standard Industrial Classification (SIC) industry level. The MISER export data are regarded as the best available data source for state exports; however, these data have some well-known weaknesses that have been discussed in Cronovich and Gazel (1999) and Coughlin and Mandelbaum (1991). One potentially important problem is that the identified export state may not be the state of manufacture, but rather the state of a broker (or wholesaler) or the state where a number of shipments were consolidated. This problem is more pronounced for exports of agricultural commodities than the focus of our study, manufactured goods.

State exports exhibit much variety in both their absolute size and relative importance for economic activity in their respective states. Exports during 1998 ranged from $98.9 billion in California to $0.2 billion in Hawaii. As shown in Table 1, California and Texas led the nation during 1998 with 15.8 percent and 13.1 percent of the nation's manufacturing exports, respectively. Meanwhile, primarily because of their small economic size, seven states—Alaska, the District of Columbia, Hawaii, Montana, North Dakota, South Dakota, and Wyoming—had shares of the nation's manufacturing exports that were 0.1 percent or lower.[2]

Adjusting for the size of a state's economy, using 1998 gross state product data, produces a different picture of the importance of a state's exports. As shown in Table 2, the relative importance of exports as a share of gross state product varied substantially across states. Vermont (one of the smaller states in terms of total exports) and Washington had export shares exceeding 20 percent.[3] Michigan and Texas were also leading states, with export shares exceeding 10 percent. At the other extreme, the states showing the lowest relative manufacturing export involvement—the District of Columbia and Hawaii—had export shares of less than 1 percent.

A final point illustrated in Table 2 is the increasing importance of manufacturing exports for state economies. Between 1988 and 1998, only 6 of the 51 states experienced a decline in their ratios of manufacturing exports to gross state product—Alaska, Delaware, the District of Columbia, Louisiana, Michigan, and Montana. In seven states the share of manufacturing exports increased by more than 3 percentage points. The increase was largest in Vermont—more than 13 percentage points.

In the present paper, we focus on the growth of manufacturing exports and connect this growth to differences among states in the competitive, industry mix, and destination effects. For completeness we examined whether expressing the changes in exports in real terms, as opposed to nominal terms, altered our results in any meaningful way. The short answer is no.[4] One reason is that state manufacturing export growth rates in real and nominal terms are virtually identical. Between 1988 and 1998 the real and nominal compound annual growth rates are within 1 percentage point of each other for 47 of the 51 states. Not surprisingly, the simple correlation between these two growth rate measures is quite high (0.99). Thus, all our calculations use nominal values.

An Industry View of Manufacturing Export Growth

U.S. manufacturing exports grew at different rates across industries. Table 3 shows these different rates using two-digit SIC codes. Lumber and

[2] We treat the District of Columbia as the 51st state.

[3] A note of caution is in order. Because the measure of manufacturing exports is based on shipments, the value of exports for a state is not equivalent to value added. Thus, we are not suggesting that more than 23 percent of Vermont's gross state product was due to manufacturing exports. We are using this measure only as suggestive evidence that the importance of manufacturing exports varies across states.

[4] To calculate the real percentage change in exports, exports in 1998 were deflated by their change in price between 1988 and 1998; however, export price data are available using the Standard International Trade Classification (SITC) system rather than by SIC code. Thus, we started with an export price index that groups the data based on the SITC system and matched these industries with the appropriate SIC codes. When multiple SITC codes fit one SIC category, a weighted average of the price indices for those categories was constructed to produce the price index on an SIC basis. For additional details, see Pollard and Coughlin (1999).

Table 1

State Manufacturing Exports

State	Annual growth rate 1988-98 (percent)	Share of national manufacturing exports 1998 (percent)
Alabama	10.6	1.04
Alaska	–10.9	0.10
Arizona	13.4	1.86
Arkansas	13.8	0.38
California	9.1	15.83
Colorado	10.7	0.88
Connecticut	7.9	1.22
Delaware	6.9	0.37
District of Columbia	3.2	0.05
Florida	8.3	4.35
Georgia	12.7	2.24
Hawaii	5.5	0.04
Idaho	9.8	0.24
Illinois	10.6	4.92
Indiana	10.9	2.11
Iowa	9.3	0.80
Kansas	9.2	0.65
Kentucky	12.7	1.33
Louisiana	4.3	1.61
Maine	8.7	0.29
Maryland	7.9	0.80
Massachusetts	5.9	2.65
Michigan	4.1	4.90
Minnesota	6.9	1.45
Mississippi	6.6	0.38
Missouri	9.2	0.98
Montana	3.4	0.05
Nebraska	9.6	0.32
Nevada	12.0	0.11
New Hampshire	6.4	0.29
New Jersey	7.7	2.58
New Mexico	28.2	0.31
New York	4.7	6.05
North Carolina	10.5	2.50
North Dakota	12.9	0.10
Ohio	8.8	4.19
Oklahoma	7.6	0.47
Oregon	10.4	1.33
Pennsylvania	8.6	2.69
Rhode Island	9.1	0.17
South Carolina	11.4	1.34
South Dakota	18.1	0.07
Tennessee	13.3	1.58
Texas	10.4	13.14
Utah	14.0	0.52
Vermont	14.1	0.62
Virginia	7.9	1.92
Washington	9.7	6.25
West Virginia	4.4	0.23
Wisconsin	9.5	1.58
Wyoming	8.6	0.08

Table 2

Manufacturing Exports as a Share of Gross State Product

State	1998 (percent)*	1988 (percent)	Difference between 1998 and 1988 (percentage points)†
Alabama	5.93	3.64	2.30
Alaska	2.60	9.36	–6.76
Arizona	8.69	5.24	**3.44**
Arkansas	3.88	1.91	1.97
California	8.84	6.11	2.73
Colorado	3.88	3.00	0.87
Connecticut	5.38	4.04	1.34
Delaware	6.88	6.97	–0.09
District of Columbia	*0.59*	0.66	–0.07
Florida	6.49	5.46	1.03
Georgia	5.52	3.37	2.15
Hawaii	*0.56*	0.51	0.05
Idaho	4.90	3.99	0.91
Illinois	7.22	4.53	2.69
Indiana	7.56	4.76	2.80
Iowa	5.92	4.26	1.65
Kansas	5.30	3.66	1.64
Kentucky	7.77	4.14	**3.64**
Louisiana	7.79	8.06	–0.28
Maine	5.52	3.64	1.88
Maryland	3.05	2.31	0.74
Massachusetts	6.92	6.21	0.71
Michigan	**10.39**	11.68	–1.28
Minnesota	5.62	5.23	0.39
Mississippi	3.79	3.50	0.29
Missouri	3.75	2.62	1.13
Montana	1.58	1.89	–0.32
Nebraska	3.84	2.74	1.10
Nevada	1.11	0.90	0.21
New Hampshire	4.35	4.21	0.15
New Jersey	5.06	3.93	1.12
New Mexico	4.06	0.68	**3.38**
New York	5.35	5.27	0.09
North Carolina	6.62	4.53	2.09
North Dakota	3.72	1.96	1.76
Ohio	7.67	5.47	2.20
Oklahoma	3.60	2.71	0.90
Oregon	7.95	6.32	1.63
Pennsylvania	4.63	3.34	1.28
Rhode Island	3.54	2.31	1.23
South Carolina	8.36	4.93	**3.43**
South Dakota	1.95	0.70	1.25
Tennessee	6.19	3.26	2.93
Texas	**12.72**	9.16	**3.56**
Utah	5.46	3.26	2.20
Vermont	**23.80**	10.07	**13.72**
Virginia	5.21	4.29	0.92
Washington	**20.24**	16.36	**3.89**
West Virginia	3.66	3.61	0.05
Wisconsin	6.27	4.51	1.76
Wyoming	2.90	1.90	1.00

*Export shares of 10 percent or above are shown in bold; values of 1 percent or below are shown in italic.
†Increases in export share exceeding 3 percentage points are shown in bold.

Table 3

U.S. Export Growth by Industry 1988-98

SIC	Description	Compound annual rate (percent)
20	Food and kindred products	5.3
21	Tobacco products	5.4
22	Textile mill products	11.4
23	Apparel and related products	16.8
24	Lumber and wood products (except furniture)	1.1
25	Furniture and fixtures	18.6
26	Paper and allied products	6.8
27	Printing and publishing	9.9
28	Chemicals and allied products	6.4
29	Refined petroleum and coal products	4.5
30	Rubber and miscellaneous plastics products	11.2
31	Leather and leather products	7.3
32	Stone, clay, glass, and concrete products	8.3
33	Primary metal products	6.6
34	Fabricated metal products (except machinery and transportation equipment)	10.3
35	Industrial and commercial machinery and computer equipment	7.9
36	Electrical and electronic machinery, equipment, and supplies	13.1
37	Transportation equipment	8.7
38	Scientific and professional instruments; photographic and optical goods, etc.	8.8
39	Miscellaneous manufactured goods	10.0
20-39	All manufacturing industries	8.7

wood products (SIC 24) exports grew slowest (1.1 percent), while furniture and fixtures (SIC 25) exports grew fastest (18.6 percent). If the industry mix of exports was identical across states, then these differences in growth rates of industry exports at the national level would not explain differences in export growth at the state level. An obvious question is: Was the industry mix of state exports identical?

Using an index proposed by Finger and Kreinin (1979) for a slightly different purpose, we calculate a measure of the similarity between the sectoral concentration of a state's exports and that of the United States overall.[5] The range of this index is from zero, indicating complete dissimilarity, to 100, indicating the state's sectoral distribution of exports is identical to the national distribution. Table 4 reveals a wide range of export similarity with values for 1988 ranging from 19.4 for Alaska, which indicates very little similarity with the national distribution, to levels exceeding 80.0 for Florida, Indiana, Kentucky, Maryland, and Pennsylvania.

Table 4 also provides information on how export similarity in each state changed during 1988-98. For 36 of the 51 states, this export-similarity index increased, indicating that the industry distribution of exports from these states became more similar to the national distribution. Twenty-three states had increases of more than 5

[5] This export-similarity index is calculated quite easily: For a specific state, calculate the state's share of its total exports by a specific industry and corresponding national share for each of the 20 SIC categories. For each industry, compare the state share with the national share, take the minimum, and then sum these 20 values; next, multiply by 100.

Table 4

Export-Similarity Index on an Industry Basis

State	1988	1998	Difference between 1998 and 1988*
Alabama	72.4	71.4	–1.0
Alaska	19.4	34.1	**14.7**
Arizona	69.6	72.5	3.0
Arkansas	66.0	66.8	0.8
California	79.5	77.0	–2.5
Colorado	55.9	64.0	**8.1**
Connecticut	78.3	73.9	–4.3
Delaware	46.1	55.6	**9.5**
District of Columbia	56.7	59.1	2.4
Florida	81.8	89.5	**7.7**
Georgia	69.7	78.5	**8.8**
Hawaii	37.9	52.3	**14.4**
Idaho	55.0	58.7	3.7
Illinois	74.2	88.2	**14.1**
Indiana	82.5	78.5	–4.0
Iowa	66.9	69.6	2.7
Kansas	59.1	59.0	–0.2
Kentucky	80.1	74.2	*–5.9*
Louisiana	36.6	36.7	0.1
Maine	39.4	45.6	**6.2**
Maryland	82.7	81.8	–0.9
Massachusetts	61.2	71.9	**10.8**
Michigan	47.3	63.1	**15.8**
Minnesota	60.9	68.5	**7.6**
Mississippi	51.3	61.1	**9.8**
Missouri	78.8	77.7	–1.2
Montana	39.7	54.3	**14.6**
Nebraska	53.8	56.6	2.8
Nevada	48.5	71.6	**23.1**
New Hampshire	61.6	66.5	5.0
New Jersey	74.3	72.9	–1.4
New Mexico	62.0	31.8	*–30.2*
New York	70.2	75.9	**5.6**
North Carolina	65.3	71.5	**6.2**
North Dakota	64.5	52.7	*–11.8*
Ohio	77.5	78.5	1.0
Oklahoma	73.9	74.5	0.6
Oregon	62.1	71.4	**9.2**
Pennsylvania	81.9	85.3	3.4
Rhode Island	64.0	65.9	1.9
South Carolina	59.5	70.1	**10.6**
South Dakota	62.4	65.2	2.8
Tennessee	78.2	84.3	**6.0**
Texas	74.7	82.0	**7.3**
Utah	55.5	63.2	**7.6**
Vermont	52.1	35.0	*–17.0*
Virginia	67.4	73.1	**5.7**
Washington	48.5	41.3	*–7.2*
West Virginia	37.0	34.3	–2.6
Wisconsin	67.8	73.0	**5.2**
Wyoming	29.6	17.5	*–12.1*

* Increases of 5 or more index points are shown in bold; declines of 5 or more index points are shown in italic.

index points. The increase was largest in Nevada—roughly 23 points. Seven other states—Alaska, Hawaii, Illinois, Massachusetts, Michigan, Montana, and South Carolina—experienced increases of 10 or more index points. On the other hand, only six states experienced declines of 5 or more points. Of these states, New Mexico had the largest decline, about 30 points.

A Geographic View of Manufacturing Export Growth

The importance of specific destinations has also changed over time and varies across states. Table 5 separates the world into eight regions: the three leading countries for U.S. exports (Canada, Mexico, and Japan) and five areas (Africa, other Asia, Europe, Oceania, and other Western Hemisphere).[6] The data show that during 1988-98 U.S. export growth ranged from 14.8 percent in Mexico to 4.9 percent in Africa. If the geographic mix of exports was identical across states, then differences in growth rates of exports by geographic area at the national level would not explain differences in export growth at the state level.

Using an export-similarity index based on export destination, Table 6 reveals a range of export similarity in 1988 from 34.1 for Alaska to 92.5 for Alabama.[7] Three other states—Mississippi, North Carolina, and Pennsylvania—had index values exceeding 90.0. Numerous other states, 24 to be precise, had index values between 80.0 and 90.0. Consequently, the geographic distributions of exports for nearly half the states matched very closely with the national distribution of exports.

Table 6 also provides information on how the geographic concentration of each state's exports have changed during 1988-98. Although there is clear evidence that the industry mix of exports by states became more similar to the national distribution, there is little evidence that the distribution of exports based on destination changed much. Most states, 32 to be precise, experienced a change in this index in the range of –5 to 5 index points. Only eight states experienced increases of more than 5 points, with Delaware having the largest (roughly 38 points). On the other hand, 11 states experienced declines of 5 or more points, with New Mexico's index declining the most (roughly 46 points).

Table 5

Manufacturing Export Growth by Foreign Market 1988-98

Region	Compound annual rate (percent)
Canada	9.7
Mexico	14.8
Other Western Hemisphere	10.8
Japan	5.3
Other Asia	8.4
Africa	4.9
Europe	7.1
Oceania	5.6
World	8.7

THE BASICS OF SHIFT-SHARE ANALYSIS

Shift-share analysis is a method of separating a change, in our case the change in a state's manufacturing exports between 1988 and 1998, into meaningful components. The insert discusses the difference between this accounting explanation and an economic explanation of the change in a state's manufacturing exports. An economic explanation identifies factors that interact to determine the pattern and level of trade flows. Various international trade theories provide guidance as to the potential determinants. Similarly, the existence of alternative shift-share formulations reflects differences of opinion as to exactly which components are most useful.[8]

The Classic Shift-Share Model

Using the classic shift-share model, the change in a state's manufacturing exports is separated into a national growth effect, an industry mix effect, and a competitive effect. The national growth

[6] The Middle East is included in other Asia.

[7] This export-similarity index is also calculated quite easily: For a specific state, calculate the state's share of its total exports that are shipped to a specific region for each of the eight regions and the corresponding national share. For each destination, compare the state share with the national share, take the minimum, and then sum these eight values; next, multiply by 100. The range of this index is from zero, indicating complete dissimilarity, to 100, indicating the state's regional distribution of exports is identical to the national distribution.

[8] See Loveridge and Selting (1998) for a review of seven shift-share models.

Table 6

Export-Similarity Index on a Destination Basis

State	1988	1998	Difference between 1998 and 1988*
Alabama	92.5	87.9	–4.6
Alaska	34.1	61.4	**27.3**
Arizona	76.3	73.9	–2.3
Arkansas	89.2	88.3	–0.9
California	81.5	82.4	0.9
Colorado	77.2	77.1	–0.1
Connecticut	84.9	82.6	–2.3
Delaware	45.7	84.1	**38.4**
District of Columbia	53.5	66.1	**12.6**
Florida	57.6	50.7	*–6.9*
Georgia	85.2	86.9	1.8
Hawaii	49.2	34.2	*–15.0*
Idaho	77.4	76.2	–1.2
Illinois	87.3	84.9	–2.4
Indiana	83.1	74.5	*–8.6*
Iowa	78.7	77.7	–1.0
Kansas	86.6	82.6	–4.0
Kentucky	78.8	80.2	1.4
Louisiana	78.8	73.8	*–5.0*
Maine	80.9	69.6	*–11.3*
Maryland	82.8	80.5	–2.4
Massachusetts	76.8	81.4	4.6
Michigan	49.2	63.9	**14.8**
Minnesota	84.8	84.6	–0.1
Mississippi	90.5	83.4	*–7.1*
Missouri	85.0	82.5	–2.5
Montana	55.2	72.9	**17.7**
Nebraska	79.2	73.4	*–5.7*
Nevada	71.8	78.9	**7.1**
New Hampshire	82.1	81.9	–0.2
New Jersey	85.0	89.8	4.9
New Mexico	80.8	35.1	*–45.7*
New York	85.1	87.9	2.8
North Carolina	91.8	90.9	–0.9
North Dakota	47.7	61.3	**13.6**
Ohio	79.4	72.9	*–6.5*
Oklahoma	84.2	85.5	1.3
Oregon	77.9	76.9	–1.1
Pennsylvania	91.2	88.9	–2.3
Rhode Island	87.0	87.5	0.5
South Carolina	86.8	87.7	0.9
South Dakota	76.5	79.6	3.1
Tennessee	87.3	89.4	2.0
Texas	72.5	67.5	–4.9
Utah	86.7	69.5	*–17.2*
Vermont	52.3	54.9	2.7
Virginia	80.2	81.3	1.1
Washington	81.7	66.5	*–15.2*
West Virginia	82.4	89.1	**6.8**
Wisconsin	83.1	82.7	–0.3
Wyoming	72.9	71.6	–1.4

* Increases of 5 or more index points are shown in bold; declines of 5 or more index points are shown in italic.

CONNECTING SHIFT-SHARE ANALYSIS TO INTERNATIONAL TRADE FLOWS

In the present analysis, shift-share analysis is an accounting tool to separate the change in a state's manufacturing exports into potentially meaningful components. The analysis, however, does not provide an economic explanation as to why a state's exports grew faster or slower than the national average. The following discussion elaborates on the distinction between an accounting and an economic explanation.

International trade occurs in response to differences in prices for the same good between countries.[1] If a potential U.S. consumer can purchase a product at a lower price from a producer in Mexico than in the United States, then an incentive exists to engage in international trade. Assuming the costs stemming from trade barriers, including governmental policies such as tariffs and natural barriers such as transportation costs, are not so large as to eliminate the price advantage, then the product will be exported from Mexico to the United States.

A focal point of international trade theory is to identify the reasons why prices differ across countries. Differences across countries in terms of labor forces, stocks of public and private capital, technologies, tastes—even labor laws and environmental standards—are some of the many reasons that might cause prices to differ. Moreover, the economic size of trading partners is likely to be a key determinant of the magnitude of the trade flows between two countries. Larger economic size is likely associated with larger trade flows.

All of these factors—trade policies, transportation costs, productive resources, technology, tastes, and income—and more interact to determine the pattern and level of trade flows. Consequently, changes in these factors will likely affect how trade patterns and levels change over time. In the present study numerous factors are undoubtedly responsible for the export performance of a state between 1988 and 1998.

The shift-share analysis we perform does not allow us to identify which factors determined the relative export performance of a state. At best it suggests which factors deserve scrutiny. For example, assume a state was found to have a favorable destination effect. In 1988 a specific state might have exported a relatively larger portion of its manufactured exports to Mexico than other states. This initial situation reflects the advantages possessed by the state with respect to exporting to Mexico. Transportation costs might have played a key role in this initial condition. Between 1988 and 1998, faster U.S. export growth to Mexico than to other regions throughout the world could be expected to benefit states with relatively larger dependence on the Mexican market. The shift-share analysis provides information as to the extent to which the state is likely to be affected by this development. For the estimate of the destination effect to be plausible, one must anticipate that the advantages under-lying the state's initial export relationship with Mexico are not altered substantially during the period under consideration. The shift-share analysis, however, does not provide the economic reasons for the actual change in a state's exports to Mexico. Two possible economic reasons that come to mind immediately are the implementation of the North American Free Trade Agreement and faster economic growth in Mexico than in other world areas.

Similar comments can be made concerning the insights revolving around the industry mix results. A state with a favorable industry mix is one whose exports initially were relatively more concentrated in industries that experienced relatively rapid growth between 1988 and 1998. The shift-share analysis provides information on the extent to which the state is likely to be affected by the rapid export growth in a specific industry. Additional analysis of economic factors is needed to determine the reasons for the actual change in a state's exports in a specific industry. Some resource or technological change may cause the relatively rapid export growth.

In summary, the shift-share analysis provides some basic information to begin the analysis as to why the export performance of a specific state was above or below the national average. Looking at a state's industry mix and geographic distribution of exports is a reasonable first step in trying to provide an economic explanation for a state's export performance.

[1] Trade may also result from a difference across countries in the quality or variety of goods.

effect is the amount that a state's exports would have increased (or decreased) had they grown at the same rate as the nation's exports. Because the focus of many studies is how well a specific state has performed relative to the nation, frequently this national growth effect is simply subtracted from the change in a state's manufacturing exports to yield a state's net relative change. Then the analysis focuses on the reasons that a state's performance differs from the nation's performance.

Regardless of the handling of the national growth effect in the classic shift-share model, differential state performance is accounted for by an industry mix effect and a competitive effect. The industry mix effect is the amount of change attributable to differences in the initial industry makeup of the state relative to the nation. A positive (negative) industry mix effect indicates that a state's exports were initially relatively more concentrated in industries whose exports expanded faster (slower) than the overall national average. The competitive effect measures state economic changes not attributable to national growth or industry mix effects; it captures how much the state deviates from what would be expected if state export growth were due solely to national export expansion and the state's industry makeup. In the classic shift-share model, a competitive effect indicates the quantitative difference between a state's exports and those of the nation caused exclusively by the difference in the growth rate of that state's industries compared with that of the nation. Thus, the competitive effect is a residual. It captures the effect of changes in various factors operating at the state level, such as endowments of human capital and, possibly, export promotion expenditures.[9]

Because a state's net relative change is simply the sum of the industry mix and competitive effects, this relationship can be expressed mathematically in a straightforward manner. Using the same notation as Gazel and Schwer (1998), the relationship can be expressed:

$$(1) \qquad NRC^s = \sum_i X^s_{i,o}\,(x^n_i - x^n) + \sum_i X^s_{i,o}\,(x^s_i - x^n_i)$$

where *NRC* stands for net relative change; *s* is a superscript designating a specific state; *X* is the dollar value of exports; *x* is the growth rate of exports over the entire period of the study; *o* is a subscript designating the first year of the period of study; *i* is a subscript designating a specific two-digit manufacturing industry; and *n* is a superscript designating the nation.

The first term on the right side of equation (1) is the industry mix effect. The second term is the competitive effect. In terms of the notation, the industry mix effect for state *s* is the summation over the *i* two-digit manufacturing industries ($\sum_i$) of the difference between the growth nationally of exports of industry *i* (x^n_i) and the overall national growth rate of exports (x^n), multiplied by the level of the state's exports of industry *i* at the beginning of the period ($X^s_{i,o}$). The competitive effect for state *s* is the summation over the *i* two-digit manufacturing industries ($\sum_i$) of the difference between the state's growth rate of exports of industry *i* (x^s_i) and the corresponding national growth rate of exports of industry *i* (x^n_i), multiplied by the level of the state's exports of industry *i* at the beginning of the period ($X^s_{i,o}$).

INCORPORATING DESTINATION INTO SHIFT-SHARE ANALYSIS

Gazel and Schwer's incorporation of the destination of a state's exports into a shift-share model is straightforward. The destination effect is the amount of the net relative change attributable to differences in the state's initial export destinations relative to those of the nation. A positive (negative) destination effect indicates that a state's exports were relatively more concentrated in foreign markets whose purchases from the United States expanded faster (slower) than the overall national increase in exports.[10]

A state's net relative change is now the sum of the industry, competitive, and destination effects. The industry mix effect (the first term) is unchanged from equation (1), while the competitive effect from the formula is decomposed into a new competitive effect (the second term) and the destination effect

[9] Coughlin and Mandelbaum (1990) found that the percentage change in human capital per worker was a statistically significant determinant of the competitive effect for the change in state exports from 1976 to 1986.

[10] Cronovich and Gazel (1998) used state-specific trade weights to create a measure of trade-weighted foreign income and found this measure to be a positive, statistically significant determinant of state-level manufacturing exports.

(the third term). Thus, a state's net relative change becomes:

$$(2)\quad NRC^s = \sum_i X^s_{i,o}(x^n_i - x^n) + \left(\sum_i X^s_{i,o}(x^s_i - x^n_i) - \sum_j X^s_{j,o}(x^n_j - x^n)\right) + \sum_j X^s_{j,o}(x^n_j - x^n)$$

where j is a subscript designating a foreign market.

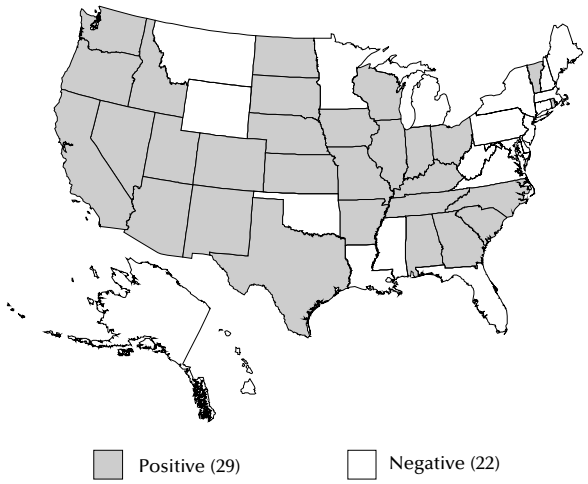
Focusing on changes from equation (1), it is easier to begin with the destination effect. In terms of the notation, this effect is the summation over the j foreign markets ($\sum_j$) of the difference between the growth rate nationally of exports to foreign market j, (x^n_j), and the overall national growth rate of exports (x^n), multiplied by the level of the state's exports to foreign market j at the beginning of the period ($X^s_{j,o}$). The redefined competitive effect is simply the competitive effect defined in equation (1) less the destination effect. By removing the destination effect from the competitive effect, Gazel and Schwer eliminate one of the explanations as to why exports from individual state industries grow at a rate different from that of the corresponding national industries. Gazel and Schwer argue that their modification is especially appealing because it retains the traditional shift-share approach, while highlighting factors that can be viewed as proxies for the supply side (the industry mix effect) and the demand side (the destination effect). The competitive effect, the residual, still may be picking up both unmodeled supply and demand factors.

SHIFT-SHARE ANALYSES OF MANUFACTURING EXPORTS

We present and discuss two sets of results. We examine the results using classic shift-share analysis and then the results using Gazel and Schwer's extension.

States in which exports grew more rapidly than the national average between 1988 and 1998 exhibit a positive net relative change, while those states whose exports grew less rapidly exhibit a negative net relative change. Over this period, exports of 29 states grew more rapidly than the national average, while exports of the remaining 22 states grew less rapidly. The map in Figure 2 distinguishes states on the basis of their net relative change. States with positive values for net relative change can be found throughout the continental United States; however, the states along the Atlantic Ocean northward from Virginia tend to have negative values for net relative change. Selected states in the South, Midwest, and the Rocky Mountains, as well as Alaska and Hawaii, also show slower export growth than the national average.

Figure 2



The classic shift-share results are presented in Table 7. To increase comparability among states, each state's net relative change and the individual components accounting for the net relative change are expressed as percentages of the export levels that would have been achieved in 1998 had the state's exports grown at the national rate between 1988 and 1998. Thus, California's exports in 1998 were 4.1 percent higher than if its exports had grown at the national rate between 1988 and 1998. This normalization allows us to highlight the export performance of those states that have substantially over- and under-performed the nation as a whole. Export growth in 11 states was more than 30 percent higher than would have been the case had their exports grown at the national rate between 1988 and 1998. This difference was most pronounced in New Mexico. Meanwhile, seven states, with Alaska leading the way, had substantially slower export growth than that of the nation.

The net relative change in state exports was driven by the competitive effect, a result similar to that of Coughlin and Mandelbaum (1990).[11] For

[11] To check whether our results were sensitive to the time period, we also examined the periods 1988-93, 1993-98, and 1996-98 separately and found results similar to those reported in Table 7.

Table 7

Classic Shift-Share Results

State	Net relative change*	Industry mix effect	Competitive effect
Alabama	19.5	–3.2	22.7
Alaska	*–86.3*	–29.0	–57.3
Arizona	**53.3**	18.5	34.8
Arkansas	**59.2**	–8.9	68.1
California	4.1	6.2	–2.1
Colorado	20.0	1.8	18.1
Connecticut	–7.1	3.0	–10.2
Delaware	–14.7	–0.8	–13.9
District of Columbia	*–40.2*	8.9	–49.1
Florida	–3.2	1.2	–4.4
Georgia	**43.3**	0.5	42.9
Hawaii	–25.7	–9.8	–16.0
Idaho	11.1	4.0	7.1
Illinois	19.6	0.8	18.7
Indiana	22.7	–0.4	23.1
Iowa	5.9	–3.9	9.8
Kansas	4.9	–7.8	12.8
Kentucky	**44.1**	–4.4	48.5
Louisiana	*–33.9*	–19.9	–14.0
Maine	–0.1	–5.3	5.2
Maryland	–6.5	1.9	–8.5
Massachusetts	–22.9	1.8	–24.7
Michigan	*–35.0*	1.9	–36.9
Minnesota	–15.3	–0.6	–14.6
Mississippi	–17.7	–8.8	–8.9
Missouri	5.2	–1.0	6.3
Montana	*–39.0*	–16.1	–22.9
Nebraska	9.4	–8.4	17.8
Nevada	**34.7**	–1.8	36.5
New Hampshire	–19.2	5.4	–24.7
New Jersey	–8.4	–1.4	–7.1
New Mexico	**420.9**	–5.1	426.0
New York	*–31.2*	3.2	–34.4
North Carolina	18.3	–0.6	18.9
North Dakota	**46.5**	–7.1	53.5
Ohio	1.7	0.1	1.6
Oklahoma	–9.2	–2.1	–7.1
Oregon	16.8	–17.2	34.0
Pennsylvania	–0.8	3.5	–4.3
Rhode Island	4.4	6.4	–2.0
South Carolina	28.5	–0.1	28.7
South Dakota	**128.2**	–2.3	130.5
Tennessee	**52.0**	–0.2	52.2
Texas	17.1	–0.5	17.5
Utah	**61.7**	12.2	49.6
Vermont	**62.7**	23.1	39.6
Virginia	–6.8	–7.0	0.2
Washington	9.9	–9.5	19.4
West Virginia	*–33.2*	–12.7	–20.6
Wisconsin	7.4	–0.8	8.2
Wyoming	–0.4	–17.7	17.3

* Net relative increases of 30 percent or more are shown in bold; decreases of 30 percent or more are shown in italic.

example, for the 29 states with a positive net relative change, the competitive effect is positive for 27 states, whereas the industry mix effect is positive for only 10 states. For the 22 states with a negative net relative change, the competitive effect is negative for 19 states, whereas the industry mix effect is negative for 13 states.

Results based on equation (2) are presented in Table 8. The competitive effect remains the most important factor accounting for a state's net relative change. The industry mix and destination effects are similar in importance, with the destination effect arguably being slightly more important. Using the absolute values of the individual effects, one finds that the competitive effect is the largest effect for 45 of the 51 states, whereas the industry mix and destination effects are the largest for 4 and 2 states, respectively.[12] The destination effect is the second largest effect for 28 states, whereas the industry mix effect is the second largest effect for 20 states. Finally, the industry mix effect is the smallest effect for 27 states, whereas the destination effect is the smallest for 21 states.

California, Louisiana, Montana, and Rhode Island were the four states for whom the industry mix effect dominated the shift-share results. For California and Rhode Island the industry mix effects were positive, indicating that their exports were relatively more concentrated in industries whose exports were rising faster than the national average for all manufacturing exports. For California this was primarily the electrical and electronic machinery industry (SIC 36) and for Rhode Island these were the miscellaneous manufactured goods industry (SIC 39) and the electrical and electronic machinery industry. As Table 3 shows, exports of both of these industries grew faster than the average for all manufacturing exports.

For Louisiana and Montana the industry mix effects were negative, indicating that their exports were relatively more concentrated in industries whose exports were rising less than the national average for all manufacturing exports. Food (SIC 20) and chemicals (SIC 28) were the key industries for Louisiana, whereas primary metals (SIC 33), lumber and wood products (SIC 24), and chemicals were the key industries for Montana. All of these industries had export growth rates below the national average, as shown in Table 3.

Hawaii and Texas were the two states for whom the foreign destination effect dominated the shift-share results. For Hawaii this effect was negative, indicating that its exports were relatively more concentrated in markets whose purchases from the United States expanded less than the national increase in manufacturing exports. Japan accounted for over 50 percent of Hawaii's manufacturing exports in 1988. National exports to Japan rose more slowly than did exports to all countries, as shown in Table 5.

For Texas the destination effect was positive, indicating that its exports were relatively more concentrated in markets whose purchases from the United States expanded faster than the national increase in manufacturing exports. Mexico accounted for 28 percent of Texas's manufacturing exports in 1988. U.S. exports to Mexico rose much faster than exports to all countries, as shown in Table 5.

The absolute values of these three effects are not the entire story. For the 29 states with faster export growth rates than the national average, the competitive effect was positive in all 29 states. For these states, the industry mix effect was positive for 10 states and the destination effect was positive for 6 states. Thus, the industry mix and foreign destination effects were more likely to be *negative* than positive for these states. For the 22 states with slower growth rates than the national average, the competitive effect was negative for 18 of them. The industry mix and destination effects also tended to be negative. The industry mix effect was negative for 13 of the 22 states, whereas the destination effect was negative for 17 of the 22 states.[13]

In view of the conflicting results concerning the relationship between net relative change and the destination effect and between net relative

[12] Our discussion of the results makes no attempt to differentiate states on the basis of size; however, two of the six states in which the competitive effect is not the largest shift-share component were California and Texas. These two were the leading export states in 1998.

[13] When we examined the periods 1988-93 and 1993-98 separately, the results for these periods were very similar to the results reported in Table 8. For 1996-98 the competitive effect is the most important factor; however, it is not as dominant as in the other periods. The industry mix effect is the second most important factor, whereas the foreign destination effect is the least important factor. As Gazel and Schwer (1998) note, the results might be sensitive to the level of data aggregation. The use of a two-digit SIC aggregation rather than a four-digit SIC aggregation might result in a smaller industry mix effect; however, the absence of data precludes exploring this possibility. To see if our results were sensitive to the level of geographic aggregation, we recalculated the model using 20 foreign destinations with the same 20 manufacturing industries. The results are virtually identical to those reported in Table 8.

Table 8

Gazel-Schwer Shift-Share Results*

State	Net relative change	Industry mix effect	Competitive effect	Destination effect
Alabama	19.5	–3.2	**25.9**	–3.2
Alaska	–86.3	–29.0	**–35.4**	–21.9
Arizona	53.3	18.5	**24.9**	9.9
Arkansas	59.2	–8.9	**68.4**	–0.3
California	4.1	**6.2**	1.6	–3.6
Colorado	20.0	1.8	**26.7**	–8.6
Connecticut	–7.1	3.0	**–5.3**	–4.9
Delaware	–14.7	–0.8	**–21.1**	7.2
District of Columbia	–40.3	8.9	**–39.5**	–9.6
Florida	–3.2	1.2	**–12.1**	7.7
Georgia	43.3	0.5	**45.2**	–2.3
Hawaii	–25.7	–9.8	1.7	**–17.7**
Idaho	11.1	4.0	**13.5**	–6.4
Illinois	19.6	0.8	**21.3**	–2.6
Indiana	22.7	–0.4	**23.7**	–0.6
Iowa	5.9	–3.9	**12.5**	–2.7
Kansas	4.9	–7.8	**17.6**	–4.8
Kentucky	44.1	–4.4	**51.1**	–2.7
Louisiana	–33.9	**–19.9**	–11.5	–2.4
Maine	–0.1	–5.3	**7.5**	–2.3
Maryland	–6.5	1.9	**–7.1**	–1.3
Massachusetts	–22.9	1.8	**–15.4**	–9.3
Michigan	–35.0	1.9	**–46.3**	9.4
Minnesota	–15.3	–0.6	**–8.3**	–6.4
Mississippi	–17.7	–8.8	**–10.1**	1.2
Missouri	5.2	–1.0	**4.4**	1.9
Montana	–39.0	**–16.1**	–16.0	–6.9
Nebraska	9.4	–8.4	**21.8**	–3.9
Nevada	34.7	–1.8	**44.1**	–7.6
New Hampshire	–19.2	5.4	**–18.1**	–6.5
New Jersey	–8.4	–1.4	**–3.8**	–3.2
New Mexico	420.9	–5.1	**420.4**	5.6
New York	–31.2	3.2	**–31.1**	–3.3
North Carolina	18.3	–0.6	**23.6**	–4.7
North Dakota	46.4	–7.1	**43.4**	10.2
Ohio	1.7	0.1	**2.2**	–0.6
Oklahoma	–9.2	–2.1	**–7.1**	–0.0
Oregon	16.8	–17.2	**45.2**	–11.1
Pennsylvania	–0.8	3.5	**–4.6**	0.4
Rhode Island	4.4	**6.4**	0.3	–2.3
South Carolina	28.5	–0.1	**32.8**	–4.2
South Dakota	129.0	–2.3	**133.1**	–2.1
Tennessee	52.0	–0.2	**52.5**	–0.3
Texas	17.1	–0.5	0.6	**16.9**
Utah	61.7	12.2	**50.2**	–0.6
Vermont	62.7	23.1	**36.3**	3.3
Virginia	–6.8	–7.0	**7.1**	–6.9
Washington	9.9	–9.5	**30.1**	–10.7
West Virginia	–33.2	–12.7	**–17.8**	–2.8
Wisconsin	7.4	–0.8	**11.0**	–2.8
Wyoming	–0.4	–17.7	**22.7**	–5.4

* The largest effect for each state is shown in bold.

change and the industry mix effect, we calculated some simple correlation coefficients between net relative change and each of the shift-share components. Not surprisingly, a large positive and statistically significant correlation existed between net relative change and the competitive effect (0.87). Albeit positive, the correlation between net relative change and the destination effect (0.20) was not statistically significant. No statistically significant correlation between net relative change and the industry mix effect was found either, and, in fact, a weak negative correlation existed (–0.05).

The preceding results are similar to those generated by Gazel and Schwer using state export data for 1989-92; however, noteworthy differences exist. As with our results, they found that the competitive effect tended to be the most important factor in accounting for a state's net relative change. Using the absolute values of the individual effects, their results revealed that the competitive effect was the largest effect for 39 of the 51 states, whereas the industry mix and destination effects were the largest effects for 5 and 7 states, respectively. Furthermore, for the 35 states with faster export growth than the nation as a whole, their competitive effect was positive for 32 of them.

Meanwhile, somewhat contrary to our findings, their industry mix effect was positive for 21 of these states and the foreign destination effect was positive for 17 states. For the states with slower export growth than the nation as a whole, the signs of the shift-share components were more similar than those for the states with relatively fast export growth. For these 16 states, the competitive effect was negative for 12 states, whereas the industry mix and destination effects were negative for 10 states (not all of which were the same states). Finally, contrary to our findings, they found that both the industry mix and destination effects were correlated positively to a statistically significant extent with net relative change. The differences in their results and ours are due primarily to the dissimilarity in industry coverage. Our study is limited to manufacturing industries, whereas Gazel and Schwer include agricultural and natural resources.

CONCLUSION

State export performance over 1988-98 shows much variation. To account for this variation, the present study used both a classic shift-share analysis and an extension proposed by Gazel and Schwer. In the classic shift-share analysis, differences in state export growth relative to the nation are accounted for by differences in industry mix and competitive effects. The former is positive (negative) if a state's exports were relatively more concentrated in industries whose exports expanded faster (slower) than the national average. The latter effect captures differences accounted for by differences in industry mix. The Gazel and Schwer extension incorporates a destination effect. It is positive (negative) if a state's exports were relatively more concentrated in foreign markets whose purchases from the U.S. expanded faster (slower) than the overall national increase in exports. The competitive effect, now captures differences unaccounted for by the industry mix and destination effects. It is important to stress that these shift-share models are accounting identities and are not economic explanations of, in this case, relative state export growth.

Regardless of the shift-share formula, the competitive effect is the key determinant of whether a state's exports grew more or less rapidly than the national average. Increased knowledge of the factors determining this effect is essential for understanding the relative export performance across states. Prior research suggests one possible economic explanation for this result: that those states with larger increases in human capital per worker have seen their industries outperform the corresponding national industries in terms of export growth.

Generally speaking, the destination and industry mix effects were equally important but not necessarily in the ways one might expect. For example, for those states whose exports grew more rapidly than the national average, both the industry mix and foreign destination effects were negative. For those states with slower export growth rates than the national average, the industry mix and destination effects were negative, as expected. Overall, the destination effect was correlated positively with net relative change; however, this relationship was not statistically significant. Consequently, the results associated with the foreign destination effect, while enriching the shift-share formula, reveal that this effect is, at most, a small piece of the puzzle for understanding the relative manufacturing export performance across states between 1988 and 1998.

Looking forward, because the industry distribution of most states became more similar to the nation's between 1988 and 1998, the industry mix

effect is likely to become less important in accounting for state manufacturing export growth. Because the export similarity on a geographic basis has changed little, the importance of the foreign destination effect is likely to increase in importance relative to the industry mix effect.

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Membership Structure, Competition, and Occupational Credit Union Deposit Rates

William R. Emmons and
Frank A. Schmid

How do credit unions set deposit rates? As we will show, the answer to this question depends on (i) who actually makes business decisions in credit unions (who is in control), and (ii) whether local deposit market conditions are important. Although members legally control all credit unions, an occupational credit union requires a sponsor (i.e., an employer) that could withdraw its support from the credit union or apply pressure on members if the sponsor's interests were not being served. Thus, the question of who effectively controls an occupational credit union is an empirical question.

If members effectively control an occupational credit union, then the array of services offered and the pricing of these services may be skewed toward the interests of a subset of members. This is because, in a one-member, one-vote governance system, there is a strong "winner-takes-all" incentive to gain (and exploit) control. Conversely, if the credit union's sponsor (i.e., the employer) controls the institution, then there is likely to be a more balanced distribution of surplus to all members. This is because employers sponsor occupational credit unions to maximize the total surplus the credit union creates for all employees rather than to maximize the surplus for a particular group of employees. Finally, if local deposit-market competition tends to constrain rate-setting behavior, then the credit union's membership structure shouldn't matter at all in the determination of deposit rates.

This paper explores the member-control, the sponsor-control, and the market-control hypotheses and then tests a key prediction made by each. The test is motivated by our theoretical examination of the pricing of deposits that would be expected under each of the three regimes. Because we present a simple model in which there is no risk, we restrict our empirical analysis to deposit rates. An examination of loan rates, by way of contrast, would require controls for the riskiness of individual borrowers and is rife with complications that would only obscure our simple objective. Furthermore, we assume that each credit union member is either a borrower or a depositor but not both (again, for simplicity).

We hypothesize that, if depositors are in control, they will maximize their own surplus by setting high deposit and loan rates, taking into account local market conditions that constrain their actions.[1] We will show that the larger the majority that depositors enjoy, the lower deposit rates should be. This is because the number of members that the depositors are able to "exploit" is lower. Thus, we expect a positive relationship between the borrower-to-member ratio and deposit rates, conditional on depositor control of the credit union. We also expect that the loan rate in this regime is independent of the membership distribution, corresponding to the familiar textbook monopoly case for constant marginal costs.

If borrowers are in control, on the other hand, we hypothesize that the credit union chooses relatively low deposit and loan rates to maximize the surplus of borrowers, taking due account of local market conditions. In this regime, the deposit rate is independent of the number of borrowers in the membership, corresponding to the textbook "monopsony" result (monopoly of the buyer, rather than the seller). Meanwhile, a higher number of borrowers implies a higher loan rate, because the number of "exploitable" members is lower.

In summary, the member-control hypothesis implies that, as we examine the membership structure of credit unions in cross-section, deposit rates will rise as the number of borrowers in the membership rises as long as the borrowers are in the minority. Once the majority changes from depositors to borrowers, the deposit rate drops

William R. Emmons is an economist and Frank A. Schmid is a senior economist at the Federal Reserve Bank of St. Louis. William Bock and Judith Hazen provided research assistance.

[1] Technically, members buy "shares" or "share drafts" in credit unions rather than make deposits. Instead of interest on deposits, credit union members receive "dividends." We use the terms deposits and interest to avoid any confusion with shares and dividends issued by for-profit firms.

and remains at a low level, independent of how big the borrower majority is.

The sponsor-control hypothesis of occupational credit unions, by way of contrast, presumes that the welfare of each member is weighted equally. The only reason why deposit rates would be associated with the membership structure in a given credit union would be if deposits were an important marginal source of loanable funds. That is, by virtue of having a high number of borrowers, a credit union would have high loan demand. This higher demand would be met by attracting additional deposit funds from members (existing or new). To do this, a credit union would need to offer higher deposit rates. Thus, when examining the cross-section of occupational credit unions, deposit rates would be higher for credit unions with a high proportion of borrowers in the membership.

Finally, the market-control hypothesis describes a situation in which local deposit-market competition constrains credit union rate-setting behavior completely. In other words, no single credit union could set its own deposit rates below local deposit rates without suffering a deposit outflow. Likewise, it could not set rates above the local market without attracting a huge and unusable deposit inflow (limited by its potential membership, of course). The important point for our purposes is that local market competition, rather than the credit union's number of borrowers or lenders in the membership, would dictate rate-setting behavior.

We analyze a large sample of occupational credit unions that reported financial results at the end of 1997. We characterize the membership distribution by calculating the ratio of the number of loans to the number of members. Our assumption is that this ratio can serve as a proxy for the number of borrowers in the membership. Our sample contains some occupational credit unions with relatively low loan-to-member ratios, which is consistent with depositor majorities. It also contains observations with loan-to-member ratios so high that borrower majorities can be assumed. We find that observed deposit rates are positively associated with the loan-to-member ratio over virtually the entire range of loan-to-member ratios. This result is consistent with the sponsor-control hypothesis of occupational credit unions but is inconsistent with both the member-control and the market-control hypotheses.

BACKGROUND AND RESEARCH ON OCCUPATIONAL CREDIT UNIONS

Credit unions numbered 11,392 at year-end 1996, serving some 70 million individual members (U.S. Treasury, 1997, p. 15). Credit-union assets were $327 billion, compared with $5,606 billion held by commercial banks and thrifts (U.S. Treasury, 1997, p. 21). Of the 7,068 federally chartered institutions at year-end 1996, about three fourths were occupational credit unions (U.S. Treasury, 1997, p. 19).[2] One or more firms sponsor each occupational credit union, sometimes providing office space, paid time off for volunteer workers, and other forms of support. The remaining federal credit unions are as follows: (i) single-group credit unions of the associational or community type, or (ii) multiple-group credit unions with predominantly associational, community, or more than one type of membership (i.e., several types of membership groups that span the usual classifications). According to a credit union survey in 1987, 79 percent of all Americans who were eligible to join a credit union had done so (American Bankers Association, 1989, p. 29). Given the prominent role of occupational credit unions, a majority of members are in the prime working ages of 25 to 44 (American Bankers Association, 1989, p. 30).

Most members of occupational credit unions easily could (and often do) obtain financial services from a for-profit financial intermediary such as a commercial bank or a thrift institution. Why then do so many employers sponsor credit unions? Hansmann (1996) suggests that occupational credit unions continue to thrive today because employers (sponsors) benefit from them:

> Employers can also benefit from having a credit union for their employees. The credit union ties the employees more tightly to the employer, improves the employees' financial situation (and consequently their effective wage), and helps keep the employees out of financial difficulties that may interfere with their work or create bother for the employer (such as garnishment of wages). For these reasons

[2] We concentrate on federally chartered credit unions because the National Credit Union Association does not vouch for the accuracy of data provided by state-chartered credit unions, which report directly to their state's regulatory authorities.

> employers have often helped promote the formation of credit unions, for example, by providing free office space and free time off to the employees who administer them. (Hansmann, 1996, pp. 259-60)

Most credit union sponsors are in nonfinancial businesses, so they may not be well-suited—or particularly eager—to operate a financial institution. At the same time, credit unions are legally governed by their members on a one-member, one-vote basis. Do the members therefore control occupational credit unions? Or do local market conditions dictate many of the business decisions an occupational credit union must make, such as setting deposit rates?

The possibility of member control is important because there may be (roughly speaking) two distinct types of members: those whose primary reason for joining the credit union is to borrow money and those whose primary reason for joining is to save in the form of insured deposits. If members (or member coalitions) effectively control occupational credit unions, then the relative size of the two groups of members determines how deposit and loan terms are set. Gaining effective control of the credit union would allow one group or the other to skew the credit union's terms in their own favor.

The question of who controls cooperative financial institutions, such as occupational credit unions, is an old one (Taylor, 1971; Flannery, 1974; Smith, Cargill, and Meyer, 1981; Smith, 1984; Hart and Moore, 1996, 1998; Emmons and Mueller, 1997; Emmons and Schmid, 1999a, 2000b). Most studies of this type assume that one group of members, such as depositors or borrowers, controls the cooperative firm. Empirical evidence about credit unions is mixed; some studies find depositor domination and others find borrower domination. Emmons and Schmid (1999a) offer an exception to the usual approach that members control the cooperative financial institution. They assume the sponsor exercises control. This study revisits this question in an attempt to find evidence consistent with the member-control, the sponsor-control, or the market-control hypothesis.

A MODEL OF CONTROL IN OCCUPATIONAL CREDIT UNIONS

We examine a simple credit union that generates surplus for its members by presenting opportunities to borrow and to deposit funds in an insured account. The supply and demand functions are reduced-form equations that result from household optimization subject to the local deposit-market conditions. To keep the model simple, we do not explicitly model these household decisions but instead postulate the existence of demand and supply functions.

We present three (mutually exclusive) hypotheses regarding effective control of an occupational credit union: (i) the member-control hypothesis, under which a controlling group of members sets deposit and loan rates to maximize its own surplus, (ii) the sponsor-control hypothesis, under which the sponsoring firm sets deposit and loan rates to maximize the total surplus for all members, and (iii) the market-control hypothesis, under which local deposit-market competition dictates the rates every credit union sets.

In our model, all potential credit-union members are identical except that some are borrowers while others are depositors.[3] We assume that the number of loans is proportional to the number of borrowers, and likewise for depositors. More specifically, we assume that each borrowing member wants one loan and responds to changes in the loan rate by adjusting the size of the loan.[4] The aggregated demand curve for loans and the aggregated supply curve of deposits are obtained by adding up the individual quantities for each price (loan rate and deposit rate, respectively) for each credit union. We analyze aggregated demand and supply curves to derive hypotheses about optimal rate-setting under the three control regimes analyzed here.

We assume the credit union operates under a zero-profit constraint, given its not-for-profit character. The credit union can lend or borrow in the interbank market at the same rate, r. For simplicity, we assume that the demand for loans and the supply of deposits are both linear in the borrowing and the deposit rates, respectively. In indirect form, the loan-demand and deposit-supply schedules facing the credit union are as follows:

[3] Assuming identical potential members implies that all potential members are also actual members (or the credit union would not have formed). See Emmons and Schmid (1999b, 2000a) for models with endogenous membership decisions.

[4] The specific proportionality assumption—that each borrower takes out one loan—allows us to use the ratio of loans to members as a proxy for the number of borrowers in the credit union's membership in the empirical section of the article.

Figure 1

Sponsor Control: Credit Union Maximizes Total Surplus

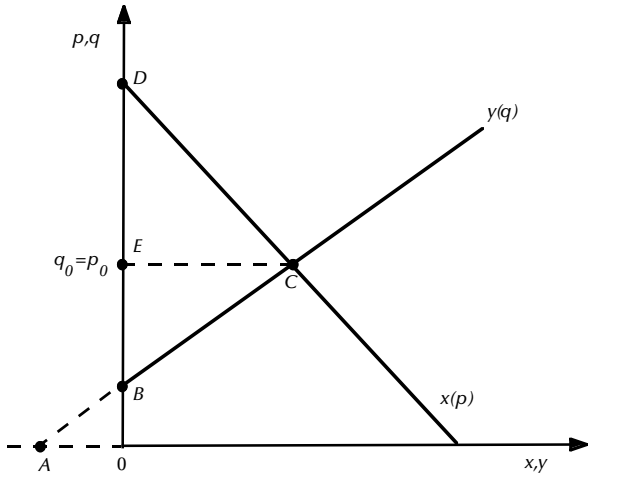
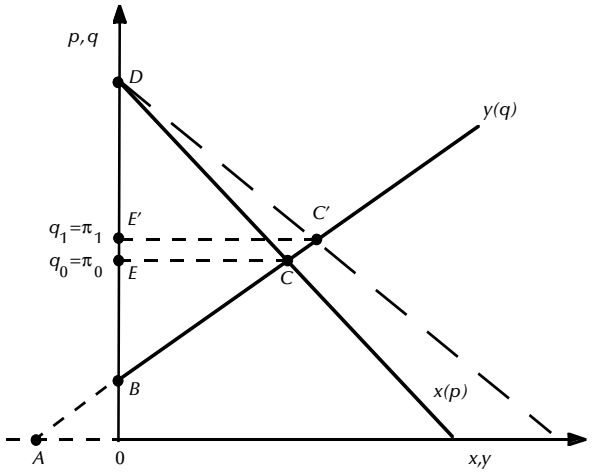


Figure 2

Sponsor Control: Number of Borrowers and Deposit Rates



(1a) $$p(x) = a - bx, \quad a, b > 0$$

(1b) $$q(y) = c + dy, \quad c, d > 0 \ ,$$

where p and q denote the loan rate and the deposit rate, respectively; x and y are the dollar amounts of loans made and deposits accepted by the bank, respectively; and a, b, c, and d are fixed parameters reflecting member preferences. In particular, we assume that the maximum loan rate the borrowers are willing to pay, a, exceeds the interbank rate, r. Likewise, the minimum deposit rate the depositors are willing to accept, c, is below the interbank rate, r. The parameters b and d reflect the sensitivities of the loan demand and deposit supply to the credit union's deposit and loan rates, respectively. For simplicity, we assume the credit union has no operating costs. This does not affect the results qualitatively and simplifies the analysis.

Sponsor Control

Sponsor control implies that the objective of an occupational credit union is to maximize the surplus enjoyed by all members. Figure 1 shows that a sponsor-controlled credit union optimally equates the deposit and loan rates at the level dictated by the intersection of members' demand and supply curves. This result follows from the basic principles of welfare economics. The surplus of borrowers is the area under the demand curve and above the optimal loan rate, p_0 (triangle ECD). Intuitively, the surplus equals the difference between the borrowers' aggregate willingness to pay for loans (indicated by the demand curve) and the amount that they actually pay. Similarly, the surplus of the depositors is equal to the difference between the amount of interest they receive and the amount of interest they are willing to accept, which is reflected in the deposit supply curve. This surplus is the area between the supply curve and the optimal deposit rate, q_0 (triangle BCE).

Figure 2 compares two credit unions with the same number of depositors (the same deposit supply curve) but with different numbers of borrowers. The credit union with the higher number of borrowers (and thus the higher borrower-to-member ratio) has a deposit and loan rate equal to q_1, compared with the lower value q_0, which is the rate of the credit union with the smaller borrower-to-member ratio.[5] This simple analysis leads to our first hypothesis:

Hypothesis 1: Sponsor Control. The deposit rate strictly increases as the number of members who are borrowers increases.

A later section discusses our strategy for testing this hypothesis.

[5] The demand curve rotates upward—rather than tracing out a parallel upward shift—because each individual borrower's willingness to pay is identical and the credit union's aggregate demand curve represents a horizontal summation of individual loan demands.

Member Control

Member control of a cooperative firm inevitably leads to conflicts of interest if there is more than one type of member. Control of decision-making determines how much surplus the credit union will generate and how this surplus will be distributed among the members. The key difference between a member-controlled credit union and one that is controlled by a sponsor is that, in the former case, the dominant member group will act like a monopoly with respect to minority members. The latter will act like a "benevolent dictator," resulting in the competitive market outcome.

Depositor Control. If depositors are in control they will maximize their surplus by solving the following optimization problem:

$$\text{(2a)} \qquad \underset{p,q}{Max} \ \frac{q-c}{2}\, y(q)$$

subject to

$$\text{(2b)} \qquad 0 = p \cdot x(p) - q \cdot y(q) + r \cdot \left[y(q) - x(p) \right]$$

$$\text{(2c)} \qquad p \geq q.$$

The quantity to be maximized is the area above the deposit-supply curve, which is determined by the choice of the deposit rate, q. Constraint (2b) sets out the credit union's zero-profit constraint and reflects the fact that interbank borrowing or lending is used to offset imbalances in the amount of loanable funds demanded and supplied by members at the chosen interest rates. Constraint (2c) excludes profitable roundtrip transactions in which members finance high-rate deposits by borrowing low-rate funds from the credit union.

Solving the maximization problem shown above, the optimal deposit rate, q^*, and the optimal loan rate, p^*, are as follows[6]:

$$\text{(3a)} \qquad q^* = \frac{c + r + \sqrt{(c-r)^2 + \frac{d}{b}(a-r)^2}}{2}$$

$$\text{(3b)} \qquad p^* = \frac{a+r}{2}.$$

Equation (3a) shows that, if we compare two credit unions that differ in the number of borrowers (i.e., in the demand parameter b) but are otherwise comparable, the credit union with the higher number of borrowers (lower value of b) has the higher deposit rate, q^*. This reflects the fact that with a higher borrower-to-member ratio there are more minority members who can be "exploited" in terms of high loan rates, which, in turn, allows the credit union to pay higher deposit rates. A depositor-controlled credit union chooses the monopoly loan rate, p^*, and pays q^* on deposits, producing surplus for depositors. The credit union has excess deposits, in the amount $y(q^*) - x(p^*)$, which are lent in the interbank market. In effect, the monopoly profit obtained through lending the amount $x(p^*)$ is distributed to depositors in the form of deposit rates that are higher than interbank rates. Note that the loan rate changes in response to changes in the membership structure only if control of the credit union also switches from depositors to borrowers.

Borrower Control. Borrowers will control the credit union if they constitute a large enough fraction of the membership. Under borrower control, the credit union's maximization program is the following:

$$\text{(4)} \qquad \underset{p,q}{Max} \ \frac{a-p}{2}\, x(p)$$

subject to

$$\text{(2b)} \qquad 0 = p \cdot x(p) - q \cdot y(q) + r \cdot \left[y(q) - x(p) \right]$$

$$\text{(2c)} \qquad p \geq q.$$

In this case, the quantity to be maximized is the area below the loan demand curve, which is determined by the choice of the loan rate, p. The optimal deposit rate, q^*, and the optimal loan rate, p^*, are as follows[7]:

$$\text{(5a)} \qquad q^* = \frac{c+r}{2}$$

$$\text{(5b)} \qquad p^* = \frac{a + r - \sqrt{(a-r)^2 + \frac{b}{d}(r-c)^2}}{2}.$$

---

[6] The second solution to the deposit is

$$q^* = \left(c + r - \left[(c-r)^2 + \tfrac{d}{b}(a-r)^2 \right]^{\frac{1}{2}} \right) / 2.$$

The solution represents a minimum in the depositors' surplus. We assume the solution is interior (constraint (2c) is not binding).

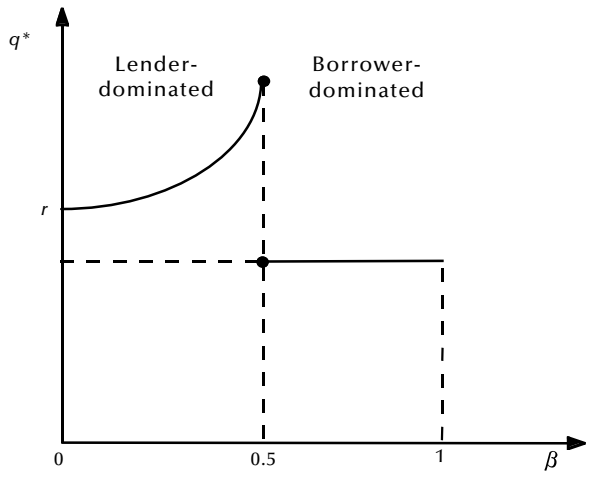
[7] The second solution to the loan rate is

$$p^* = \left(a + r + \left[(a-r)^2 + \tfrac{b}{d}(r-c)^2 \right]^{\frac{1}{2}} \right) / 2.$$

The solution represents a minimum in the borrowers' surplus. Again, we assume $p < q$.

Figure 3

Member Control: Loan-to-Member Ratio and Deposit Rates



In a way analogous to the case considered above in which the loan rate was invariant, the deposit rate is unaffected by changes in the number of borrowers (represented by variations in the loan demand parameter, b). Holding all else equal, the optimal loan rate increases with the number of borrowers because progressively more borrowers must share the surplus generated by low-priced deposits. A borrower-controlled credit union sets a relatively low lending rate, p^*, and attracts more loan demand, $x(p^*)$, than there is deposit supply, $y(q^*)$. The shortfall in deposit funding is met by borrowing in the interbank market at rate r. In effect, the monopsony profits earned by the credit union on deposits collected at rate q^* are distributed to borrowers in the form of a below-interbank market lending rate of p^*. In this case it is the deposit rate that is insensitive to small changes in the membership structure as long as these changes do not transfer control away from borrowers.

Implications of Member Control. When combining the two variations on the theme of member control, two features are noteworthy. First, the deposit rate is greater throughout the depositor-dominated regime than it is anywhere in the borrower-dominated regime. This makes intuitive sense because depositors who exercise control over the credit union will capitalize on this fact and pay themselves a higher deposit rate. Second, the fact that control must shift from depositors to borrowers at some point as the percentage of borrowers in the membership increases implies that there is a discontinuity in the schedule of optimal deposit rates. Figure 3 displays these two features, where β is the fraction of members who are borrowers. The results of our analysis of the case of member control lead us to the following hypothesis:

Hypothesis 2: Member Control. The deposit rate strictly increases as the number of borrowers increases if a credit union is under depositor control. The deposit rate is constant and takes on its global minimum value if a credit union is under borrower control.

Market Control

Thus far, we have focused only on the internal control features of occupational credit unions. It is clear, however, that external factors may constrain the ability of a controlling group of credit union members to extract surplus. If price competition is strong in local deposit or loan markets, minority members may threaten to leave the credit union to improve the terms they receive. This leads to our third testable hypothesis:

Hypothesis 3: Market Control. Deposit rates are independent of credit-union membership structure (the fraction of members who are borrowers).

EMPIRICAL EVIDENCE

We use the loan-to-member ratio as a proxy for the borrower-to-member ratio. Our sample includes occupational credit unions with loan-to-member ratios so low that depositors almost certainly are in the majority. The sample also contains credit unions in which the loan-to-member ratio is so high that a borrower majority appears inevitable. Given the wide range of membership structures that we observe and our model's predictions, a deposit rate that strictly increases as the loan-to-member ratio increases would support Hypothesis 1, namely, sponsor control of occupational credit unions. A deposit rate that initially increases, drops discontinuously, and then remains constant as the loan-to-member ratio increases would support Hypothesis 2, namely, member control. A pattern of deposit rates that is completely unrelated to the loan-to-member ratio would support Hypothesis 3, namely, market control. Note that these qualitative predictions about the dataset do not require us to identify which credit unions are depositor-controlled and which are borrower-controlled (if any).

Table 1

Distribution of Credit Unions by Type of Membership

Type of membership (TOM)	TOM codes *		Number of credit unions	
	Single-group credit unions	Multiple-group credit unions	Single-group credit unions	Multiple-group credit unions
Educational	4	34	327	494
Military	5	35	39	130
Federal, state, local government	6	36	417	649
Manufacturing	10-15	40-49	843	871
Services	20-23	50-53	585	779
Totals			2,211	2,923

* National Credit Union Association (NCUA), Instruction No. 6010.2, July 28, 1995.

Table 2

Descriptive Statistics

	Minimum	Median	Mean	Maximum	Standard deviation
Deposit rate	0.004	0.038	0.038	0.089	0.008
Loan-to-member ratio	0.009	0.447	0.471	1.859	0.177
Herfindahl index	0.053	0.208	0.208	1	0.095

We use a semi-parametric estimation method to address the possibility that the deposit rate is nonlinear in the loan-to-member ratio (as indeed it appears to be). This ratio is included in the nonparametric part of the regression along with a constant regressor, whereas the parametric part of the regression contains a set of normalizing regressors. The normalizing regressors are four zero-one indicator variables that represent the type of membership (TOM) categories shown in Table 1, with educational credit unions serving as the numeraire unit (the excluded category). The nonparametric methodology allows the relationship between the deposit rate and the loan-to-member ratio to take on a (smooth) functional form. The assumption of a smooth relationship between the loan-to-member ratio and the deposit rate is not restrictive if the relationship between the loan-to-member ratio and the borrower-to-depositor ratio is stochastic. For example, the number of loans per borrower might not be the same for all credit unions in the sample. For details on the econometric methodology, see the Appendix.

We examine a subset of all federally chartered and federally insured occupational credit unions that reported financial information at the end of 1997 (see the Appendix for details on construction of the dataset and the variables used). Table 1 provides a breakdown of our sample according to the type of membership group characterizing each credit union. The Table distinguishes between credit unions with a single common bond and those with multiple common bonds. Overall, 2,211 credit unions in our sample had a single common bond (43 percent of the sample), whereas 2,923 credit unions (57 percent of the sample) had multiple common bonds among their membership.

Membership Structure and Deposit Rates

The estimated relationship between deposit rates and the loan-to-member ratio in our sample is displayed in Figure 4 by the solid line. In essence, the figure depicts the expected deposit rate (vertical axis) for an occupational credit union with a given loan-to-member ratio (horizontal axis). Ninety percent confidence intervals for the point estimates are shown as dashed lines.[8]

[8] For econometric reasons we discarded 627 observations with zero values for the deposit rates. We also discarded 55 observations of loan-to-member ratios greater than 2 because these seemed to be aberrations or reporting errors. For instance, one credit union reported a ratio of loans to members that equaled 365.

Figure 4

Impact of Loan-to-Member Ratio on Deposit Rates

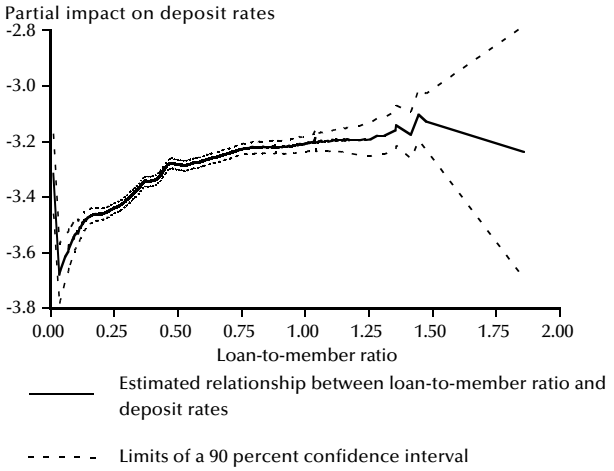


Table 3

Parametric Variables from the Semi-Parametric Regression

Type of membership (TOM) codes	Coefficient	t-Statistic
Military	2.385×10^{-2}	1.795*
Government	2.087×10^{-2}	2.239**
Manufacturing	4.560×10^{-2}	5.053***
Services	4.178×10^{-2}	4.480***
Number of observations	5,134	

*/**/*** Significant at 10/5/1 percent levels (two-tailed tests).

Figure 4 indicates a positive association between the loan-to-member ratio and credit union deposit rates over the bulk of observed loan-to-member ratios. The intercept is not identified in regressions of this type, so only vertical distances in the figure are meaningful (not the level itself). The tight confidence intervals over the central region in the figure (where the overwhelming number of credit-union observations lie) imply that the slope of the relationship is reliably positive. Confidence intervals widen dramatically and the point estimates appear erratic at extreme values of the loan-to-member ratio because there are very few observations in those ranges. Figure 4 therefore provides visual evidence to support the sponsor-control hypothesis of occupational credit unions. That is, it does not appear that member control switches from depositors to borrowers as the loan-to-member ratio increases in the cross-section of credit unions. Nor does it appear that loan-to-member ratios and deposit rates are completely unrelated, as the market-control hypothesis requires. Instead, the upward-sloping relationship is consistent with the sponsor-control regime where the membership structure and deposit rates are related because deposits are an important marginal source of funding for loans.[9]

Table 3 displays the coefficients from the parametric part of our semi-parametric regression equation. As mentioned above, the regressors are zero-one indicator variables that represent the type of membership with educational credit unions serving as the numeraire unit. The significant coefficients on TOM codes indicate that there are variations in the ability or willingness of occupational credit unions to pay higher deposit rates among different types of sponsors.

CONCLUSIONS

This article seeks to answer the question of how occupational credit unions set deposit rates. We investigate three potential control regimes under which occupational credit union deposit rates might be set, namely, member control, sponsor control, and market control.

If members control occupational credit unions, we would expect a positive relationship between the extent of loan demand and the deposit rate, conditional on depositor control of the credit union. If borrowers are in control, however, we expect the deposit rate to take on a value that is lower than what we would observe in the depositor-dominated regime; also, conditional on borrower control, we expect the deposit rate to be independent of the membership structure. Thus, the member-control hypothesis implies that, in a cross-sectional snapshot of many different credit unions, the deposit rate would be higher whenever the borrower-to-member ratio is higher so long as depositors are in control. For sufficiently high values of the borrower-to-member ratio, however, borrowers would be in the majority. For these

[9] We experimented with other empirical specifications including one in which a county-level Herfindahl index was used as a conditioning variable to represent the intensity of deposit-market competition. Details on the construction of this variable are in the Appendix. This variable was never significant, however, so we do not report results from models in which it was used.

credit unions, the deposit rate would take on its minimum value in the sample and would be completely independent of the membership structure.

The sponsor-control hypothesis of occupational credit unions, by way of contrast, predicts that deposit rates would be higher, the greater the proportion of borrowers in the membership. This is because deposits are an important marginal source of funds for meeting loan demand, and higher deposit rates are necessary to attract additional loanable funds.

Finally, the market-control hypothesis suggests that occupational credit union deposit rates and the loan-to-member ratios should be completely unrelated. Local competition would dictate deposit rates and there would be no statistical relationship between membership structure and deposit rates whatsoever.

Using data from a large sample of occupational credit unions observed at the end of 1997, we find that deposit rates are positively associated with a measure of the credit union's loan demand throughout most of the range of observed loan-to-member ratios. This finding is consistent with the sponsor-control hypothesis of occupational credit unions but not with the member-control or the market-control hypothesis. This result supports the theoretical approach taken in Emmons and Schmid (1999a), where effective sponsor control of occupational credit unions was assumed.

Thus, it appears that Hansmann's (1996) suggestion—that employers sponsor and operate occupational credit unions to provide surplus to all of their employees—is a better description in practice than the view that they are subject to capture by a subset of members or that local competition dictates credit union rates completely.

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Appendix

DATASET AND VARIABLES

The Dataset

We analyze a dataset comprising all federally chartered and federally insured credit unions at the end of 1997. The dataset was obtained from the Report of Condition and Income for Credit Unions (NCUA 5300, 5300S) and produced by the

National Credit Union Administration (NCUA). These reports are issued semi-annually in June and December. We used the December data. The flows in the December income statements include the entire year of 1997.

We concentrate on the following types of membership (TOM) groups among occupationally based credit unions: educational; military; federal, state, and local government; manufacturing; and services. Thus, we do not include community credit unions, associational credit unions, or corporate credit unions. Lists of TOM classification codes are from the NCUA (Instruction No. 6010.2, July 28, 1995).

We excluded observations for any of the following reasons:

- Missing TOM codes.
- Activity codes other than "active."
- Number of members or potential members not greater than one (applies to actual and to lagged values).
- Number of loans to members equal to zero (applies to actual and to lagged values).
- Ratio of lagged number of loans to lagged number of members greater than two.
- Nonpositive values for total assets or lagged total assets.
- Dividend on shares equal to zero.

We calculated county-specific Herfindahl indexes as measures of concentration of the local banking market. A Herfindahl index is defined as the sum of squared market shares. We measured market shares as the fraction of total commercial-bank and Bank Insurance Fund (BIF)-insured thrift deposits (as of June 30) within a county (or independent city) based on FDIC Summary of Deposits data. These data are available online at < http://www2.fdic.gov/sod/ >. Table 2 provides an overview of the dataset.

Definition of Variables

Definitions of variables and underlying data sources are listed below. Relevant item numbers are in brackets for data taken from the Report of Condition and Income for Credit Unions, produced by the National Credit Union Administration.

Dependent Variable. Deposit rate: Natural logarithm of the ratio of dividends on shares [CUSA6091] and total shares and deposits [CUSA6091]. We use the natural logarithm because the deposit rate has a lower bound at zero.

Independent Variables

1. Loan-to-member ratio: Number of loans to members divided by number of members. The number of loans to members was obtained as the difference between the number of total loans [CUSA1262] and the number of loans that were purchased or extended to non-members [CUSA1205]. The loan-to-member ratio was lagged by one year.
2. TOM code variables: Equal to one if the credit union is of a specific type (military, government, manufacturing, or services). Because we use an intercept in the nonparametric part of the semi-parametric regression, the TOM code variable for the educational credit union was dropped.
3. Herfindahl index: Sum of squared market shares of total commercial-bank and BIF-insured thrift deposits. By definition, the Herfindahl index is greater than zero; its maximum value is one. The Herfindahl index was lagged by one year. Results using the Herfindahl index are not reported in the text; see footnote 7.

Econometric Method

We use a semi-parametric model to allow the influence of the loan-to-member ratio on the dependent variable to be nonlinear. The parametric part of the model contains zero-one variables that indicate the TOM code. In particular, we use a semi-parametric model of a credit union's participation rate of the form:

$$y_i = f(x_i) + x_{pi} \cdot \beta_p + \varepsilon_i, \; i = 1,\ldots,n,$$

where y_i is the ith observation of the dependent variable; x_i is a vector consisting of the ith observation of the explanatory variables in the nonparametric part of the model, the loan-to-member ratio, and (in unreported versions of the model) the Herfindahl index; x_{pi} is a row vector consisting of the ith observation of the explanatory variables of the linear (parametric) part of the model; β_p is a column vector of the parameters of the linear part of the model; and ε_i is the ith realization of the error term. For details on this econometric approach, see the Appendix in Emmons and Schmid (1999a).

Retail Sweep Programs and Bank Reserves, 1994-1999

Richard G. Anderson and
Robert H. Rasche

In January 1994, the Federal Reserve Board permitted a commercial bank to begin using a new type of computer software that dynamically reclassifies balances in its customer accounts from transaction deposits to a type of personal-saving deposit, the money market deposit account (MMDA).[1] This reclassification reduces the bank's statutory required reserves while leaving unchanged its customers' perceived holdings of transaction deposits.

The use of deposit-sweeping software spread slowly between January 1994 and April 1995, but rapidly thereafter. Estimates of the amounts of transaction deposits reclassified as MMDAs at all U.S. depository institutions, prepared by the Board of Governors' staff, are shown in Figure 1.[2] By late 1999, the amount was approximately $372 billion. In contrast, the aggregate amount of transaction deposits (demand plus other checkable deposits) in the published M1 monetary aggregate, as of December 1999, was $599.2 billion.

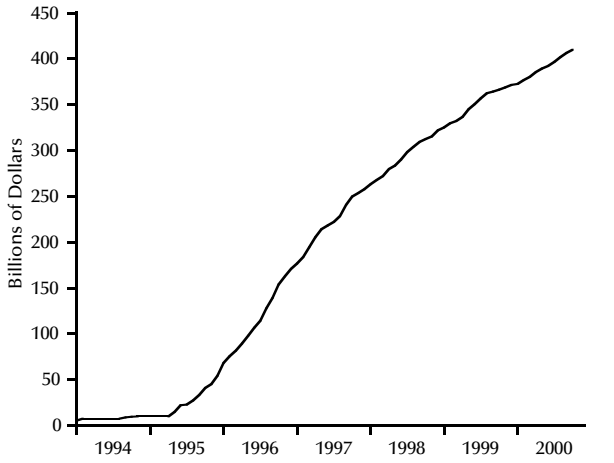
In this analysis, we interpret the effects of deposit-sweeping software on bank balance sheets to be economically equivalent to a reduction in statutory reserve-requirement ratios. We seek to measure the amount by which such deposit-sweeping activity has reduced bank reserves (vault cash and deposits at Federal Reserve Banks). Currently, transaction deposits are subject to a 10 percent statutory reserve-requirement ratio on amounts over the low-reserve tranche ($44.3 million during 2000, $42.8 million during 2001), whereas personal-saving accounts, including MMDAs, are subject to a zero ratio.[3]

To be useful in policy analysis and empirical studies, aggregate quantity data on bank reserves must be adjusted for the effects of changes in statutory reserve requirements on the quantity of reserves held by banks.[4] In the past, such adjustments were straightforward because changes in statutory reserve requirements applied simultaneously and uniformly to groups of depository

Figure 1

Sweeps of Transaction Deposits into MMDAs

Board of Governors Staff Estimates, Jan. 1994 - Oct. 2000



Richard G. Anderson is a vice president and economist and Robert H. Rasche is a senior vice president and director of research at the Federal Reserve Bank of St. Louis. Marcela M. Williams provided research assistance.

[1] O'Sullivan (1998, p. 88) identifies this bank as First Union National Bank: "The trend started almost four years ago when First National Bank applied to the Federal Reserve to do something that became known as 'the reserve sweep'." First Union's idea is reminiscent of the automatic-transfer-from-savings (ATS) account of the 1970s. It differs because transaction deposits are reclassified as MMDA deposits, a category first created in 1982 by the Garn–St. Germain Act.

[2] These data are updated monthly, with a one-month lag, and are available on this Bank's Web site at < www.stls.frb.org/research/swdata.html > .

[3] The Monetary Control Act of 1980 imposed Federal reserve requirements on net transaction deposits, which equals the sum of checkable deposits due to individuals, partnerships, corporations (including other depository institutions), the Treasury, state and local governments, and government agencies, minus the sum of cash items in process of collection and demand deposits due from other depository institutions. So far as we are aware, data on net transaction deposits have not been published by the Federal Reserve Board since implementation of the Monetary Control Act. The statutory reserve requirements applicable to transaction deposits are tiered, with a zero rate applied to the *reserve-exemption amount*, a 3 percent rate applied to the *low-reserve tranche*, and since April 1992 a 10 percent rate applied to amounts that exceed the tranche. The reserve-exemption amount and the low-reserve tranche are adjusted each year using a formula set by law. For 1992-99, the reserve-exemption amounts were $3.6, 3.8, 4.0, 4.2, 4.3, 4.4, 4.7, and 4.9 million and the low-reserve tranche amounts were $42.2, 46.8, 51.9, 54.0, 52.0, 49.3, 47.8, and 46.5 million. Prior to April 1992, the marginal ratio applicable to transaction deposits was 12 percent.

[4] A broad cross-country study illustrating the importance of such adjustments is McCallum and Hargraves (1995).

institutions within only a small number of broad classes. The effective date for changes in statutory requirements varied slightly among depositories that report data to the Federal Reserve weekly (larger banks), those that report quarterly (smaller banks), and those that report annually (very small banks). Within each group, however, the effective date was the same for all institutions. During the 1980s, the only changes in statutory requirements were due to the phase-in and indexation provisions of the Monetary Control Act. During the 1990s, the reserve-requirement ratio applicable to nonpersonal savings and time deposits was reduced from 3 percent to zero (December 1990) and the highest marginal ratio applicable to transaction deposits was reduced from 12 percent to 10 percent (April 1992).[5]

The economic effect of deposit-sweeping software is unlike these previous changes. The essence of deposit-sweeping software is that it permits banks to change the share of their transaction deposits that are subject to a non-zero statutory reserve-requirement ratio (see the insert "How Deposit-Sweeping Software Reduces Required Reserves"). Each bank is free to decide when and how to implement the software, subject to constraints discussed below. In this way, in part, banks' effective reserve requirements are "home brewed." As a result, the economic effects of deposit-sweeping software must be analyzed and measured bank-by-bank.

Our analysis suggests that required and total reserves in December 1999, measured by the reserve adjustment magnitude (RAM) developed in this article, were lower by $34.1 billion and $25.8 billion, respectively, as a result of deposit-sweeping activity. In addition, many depository institutions have reduced their required reserves to such an extent that the lower requirement places no constraint on the bank because it is less than the amount of reserves (vault cash and deposits at the Federal Reserve) that the bank requires for its ordinary day-to-day business. For these banks, the economic burden of statutory reserve requirements has been reduced to zero.

DEPOSIT-SWEEPING SOFTWARE, REQUIRED RESERVES, AND RAM

The effectiveness of deposit-sweeping software hinges on the use of the MMDA. This deposit instrument was created in 1982 by a provision in the Garn–St. Germain Act. At that time, many banks perceived extreme competitive pressures from money market mutual funds. The MMDA allowed them to offer a type of deposit that was fully competitive with money market mutual fund shares. The MMDA was not subject to Regulation Q interest rate controls, and, so long as no more than six withdrawals were made by check or preauthorized transfer during a month, it was not subject to the statutory reserve requirements applicable to transactions deposits. (If a bank permitted more than six such withdrawals, the MMDA was reservable as a transaction deposit.) The Monetary Control Act specified three categories of deposits subject to reserve requirements: net transaction deposits, savings deposits (personal and nonpersonal), and time deposits (with a minimum maturity of seven days). The act set the reserve-requirement ratio for personal-saving deposits to zero, and the Board of Governors set the ratio for nonpersonal-saving deposits to zero in December 1990. Because MMDAs are not time deposits and the Garn–St. Germain Act prohibited the Federal Reserve from imposing transaction-deposit reserve requirements, they are classified as savings deposits for reserve-requirement purposes.[6]

At its start, deposit-sweeping software creates a "shadow" MMDA deposit for each customer account. These MMDAs are not visible to the customer, that is, the customer can make neither deposits to nor withdrawals from the MMDA. To depositors, it appears as if their transaction-account deposits are unaltered; to the Federal Reserve, it appears as if the bank's level of reservable transaction deposits has decreased sharply. Although computer software varies, the objective is the same: to minimize a bank's level of reserv-

[5] For banks that reported deposit data weekly to the Federal Reserve, the reserve-requirement ratio applicable to nontransaction deposits was reduced from 3.0 percent to 1.5 percent as of December 13, 1990, and to zero as of December 27, 1990. For banks that reported deposit data quarterly, the ratio was reduced to zero as of January 17, 1991. The latter change applied to all banks as of April 2, 1992.

[6] Banks have attempted other combinations of transaction and saving deposits. In one case, a bank suggested that customers maintain several MMDA accounts and simply shift all funds among the accounts as necessary to avoid making more than six third-party payments (or transfers to other accounts) during any given month (12 CFR 204.133). In another, a bank reclassified transaction deposits as seven-day large-time deposits, staggering the maturity so as to be able to pay, each day, all checks presented (12 CFR 204.134). In these cases, the Board of Governors reclassified the saving and large-time deposits as transaction deposits and imposed transaction-deposit reserve requirements. See the Board of Governors *Regulation D*, 12 CFR Chap. 11.

HOW DEPOSIT-SWEEPING SOFTWARE REDUCES REQUIRED RESERVES

Let us consider a hypothetical $1 billion bank with $200 million in transaction deposits. We focus on two constraints faced by the bank: (i) to satisfy the Federal Reserve's statutory reserve requirements and (ii) to convert deposits into currency and settle interbank debits (related to check clearing and wire transfers) using deposits at the Federal Reserve. Fortunately, the assets involved—vault cash and deposits at the Federal Reserve—do double duty.

The Bank Before Deposit-Sweeping Software. A bank's statutory required reserves are calculated from close-of-business data. Excluding any special adjustments, the bank's required reserves as of late January 1999 would be as follows:

- 0% on the first $4.9 million of transaction deposits (the reserve-exemption amount);
- 3% on the next $41.6 million of transaction deposits (up to the low-reserve tranche of $46.5 million), equal to $1.248 million;
- 10% on the amount in excess of $46.5 million, or $15.350 million.

Banking industry data suggest that such a bank might choose to hold vault cash equal to approximately 5 percent of its transaction deposits, or $10 million. If all vault cash is "applied" to satisfy reserve requirements, the bank would need to maintain at least $6.598 million on deposit at the Federal Reserve to satisfy its statutory reserve requirement. Its balance sheet might look like Table A (see page 55).

Payments Activity and the Reserve-Requirement Tax. Banking-industry data used in our analysis suggest that a typical bank, in the absence of statutory reserve requirements, would tend to maintain deposits at the Federal Reserve equal to approximately 1 percent of its transaction deposits (in the example, $2 million). The data also suggest that deposit-sweeping activity does not affect the amount of vault cash held, relative to the sum of transaction deposits plus the amount of deposits being reclassified as MMDA. For the example bank, the reserve-requirement tax is the interest foregone by maintaining $7 million, rather than $2 million, on deposit at the Federal Reserve.

Overnight Repurchase Agreement–Based Deposit Sweeping. During the 1970s, many banks began "sweeping" customer deposits into overnight repurchase agreements (RPs). Let us suppose that the bank in this example wishes, at the behest of its large business customers, to sweep half its deposits each night. To do so, it maintains an inventory of high-quality liquid securities, such as Treasury bills. Its balance sheet at 3 p.m., prior to sweeping, might look like Table B1. At 6 p.m. after sweeping, it might appear as Table B2.

This example includes the sale (lending) of $5 million in the federal funds market; the bank is assumed to retain $2 million in deposits to service customer accounts and reduce the risk of an overnight overdraft at the Federal Reserve. If the bank's customers routinely desire to engage in overnight RPs, the bank likely will reduce its balance at the Federal Reserve and this lending will vanish.

1990s MMDA-Based Sweeping. Our examination of banking data suggests that MMDA-based sweeping may reduce transaction deposits at a typical bank by two thirds or more. If the bank in

(Continued on p. 54)

able transaction deposits, subject to several constraints. The general parameters of this optimization problem are as follows:

- The Federal Reserve calculates a bank's required reserves based on a 14-day average of the close-of-day level of its transaction deposits.[7]
- Each calendar month, an unlimited number of transfers may be made from a customer's transaction deposit account into the shadow MMDA. However, only six transfers may be made out of the shadow MMDA to the customer's transaction-deposit account.
- Checks presented to the bank for payment are only debited against the customer's transaction-deposit account, not against the MMDA. If the

[7] The computation of statutory required reserves involves two legally defined time periods: the reserve computation period and the reserve maintenance period. The former are 14-day periods that end every other Monday; the latter are 14-day periods that end every other Wednesday. Prior to August 1998, a bank's required reserves, to be maintained during a reserve maintenance period, were based on a bank's deposits during the reserve computation period ending 2 days prior to the end of the reserve maintenance period. As of August 1998, the required reserves have been based on deposits during the reserve computation period ending 30 days before the end of the reserve maintenance period. Required reserves must be satisfied by eligible vault cash and deposits held during the maintenance period at Federal Reserve Banks. Eligible vault cash is vault cash held by a bank during the reserve computation period ending 30 days before the end of the maintenance period.

(Continued from p. 53)
our example does so, its required reserves will decrease by more than 80 percent, to $3.298 million ($1.248 million on the first $46.5 million of deposits, plus $2.050 million on the next $20.5 million). Its vault cash—$10 million—is now more than adequate to fully satisfy its new, lower required reserves. After sweeping, its balance sheet might look like Table C.

Although the bank no longer needs deposits at the Federal Reserve to satisfy reserve requirements, we assume that the bank retains $2 million to service customer accounts and reduce the risk of an overnight overdraft. In a recent banking-industry journal article, a seller of MMDA-based sweep software says that an aggressive deposit-sweeping bank can reduce its holdings of reserves (vault cash and deposits at the Federal Reserve) to less than 1 percent of its total assets.[1] If our example bank reduces slightly its holdings of vault cash, it will attain that target.

In our example, both RP-based and MMDA-based sweeps reduce to zero the "burden" of statutory reserve requirements—the bank holds no more reserves than are necessary for its day-to-day operations. In addition, both types of sweeps reduce the bank's required reserves by enough that they are fully satisfied with vault cash. But, the two types of sweeps differ in other aspects. Note that RP-based sweeps constrain the bank's balance sheet—the bank must hold an inventory of suitable liquid securities, as collateral—but MMDA-based sweeps do not. Also, RP-based sweeps typically are conducted only with large business customers, often in amounts of several million dollars. These customers are economically equivalent to partners with the bank in the RP-based sweeps and hence are likely to receive a significant share of the earnings. In contrast, MMDA-based sweeps may be implemented for most, if not all, transaction-deposit customers and may be invisible to the customers. Finally, MMDA-based sweeps do not directly change the bank's total assets, liabilities, or deposits. Rather, like changes in statutory reserve requirements, they allow the bank to deploy funds from non-interest-bearing deposits at Federal Reserve Banks into loans and other investments.

The Role of Clearing Balance Contracts. The analysis above excludes one additional effect of MMDA-based deposit-sweeping activity: an increase in clearing balance contracts. A clearing balance contract is an agreement between a bank and the Federal Reserve wherein the bank agrees to maintain a certain amount of deposits at the Federal Reserve above and beyond any amount necessary to satisfy statutory reserve requirements. As compensation for (and an incentive to enter into) the contract, the bank receives earnings credits from the Federal Reserve. Earnings credits accrue at a rate slightly less than the federal funds rate and may only be used to defray the cost of financial services, such as check clearing, purchased from the Federal Reserve.

Kohn (1996, p. 48) notes that, through 1996, the aggregate amount of clearing balance contracts had tended to increase by 16 to 17 cents for each dollar that required reserves decreased due to deposit-sweep activity. Let us, therefore, reconsider our example bank. Suppose that this bank incurs an annual cost of $200,000 due to check clearing and wire transfers through the Federal Reserve, on behalf of customers. In our example, MMDA-based deposit-sweeping software reduced required reserves by more than $13 million and freed the bank from using its remaining $2 million at the Fed to satisfy required reserves. If this bank were typical of Kohn's average, it might sign a $2 million clearing-balance contract. This clearing-balance contract does not require the bank to increase its deposit at the Fed beyond the initial $2 million, nor does it infringe in any way on the bank's ability to use its $2 million deposit for routine business activity. If the federal funds rate were to be (say) 5 percent, the bank would receive approximately $100,000 per year in earnings credits. The deposit-sweeping software has done double duty—it eliminated the reserve-requirement tax and, at no cost to the bank, reduced by one-half its payments to the Federal Reserve for purchased services. *(Tables shown on p. 55)*

[1] See O'Sullivan (1998). A bank consultant, quoted in this article, estimates that almost all banks with over $750 million in assets were using deposit-sweeping software at the end of 1997 versus about 100 banks at the end of 1996. He also estimates that eventually bank profits likely will be increased between $1 billion and $3 billion by deposit-sweeping activity. The quoted consultant further suggests that most banks could reduce their vault-cash holdings by 25 to 50 percent after implementing deposit-sweeping software. To us, this seems unlikely because the deposit-sweep activity does not change the amount of deposits that the bank's customers perceive themselves to hold. In fact, we find that the impact of MMDA-based deposit-sweeping activity on vault-cash ratios (when the estimated amount of swept deposits is included in the denominator) at the banks in our sample is near zero.

DEPOSIT-SWEEPING SOFTWARE AND BANK BALANCE SHEETS

Table A: A Bank with No Sweeping Activity

Assets *		Liabilities *	
Vault cash	$10,000	Transaction deposits	$200,000
Deposits at Federal Reserve	7,000	Savings deposits	400,000
Other assets	983,000	Time deposits	300,000
		Other liabilities and capital	100,000
Total assets	1,000,000	Total liabilities	1,000,000
Memo: Required reserves	16,598		
Applied vault cash	10,000		
Surplus vault cash	0		
Applied Federal Reserve deposits	6,598		
Excess reserves (excl. vault cash)	402		

Table B1: A Bank Preparing for RP-Based Sweep

Vault cash	$10,000	Transaction deposits	$200,000
Deposits at Federal Reserve	7,000	Savings deposits	400,000
Treasury bills	100,000	Time deposits	300,000
Other assets	883,000	Other liabilities and capital	100,000
Total assets	1,000,000	Total liabilities	1,000,000
Memo: Required reserves	16,598		
Applied vault cash	10,000		
Surplus vault cash	0		
Excess reserves (excl. vault cash)	402		

Table B2: A Bank After RP-Based Sweep

Vault cash	$10,000	Transaction deposits	$100,000
Deposits at Federal Reserve	2,000	Savings deposits	400,000
Treasury bills	0	Time deposits	300,000
Federal funds sold	5,000	Other liabilities and capital	100,000
Other assets	883,000		
Total assets	900,000	Total liabilities	900,000
Memo: Required reserves	6,598		
Applied vault cash	6,598		
Surplus vault cash	3,402		
Excess reserves (excl. vault cash)	2,000		

Table C: A Bank After MMDA-Based Sweep

Vault cash	$10,000	Transaction deposits	$67,000
Deposits at Federal Reserve	2,000	Savings deposits, including MMDA	533,000
Other assets	988,000	Time deposits	300,000
		Other liabilities and capital	100,000
Total assets	1,000,000	Total liabilities	1,000,00
Memo: Required reserves	3,298		
Applied vault cash	3,298		
Surplus vault cash	6,702		
Excess reserves (excl. vault cash)	2,000		

*As of close of business; dollar amounts are in thousands.

amount of funds in the transaction deposit is inadequate, a transfer must be made from the MMDA.

- On the sixth transfer, all funds remaining in the MMDA are moved to the transaction deposit. (A seventh transfer would cause the MMDA to be subject to the reserve requirements applicable to transaction deposits.)

Because no debits are made to customer transaction deposits between just before the close of business on Friday and just before the opening of business on Monday, some early software simply reclassified transaction deposits as shadow MMDAs prior to the close of business on Friday. This reduced a bank's weekly average level of required reserves by $\frac{3}{7}$: its transaction deposit liabilities for Friday, Saturday, and Sunday, as reported to the Federal Reserve, were zero. About ten times each year, a Monday holiday allowed delaying the return of funds to transaction deposits out of the MMDA until the opening of business on Tuesday. Later software is more sophisticated and analyzes the receipt and payment patterns of customers.[8] Of course, regardless of the efficiency of the software, the bank faces two additional constraints that limit how much it can reduce its reserves. It must keep on hand sufficient vault cash so as to be able to redeem customer deposits into currency, and it must maintain sufficient deposits at Federal Reserve Banks to avoid both excessive daylight overdrafts and overdrawing its account at the end of the day.

To measure the effect of deposit-sweeping software on bank reserves, we need a benchmark, or alternative. RAM furnishes one such measure because it was designed to measure the changes in bank reserves caused by differences in statutory reserve requirements—specifically, the differences between those requirements in effect during the current period and those for a specific benchmark, or base, period.[9] The view that deposit-sweeping activity should be analyzed as a change in statutory reserve requirements, and hence included within the framework of RAM, is not universally held, however. The Board of Governors' staff, for example, does not publish reserve aggregates adjusted for the effects of deposit-sweeping activity, apparently believing that the impact of such activity is not to be interpreted as economically equivalent to a change in statutory requirements.[10]

In its economic aspects, deposit-sweeping software programs of the 1990s differ distinctly from the collateralized overnight-loan sweep programs of the 1970s—to borrow a phrase, they are not "your father's Oldsmobile." The business-oriented sweep programs of the 1970s essentially were overnight collateralized loans to mutual funds and banks, initiated by depositors (see Kohn, 1994, Chap. 9; or Stigum, 1990, Chap. 13). These loans were made with the full participation of depositors, who received directly the lion's share of the investment return; the bank's net earnings arose from being a middleman. Although such sweeps reduced banks' required reserves, their primary purpose was to simulate a legally prohibited interest-bearing demand deposit.[11]

The retail-oriented deposit-sweeping activity of the 1990s differs. First, except for competitive market pressures, it seems unlikely that banks have directly passed along the earnings from deposit-sweeping activity to transaction-account customers.[12] In part, this may be due to few retail depositors understanding the process, despite many banks notifying customers via monthly statement inserts (containing phrases such as "…your deposit may be reclassified for purposes of compliance with Federal Reserve Regulation D…"). Banks' answers to question 12 of the Federal Reserve's May 1998 *Senior Financial Officer Survey* are illustrative. On that question, banks responded

[8] O'Sullivan (1998) includes a description of one learning mechanism in recent software.

[9] For further discussion of RAM, see Anderson and Rasche (1999, 1996a, b) and earlier references therein.

[10] Alternative measures of adjusted reserves currently are published by the Board of Governors of the Federal Reserve System and by the Federal Reserve Bank of St. Louis. The measures differ with respect to both the items included and the adjustment for changes in reserve requirements. See, for example, the annual benchmark release *Reserves of Depository Institutions* (Division of Monetary Affairs, Board of Governors of the Federal Reserve System).

[11] We emphasize the *economic effects* of sweep activity. From the viewpoint of a bank manager, both RP- and MMDA-based sweeps furnish a synthetic interest-bearing demand deposit for its customers; see, for example, Coyle (2000). Note that MMDA-based sweeping may be very profitable for a bank if its customers are unaware of the practice and do not demand a share of the earnings. Some analysts have estimated that profit margins may be as high as 90 percent (O'Sullivan, 1998).

[12] To test this hypothesis, we have examined scatter plots of bank offering rates on other checkable deposits and time deposits, relative to market yields on both short- and long-term Treasury issues. In monthly data, no change is apparent during the last decade.

that even if they were permitted to pay interest on demand deposits and if the Fed paid interest on deposits at Federal Reserve Banks, they most likely would tier rates paid on demand deposits and that the highest rate "would still be considerably below the level of market interest rates." Second, the sweeps of the 1970s required banks to maintain a significant amount of high-quality liquid collateral for use in repurchase agreements with large business customers. The retail sweeps of the 1990s allow a bank to deploy into higher-earning assets, as it sees fit, the funds released by reduced required reserves. In the boxed insert "How Deposit-Sweeping Software Reduces Required Reserves," for example, the bank's earning assets increase with no increase in total deposits or funding costs.

Linkages among retail deposit-sweep programs, the Depression-era prohibition of the payment of (explicit) interest on demand deposits, and the payment by the Fed of interest on deposits at Federal Reserve Banks have been discussed by Federal Reserve Governor Lawrence Meyer in recent Congressional testimony.[13] An important issue is whether banks would reduce or eliminate the use of deposit-sweeping software if the Federal Reserve paid interest on reserve balances. Because the *economic* effects of deposit-sweeping software are similar to reductions in statutory reserve requirements, in our opinion such an outcome is unlikely. First, as noted above, it seems unlikely that banks have passed much of the benefit from 1990s-style deposit-sweeping activity on to their transaction-deposit customers. Second, because newly released funds may be invested as the bank sees fit, including in consumer and business loans, it seems unlikely that deposits at Federal Reserve Banks, earning interest at the federal funds rate, would be an attractive investment. In question 10 of the May 1998 *Senior Financial Officer Survey*, banks were asked whether they would dismantle sweep programs if the Federal Reserve paid interest on deposits. In their summary of the survey, Board staff noted that "several" banks said that they would, or might, dismantle sweep programs. More than half of the respondents, however, said that interest paid at the federal funds rate would be unattractive, relative to the higher returns available on alternative investments. The staff summary also notes, on page 8, that "the results on this question seem qualitatively different from the responses to a similar question on the May 1996 *Senior Financial Officer Survey*. On that survey, two thirds of the respondents indicated that they would dismantle their retail sweep programs either immediately or over time if interest were paid on Fed account balances held to meet reserve requirements." In our opinion, retail deposit-sweeping software is here to stay for the same economic reasons that cause banks to prefer decreases, rather than increases, in statutory reserve requirements.

Reserve-Requirement Ratios and Economically Bound Banks

To measure the effect of deposit-sweeping software on the amount of reserves held by banks, we need to separate banks wherein the quantity of reserves demanded is sensitive to changes in reserve-requirement ratios from those in which it is not.[14] When reserve requirements are "low," a depository institution's demand for reserves may be largely, or even entirely, determined by its business needs (converting customer deposits into currency, originating interbank wire transfers, settling interbank check collection debits) rather than by statutory requirements. In the United States, the level of reserves held in the absence of statutory

[13] See Meyer (1998, 2000). Meyer's 2000 testimony was in regard to House Resolution 4209, a bill that would "require the payment of interest on reserves maintained at Federal reserve [*sic*] banks…" (106th Congress, 2nd Session, as reported with amendments on October 17, 2000). The text of the bill is available on the Library of Congress' "Thomas" legislative Web site. Although the Federal Reserve does not pay explicit interest on deposits at Federal Reserve Banks, banks that enter into clearing balance contracts do currently receive at approximately the federal funds rate "earnings credits" on those deposits that are obligated under clearing balance contracts. A clearing-balance contract is a contractual agreement between a depository institution and a Federal Reserve Bank. In the contract, the depository agrees to maintain a specific amount of deposits at the Federal Reserve Bank above and beyond the amount, if any, necessary to satisfy its statutory reserve requirement. In turn, the depository institution accrues earnings credits which may be used to defray the cost of services purchased from the Federal Reserve such as check clearing and wire transfers. Earnings credits may not be converted to cash and have no cash value except in exchange for Federal Reserves services. Penalties apply for entering into such a contract and subsequently not holding sufficient deposits (Stevens, 1993). A bill now pending in Congress (H.R. 4209) would eliminate earnings credits in favor of cash interest payments.

[14] Note that in this analysis the term "total reserves" includes all vault cash held by depository institutions. In Board of Governors' publications, however, reserves includes only the amount of vault cash that is applied to satisfy statutory reserve requirements—any "surplus" amount is excluded.

reserve requirements might be very small indeed because banks are permitted daylight overdrafts on their deposit accounts at the Federal Reserve Banks (Emmons, 1997; Furfine, 2000). When statutory reserve requirements are "high," the amount of reserves held will be approximately equal to its required reserves. (This statement assumes that all base money held by depository institutions can be used to satisfy reserve requirements. In the United States, member banks could not apply vault cash to satisfy reserve requirements between 1917 and 1959.) Hence, measuring RAM requires a model of banks' demand for reserves that includes an explicit role for statutory requirements.

Let us denote a depository institution's reserve demand function as $TR^D(D,rr)$, where D denotes the institution's deposit liabilities and rr the statutory reserve-requirement ratio. Further, omitting all tiering of reserve requirements, let us denote its required reserves as $RR(D,rr) = rr \times D$. Then, when rr is relatively large,

$$\frac{\partial TR^D(D,rr)}{\partial rr} \cong \frac{\partial RR(D,rr)}{\partial rr} = D > 0$$

such that statutory reserve requirements are, at the margin, the binding constraint that determines the amount of reserves held.[15] When rr is relatively small, we assume that

$$\frac{\partial TR^D(D,rr)}{\partial rr} = 0 \ ,$$

such that the bank's business needs, rather than statutory requirements, are the binding constraint. In Anderson and Rasche (1996b), we introduced the term *economically nonbound* to describe banks where

$$\frac{\partial TR^D(D,rr)}{\partial rr} = 0$$

and *economically bound* to describe banks where

$$\frac{\partial TR^D(D,rr)}{\partial rr} > 0 \ .$$

To measure RAM, we must know (or infer) the sign of the derivative

$$\frac{\partial TR^D(D,rr)}{\partial rr}$$

at all dates and for all banks in our sample. To be specific, for an individual bank, let $RR(D_t,rr_0)$ and $RR(D_t,rr_t)$ and denote the period t levels of required reserves when the statutory requirements of a base period, 0, and of period t, respectively, are in effect. For all cases, assume that sufficient data on reservable liabilities during period t exist so as to permit calculation of the quantity $RR(D_t,rr_0)$. Then, consider four cases:

Case 1: If $rr_0 = rr_t$, that is, reserve requirements have not changed, RAM = 0.

Case 2: If

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0\\rr=rr_0}} = 0 \text{ and } \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t}} = 0 \ ,$$

that is, if the business needs of the bank were the binding constraint in both the base period *0* and period t, then RAM = 0.

Case 3: If both

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0\\rr=rr_0}} > 0 \text{ and } \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t}} > 0 \ ,$$

that is, if the statutory requirements were a binding constraint on the bank in both the base period 0 and period t, then the RAM adjustment for period t (conditional on the choice of period 0 as the base period) is

$$RAM_t = RR(D_t,rr_0) - RR(D_t,rr_t) \ .$$

Case 4: If

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0\\rr=rr_0}} > 0 \text{ but } \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t}} = 0 \ ,$$

that is, if the statutory requirements were binding in the base period but not in period t, then to measure RAM we must find the smallest reserve-requirement ratio, say rr^*, for which

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t\\rr=rr_t^*}} > 0 \ .$$

Then, $RAM_t = RR(D_t,rr_0) - RR(D_t,rr^*)$.

The above analysis is applicable to cases where the only change in statutory reserve requirements between two periods is the reserve-requirement ratio, rr, and data exist to calculate the counterfactual level

[15] Throughout this analysis, we assume that the response of excess reserves at economically bound banks to changes in the statutory reserve-requirement ratio is zero (see Anderson and Rasche, 1996b). Excess reserves at economically nonbound banks typically are positive and an inverse function of the statutory reserve-requirement ratio.

of required reserves, $RR(D_t, rr_0)$. For analysis of other cases, see Anderson and Rasche (1999).

An empirical criterion for measuring RAM in Case 4, for dates beginning November 1980, was developed by Anderson and Rasche (1996b) based on statistical analysis of a large panel dataset. That analysis suggested that a bank was economically bound during a reserve maintenance period if the bank was legally bound and had more than $135 million in net transaction deposits.

Empirical Analysis

Because the design, implementation, and operation of sweep software is idiosyncratic, our analysis focuses on a longitudinal panel of 1231 depository institutions between January 1991 and December 1999. A depository institution is included in the panel if, during at least one reserve-maintenance period, it was either economically or legally bound.[16] Our panel is a subset of a larger dataset containing more than 7500 depository institutions, which, in turn, is an updated version of the dataset used in Anderson and Rasche (1996b). For some banks, data begin after January 1991 because the bank opened for business at that point, was created by the merger of existing banks, or only then began reporting data to the Federal Reserve. For others, the data stop before December 1999 because the bank failed, merged with another bank, or was dropped from the reporting panel. For each such bank, we use the Federal Reserve's bank structure database to trace predecessors and successors. When a bank with deposit-sweeping activity is acquired by another bank, we add the amount of activity at the acquired bank to the amount at the acquiring bank. In all cases, we focus special attention on those institutions where deposit-sweeping software has reduced the level of transaction deposits to such an extent that the level of the depository's required reserves is less than the amount of reserves (vault cash and deposits at the Federal Reserve) that the bank requires for its ordinary day-to-day business.

RAM 1991-93

We begin by re-examining RAM from January 1991 through December 1993. Our previous measure of RAM was based on the statistical models of Anderson and Rasche (1996b). Those results suggested that economically bound banks (the only ones included in that measure of RAM) were characterized by two features: (i) a level of required reserves that exceeded their vault cash and (ii) having more than $135 million in net transaction deposits. This framework allowed us to classify banks into broad groups without tedious examination of time-series data for individual banks.

In this analysis, we revise our measure for 1991-93 for two reasons. First, because deposit-sweeping software allows banks to home-brew reserve requirements, our analysis for 1994-99 must necessarily be based on the examination of data for individual banks. It is important to assess whether this change in procedure—from using aggregated data for groups of banks to using individual-bank data—has any effect on measured RAM. The 1991-93 period provides an experimental control for this change in procedure. Second, we seek to reduce the number of occurrences when a bank, as well as its deposits, moves from being included in RAM to being excluded. It seems unlikely that a bank's responsiveness to possible changes in a statutory reserve-requirement ratio fluctuates very much from period to period. Absent changes in statutory reserve requirements (or a merger), we assume that a typical bank switches infrequently between economically nonbound and bound.

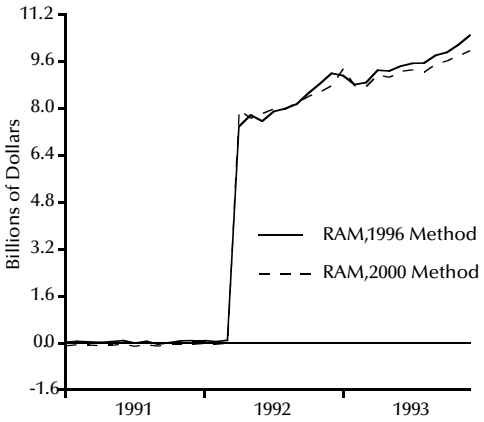
The most reliable indicator of a bank's economically bound or nonbound status is its response to a change in statutory reserve requirements. An economically bound bank will reduce its holdings of reserves, following a reduction in reserve requirements, by approximately the same amount as the decrease in its required reserves. An economically nonbound bank will not, although it might reduce its holdings by a smaller amount. Between January 1991 and December 1993, there were only two ways that the statutory reserve-requirement ratio for a bank could change:

- In April 1992, the Federal Reserve reduced the statutory reserve-requirement ratio on transaction deposits above the low-reserve tranche from 12 percent to 10 percent. If a bank reduced its deposits at Federal Reserve Banks (relative to transaction deposits) following the April 1992 reduction in reserve requirements and did not begin or increase the size of a clearing-balance contract, we classified the

[16] A bank is said to be legally bound if the amount of its required reserves exceeds the amount of vault cash that is legally permitted to apply to satisfy its reserve requirement.

Figure 2

RAM, 1991-93



bank as economically bound from January 1991 to December 1993. If the bank began or increased the amount of a clearing balance contract, we classified the bank as economically nonbound from the date of that increase through the end of December 1993. An increase in the bank's clearing balance contract at the time of the reduction indicated that payments activity, not statutory reserve requirements, had been determining the level of reserves held by the bank.

- The second change affected only banks that acquired another bank. Federal Reserve regulations permit an acquiring bank to "amortize" over eight quarters the reserve exemption amount and low-reserve tranche of the acquired bank.[17] For an acquirer with transaction deposits greater than the low-reserve tranche, the amortization reduces the acquirer's required reserves. If an acquirer did not reduce its holdings of reserves so as to match the reduced required reserves, we classified the bank as nonbound beginning in that maintenance period.

Finally, we also classified a bank as economically nonbound in a reserve-maintenance period if it is legally nonbound (that is, if its eligible vault cash exceeds its required reserves). Because some banks alternate between legally bound and nonbound, we modify this presumption by judgmentally smoothing changes in status.

Figure 2 compares two measures of RAM for 1991-93. One is based on our 1996 method, and the other on the method outlined above. The two measures, for all practical purposes, are the same.

RAM 1994-99

Deposit-sweeping activity by banks substantially complicates measuring RAM for 1994-99. To cope, we follow a three-step procedure. First, we identify the dates (reserve-maintenance periods) affected by new or expanded deposit-sweeping activity and estimate the amounts of transaction deposits relabeled as MMDA. Second, we classify each bank, for each reserve-maintenance period between January 1994 and December 1999, as economically bound or nonbound. This procedure is similar to our revised measure for RAM during 1991-93 and relies heavily on the observed response of the bank to changes in reserve-requirement ratios and the effects of implementing its deposit-sweeping software. Finally, we calculate RAM based on the framework of Cases 1, 2, 3, and 4 introduced above.

Sweep Dates and Amounts

Our first task is to identify the dates on which banks either began or changed their deposit-sweeping activity. Although the date of the first such deposit-sweep program is known (January 1994), banks are not required to notify the Federal Reserve when a program is implemented, expanded, or discontinued; nor are they required to report the amount of deposits affected.[18] To identify those dates when deposit-sweeping activity either began or was expanded, we visually analyzed time-series data for each bank. The variables examined were changes in the levels of transaction and savings deposits, changes in the size of a clearing-balance contract, and the ratios of vault cash and deposits at Federal Reserve Banks to transaction deposits.[19] For a typical bank, the data

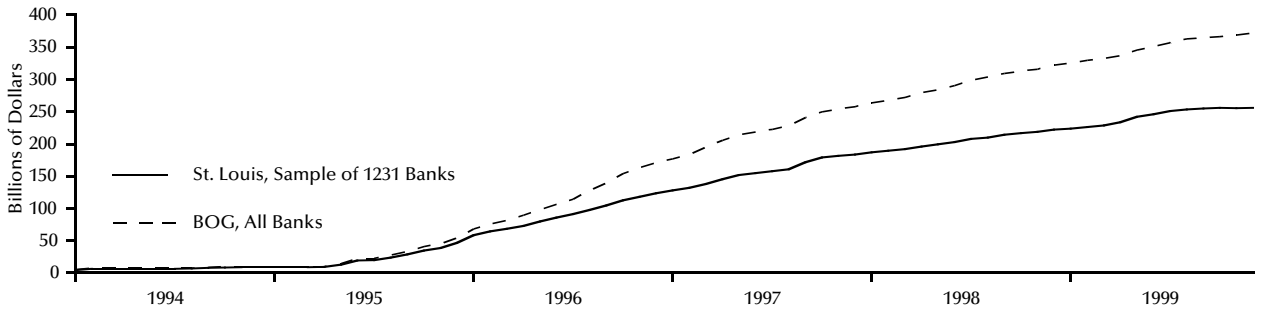
[17] Under Federal Reserve Regulation D, when a bank acquires another, the required reserves of the survivor are reduced by a *tranche loss adjustment*. The initial value of the adjustment equals the difference, during the reserve maintenance period immediately preceding the merger, between the required reserves of the survivor bank (computed as if the merger had been completed) and the required reserves of the acquired bank(s). The reduction is phased out over eight quarters: During the first quarter, the survivor's required reserves are reduced by seven eigths of the adjustment, during the next quarter by three quarters of the adjustment, etc.

[18] The staff of the Board of Governors maintains a database of sweep dates and amounts at individual banks, gleaned from deposit-report data and interviews with staff of individual banks. This database was not available for our research.

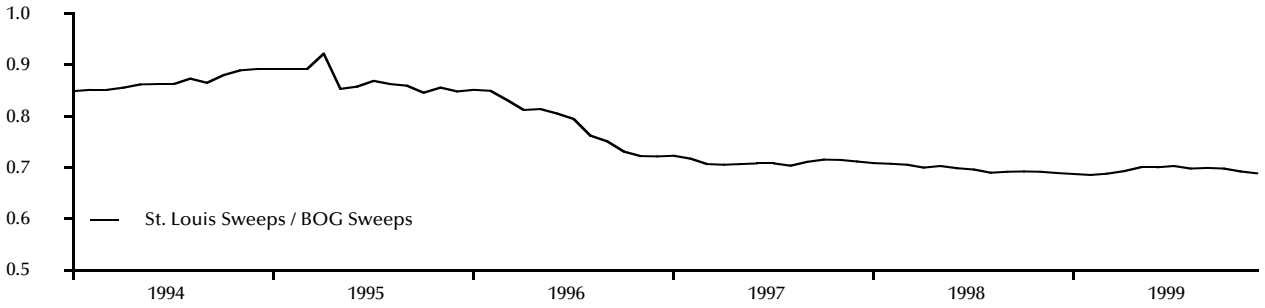
[19] We also experimented with statistical methods, including vector autoregressions containing transactions and savings deposits. The identification error rates from these methods, in our opinion, were unacceptably high.

Figure 3

A. Sweeps of Transaction Deposits into MMDAs



B. Ratio of St. Louis to Board of Governors (BOG) Staff Sweeps Estimates



signature of deposit-sweeping activity consists of two simultaneous changes:

- The level of transaction deposits decreases and the level of savings deposits increases, during the same reserve-maintenance period and by approximately the same dollar amount, while the bank's level of total deposits is approximately unchanged. It is important to condition the analysis on the level of total deposits because, in some cases, mergers of banks with different mixtures of deposits otherwise create false signals.
- The ratio of vault cash to reported transaction deposits (that is, transaction deposits not reclassified as MMDAs) increases sharply. This most likely occurs because the amount of vault cash held by a bank depends on its customers' *perceived* amount of transaction deposits, not the amount of reservable transaction deposits reported by the bank to the Federal Reserve.

For each so-identified maintenance period, our estimate of the amount of deposits affected is the smaller of the increase in savings deposits and (the absolute value of) the decrease in transaction deposits. For some identified periods, however, transaction deposits *increased*, savings deposits decreased, and the ratio of vault cash to transaction deposits fell. We interpret these changes to indicate that deposit sweeping was discontinued or reduced in amount. The amount of the change in deposit-sweeping activity is calculated as the negative of the above calculations, but is capped at the maximum amount that we estimate the bank previously had been sweeping.

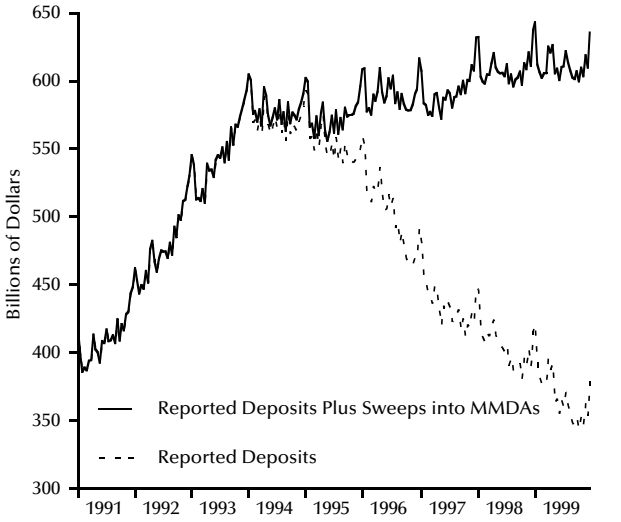
Results

Overall, we observed deposit-sweeping activity at 680 of the 1231 banks in our panel dataset.[20] Due to mergers, acquisitions, and liquidations, as of

[20] For 671 banks, we have identified specific reserve-maintenance periods in which we believe deposit-sweeping activity began or was expanded. For 9 banks, deposit-sweeping activity is inferred because they acquired other banks with deposit-sweeping activity. Among the 671 banks, there were 425 acquisitions of banks by others between January 1994 and December 1999. (This number includes acquired banks that later were acquired by others among the 671.) Bank mergers and acquisitions are handled by assuming that the acquirer continues to sweep the same amount of deposits as was being swept by the acquired bank.

Figure 4

Transaction Deposits



December 1999 our panel includes only 649 active banks. Of these, we estimate that 463 banks were operating deposit-sweeping software, affecting $255.9 billion of transaction deposits. Figure 3A shows estimates of the amount of deposit-sweeping activity at our panel of banks during 1994-99. For comparison, the figure also shows the Board of Governors staff's estimate of the amount of deposit-sweeping activity at all depository institutions. As of December 1999, the Board staff estimate is $371.8 billion. Figure 3B shows the ratio of the two estimates. Prior to mid-1995, the aggregate amount measured in our panel of banks is approximately 85 to 90 percent that of the Board staff's; since mid-1997, our measure has been approximately 65 to 70 percent of their total. The difference between the amounts may be due to one or more of three factors:

1. Deposit-Sweeping Programs at Smaller Banks. Our panel includes only 1231 banks, those which are relevant to measuring RAM; the Board staff's estimate seeks to include all banks. For our purpose—measuring the reduction in total and required reserves due to deposit-sweeping activity—the difference is unlikely to be important. Our previous analysis (Anderson and Rasche, 1996b) suggests that the smaller banks omitted from our panel are unlikely to change their holdings of reserves in response to a change in statutory reserve-requirement ratios.

2. Overlooked Deposit-Sweeping Programs. Repeated re-examinations of our data suggest that we have overlooked few, if any, banks within our sample that are operating deposit-sweeping programs. We have searched not only for the implementation of deposit-sweeping software but also for subsequent changes in the level of sweep activity.

3. Inaccurate Estimates of the Amount of Reclassified Deposits. Our estimated amounts are the smaller of the absolute values of the change in transaction and savings deposits, subject to caveats explained above. As a further check, we visually examined two ratios for each bank: vault cash (VC) divided by reported (reservable) transaction deposits (NT), VC/NT, and vault cash divided by the sum of net transaction deposits plus the estimated amounts of deposits reclassified as MMDA (SWP), VC/(NT + SWP). These data suggest that our estimates of the amounts being reclassified are quite accurate. The ratio VC/NT almost always increases sharply when deposit-sweeping activity begins or expands. On these same dates, the ratio VC/(NT + SWP) shows no such jumps.

Figure 4 displays total transaction deposits at the banks in our panel. The smaller series is the amount of transaction deposits reported by our panel of banks to the Federal Reserve, NT, and hence subject to statutory reserve requirements. The larger series is the sum of NT plus SWP. The difference, of course, is deposit-sweeping activity.

E-Bound Status

We emphasize that our purpose in this analysis is not to estimate either the total number of banks using deposit-sweep software or the total amount of deposits involved. Rather, we wish to identify how deposit-sweeping activity at economically bound banks has reduced the quantity of reserves held during each reserve maintenance period during 1994-99. The concept and calculation of RAM focuses on deposits, not on banks. It is the derived demand for reserves, arising from the level of deposits and the characteristics of the banks, that is of primary interest to us. Our next step, therefore, is to classify, for each biweekly reserve-maintenance period, a bank (and its

deposits) as either economically nonbound or economically bound. To do so, we visually analyzed time-series data, for individual banks, on a period-by-period basis from 1994-99. Similar to 1991-93, we believe that banks should not (and do not) alternate often between bound and nonbound status.

The most important indicator of the bank's bound and nonbound status is the change in its holdings of reserves, relative to the change in its required reserves.

- If a bank acquired another bank, did it make use of the reduction in required reserves as provided for by Federal Reserve regulations? If not, then the acquiring bank is revealed to be economically nonbound during those periods. In most cases, such a bank is classified as economically nonbound in all subsequent periods.
- If a bank implemented a sweep program, did its ratio of reserves to reported transaction deposits (after subtracting required reserves against the low-reserve tranche from the numerator and the deposit-amount of the low-reserve tranche from the denominator) increase above 10 percent? If so, the bank is revealed to be economically nonbound because it holds more reserves than is necessary to satisfy statutory reserve requirements. In most cases, such a bank is classified as economically nonbound for all subsequent periods.
- If a bank implemented a sweep program, did it increase its required clearing-balance contract? If so, the bank is revealed to be economically nonbound because it voluntarily increased its reserves above the amount necessary to satisfy legal requirements. In most cases, the bank is classified as economically nonbound for all subsequent periods unless it reduces or eliminates its clearing balance contract.
- If a bank implemented a sweep program, did its required reserves decrease below its vault cash (that is, did the bank become legally nonbound)? If so, the bank is revealed to be economically nonbound because the amount of vault cash necessary for its ordinary business exceeds its required reserves. The bank is classified as economically nonbound for all periods in which it is legally nonbound.

In general, if a bank is reclassified to economically nonbound from economically bound, it remains nonbound through to the end of the sample. We observed, however, that a few banks subsequently sharply reduced their excess reserves and began responding to changes in reserve requirements. Although the reasons for such changes in behavior are unknown to us, we reclassified these banks as economically bound beginning at the date of the change.

Banks that neither implemented a deposit-sweep program nor acquired another bank during 1994-99 experienced no change in their statutory required-reserve ratio. Hence, we use different criteria to classify these as economically bound or nonbound. For most banks, their status as of December 1993 is extended forward through December 1999. A bank's status might be changed if it significantly changes its level of excess reserves, enters into a clearing-balance contract, or experiences a major change in its level or mixture of deposits. In our sample, there are 551 such banks; 88 of these had their classification changed between January 1994 and December 1999.

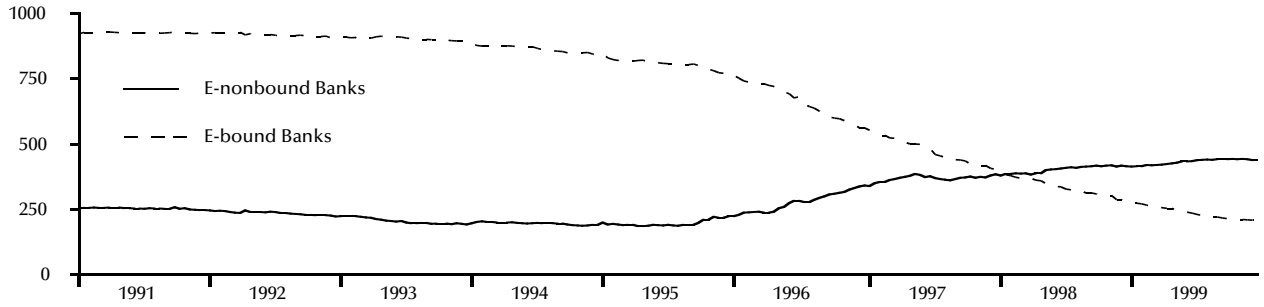
Figure 5 shows the numbers of banks in our panel classified as economically bound and nonbound and the amounts of their reservable transaction deposits. Changes in the numbers of banks should not be over-interpreted because of the large number of bank mergers and acquisitions since 1995. Regardless, the figure shows clearly that a major shift has occurred since deposit-sweeping computer software began to spread rapidly through the U.S. banking industry. In late 1994, for example, deposits in our panel's economically bound banks totaled approximately $500 billion, whereas deposits in economically nonbound banks were less than $100 billion. By late 1999, reported transaction deposits (subject to statutory reserve requirements) in economically bound banks totaled less than $100 billion, and reported transaction deposits in economically nonbound banks were approximately $250 billion.

Estimate *rr**

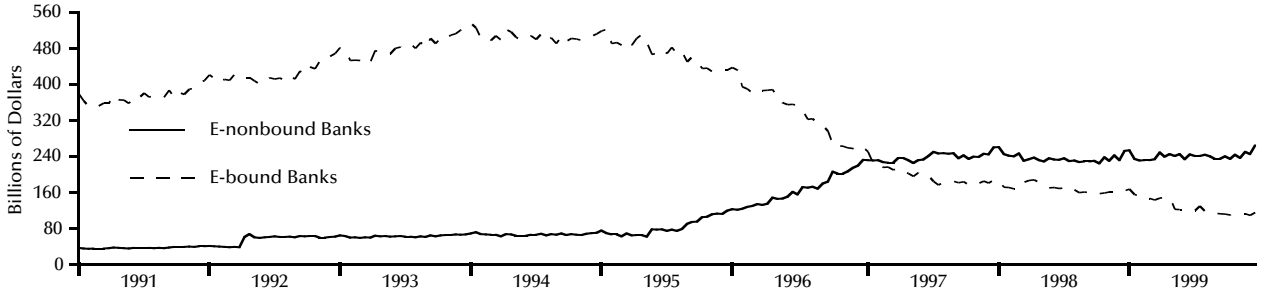
The above analysis allows us to classify each bank in our dataset, during each reserve-maintenance period, as being in Case 1, 2, 3, or 4. For those banks in Cases 1 and 2, RAM = 0. For those in Case 3, calculation of RAM is straightforward, as shown above. For banks in Case 4, it remains to estimate *rr**.

Figure 5

Number of Active Banks in Panel



Deposits



We remind the reader that rr^* does not equal the marginal reserve-requirement ratio against transaction deposits but, rather, is the smallest (counterfactual) reserve-requirement ratio for which

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t \\ rr=rr_t^*}} > 0 ,$$

when

$$\left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_0 \\ rr=rr_0}} > 0 , \quad \left.\frac{\partial TR^D(D,rr)}{\partial rr}\right|_{\substack{D=D_t \\ rr=rr_t}} = 0 ,$$

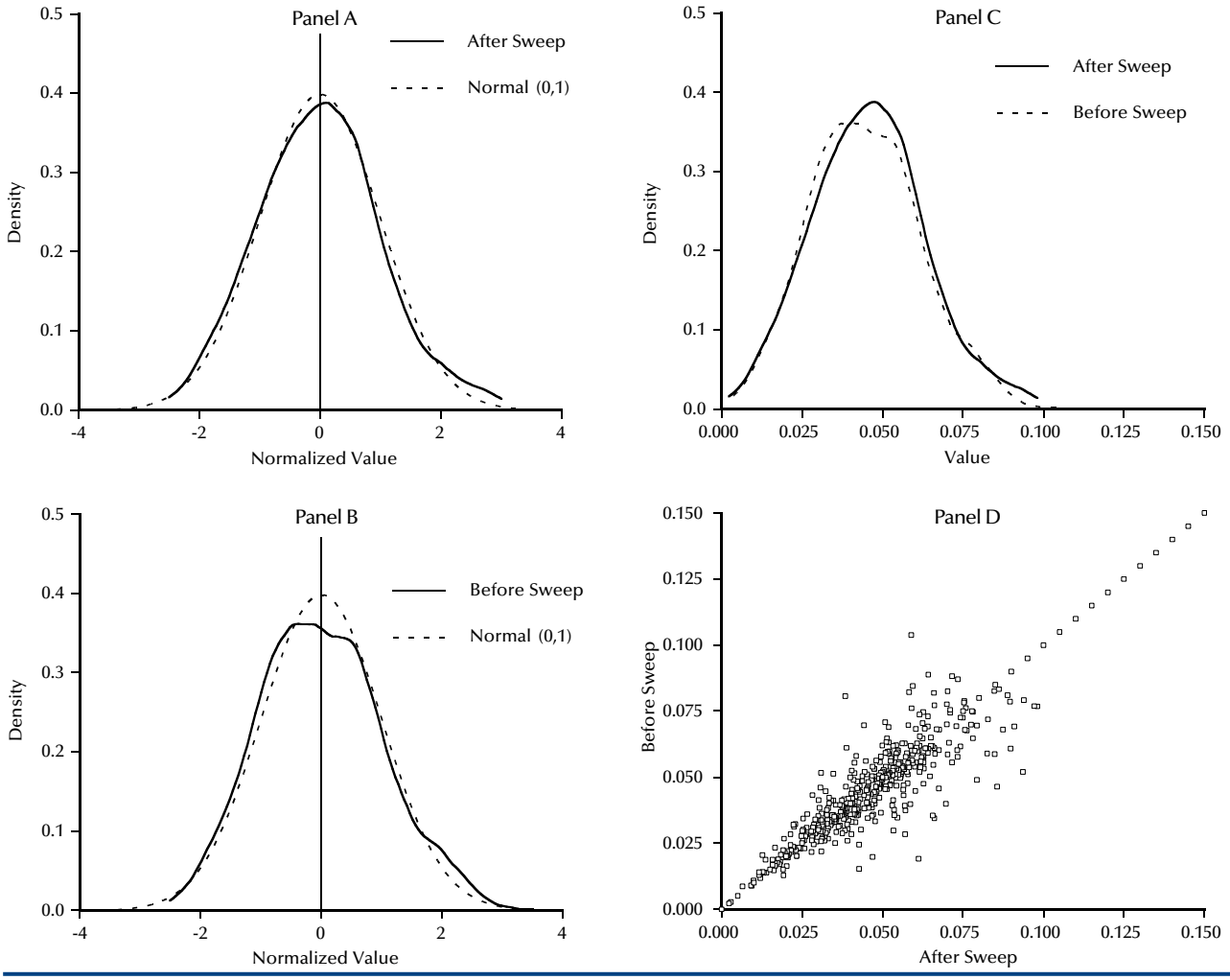
$rr_0 > rr_t$, and rr_0 and rr_t are, respectively, the base period and period t reserve-requirement ratios. In this case, $RAM_t = RR(D_t, rr_0) - RR(D_t, rr^*)$. An estimate of rr^* is calculated only once, for the maintenance period before the sweep activity that allows the bank to become economically nonbound. This mimics in spirit the pre-1994 Federal Reserve statutory regime in which reserve-requirement ratios changed by specific amounts at specific dates and then remained fixed at the new values until the next change. RAM is calculated for all subsequent periods in the dataset as if the calculated value for rr^* were the applicable statutory ratio.

In what follows, we treat rr_t and rr^* as ratios of reserves (vault cash, VC, plus deposits at Federal Reserve Banks, RB) divided by the sum (NT + SWP).[21] Complications regarding tiering (the reserve-exemption amount and low-reserve tranche) are omitted because all aspects of the statutory reserve requirement system, including tiering, are irrelevant to Case 4 banks. To estimate rr^*, recall that the amount of reserves held by an economically nonbound Case 4 bank is determined by its day-to-day business needs, not by statutory reserve requirements. Hence, the amount is less than the product of rr^* times the sum

[21] In this analysis, "RB" refers to total deposits held by banks at Federal Reserve Banks, including amounts held to satisfy clearing-balance contracts (line 25, Table 1.18, *Federal Reserve Bulletin,* August 2000). Note that this differs from the concept of reserve balances published by the Board of Governors staff, which equals deposits at Federal Reserve Banks minus the amount of clearing-balance contracts (line 1, Table 1.12, *Federal Reserve Bulletin,* August 2000). Also, "VC" includes all vault cash held by depository institutions. In Board of Governors' publications, total reserves includes only the amount of vault cash that is applied to satisfy statutory reserve requirements—any "surplus" amount is excluded.

Figure 6

Vault Cash/(Reported Net Transaction Deposits + Sweeps)
Banks E-bound Before to E-nonbound After Sweep, Obs=458



(NT + SWP):

$$VC + RB < (rr^*) \times (NT + SWP) \ .$$

Note that the opposite is true for an economically bound Case 3 bank where, at the margin, the amount of reserves is determined by the statutory reserve-requirement ratio rr_t: [22]

$$VC + RB \geq (rr_t) \times (NT + SWP) \ .$$

These two relationships are not sufficient, however, to provide an estimator for rr^*. To do so, we impose one additional condition: We assume that the amount of a bank's vault cash is determined by its day-to-day retail business needs and is not affected by statutory reserve requirements or deposit-sweeping activity. Conditional on this assumption, we examine separately the ratios VC/(NT + SWP) and RB/(NT + SWP). From these ratios, we infer upper and lower boundaries for rr^* and, thereafter, a value for rr^* itself.

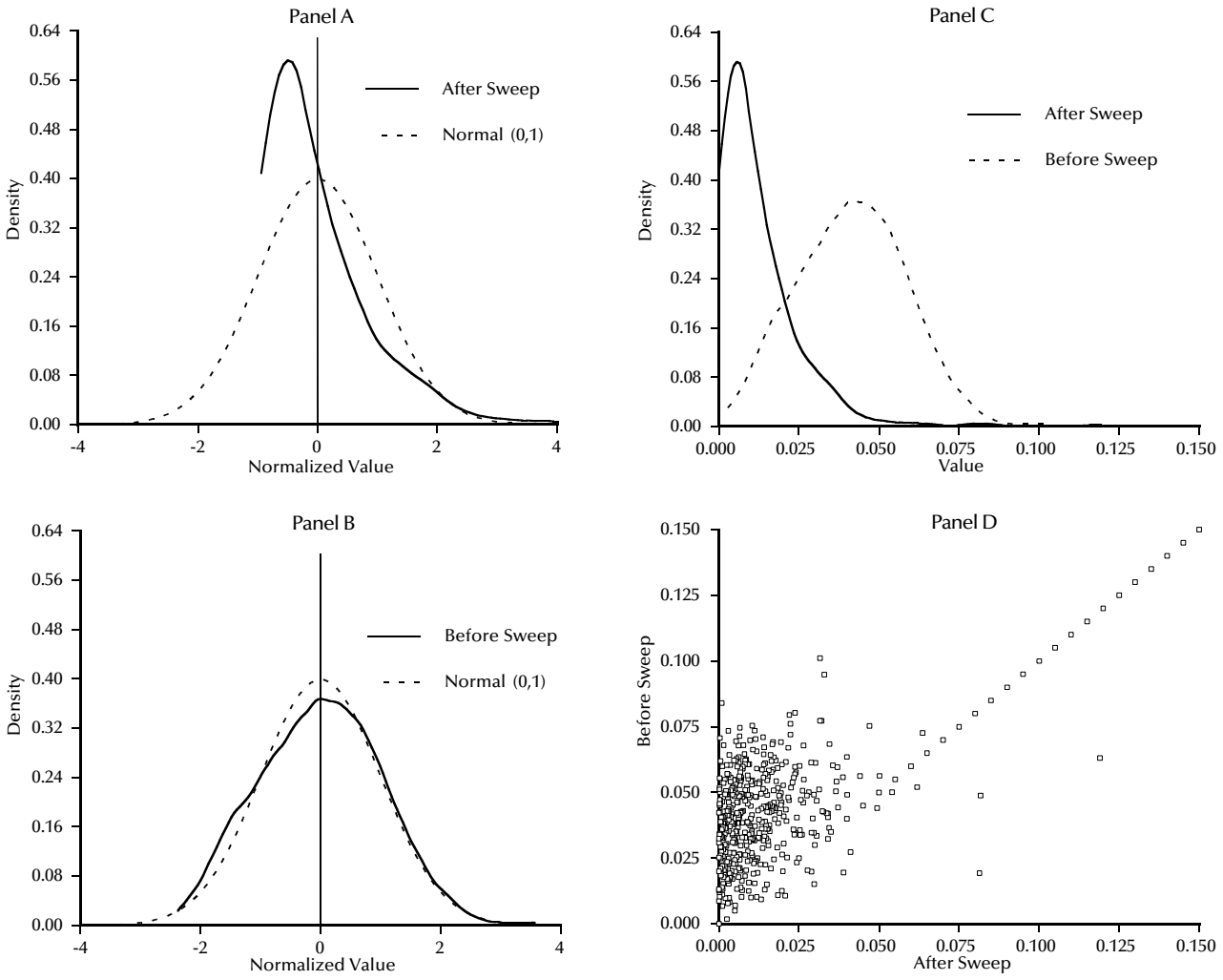
We begin by comparing the reserves held by banks before and after they implemented deposit-sweeping software. Selection of the appropriate "before" and "after" reserve-maintenance periods requires some judgement. Our data suggest that at many banks deposit-sweeping activity was phased-in during a number of reserve-

[22] This analysis ignores the carryover provision of Federal Reserve accounting. That provision allows a bank's required reserves during a reserve maintenance period to exceed the sum of its eligible vault cash and deposits at Federal Reserve Banks so long as the deficiency is offset (made up) during the following period.

Figure 7

Deposits at the Federal Reserve/(Reported Net Transaction Deposits + Sweeps)

Banks E-bound Before to E-nonbound After Sweep, Obs=458



maintenance periods. Also, we observed some banks increasing their sweep activity at later dates, often a year or more after the initial implementation.[23] For each deposit-sweeping bank, we visually searched the data to select the first ("before") reserve-maintenance and last ("after") reserve-maintenance periods affected by changes in the intensity of deposit-sweeping activity—that is, the period before sweep activity began and the period during which the bank's transaction and savings deposits later settled down to new levels or trends. We inferred from the ratios VC/(NT + SWP) and RB/(NT + SWP) whether the economically bound status of the bank was changed by implementation of deposit-sweeping software. We classified 458 banks that were economically bound before implementing deposit-sweeping software as economically nonbound after (Case 4); 155 banks that were economically bound before as remaining bound after (Case 3); 53 banks that were economically nonbound before as remaining nonbound after; and 2 banks that were economically nonbound before as bound after.[24]

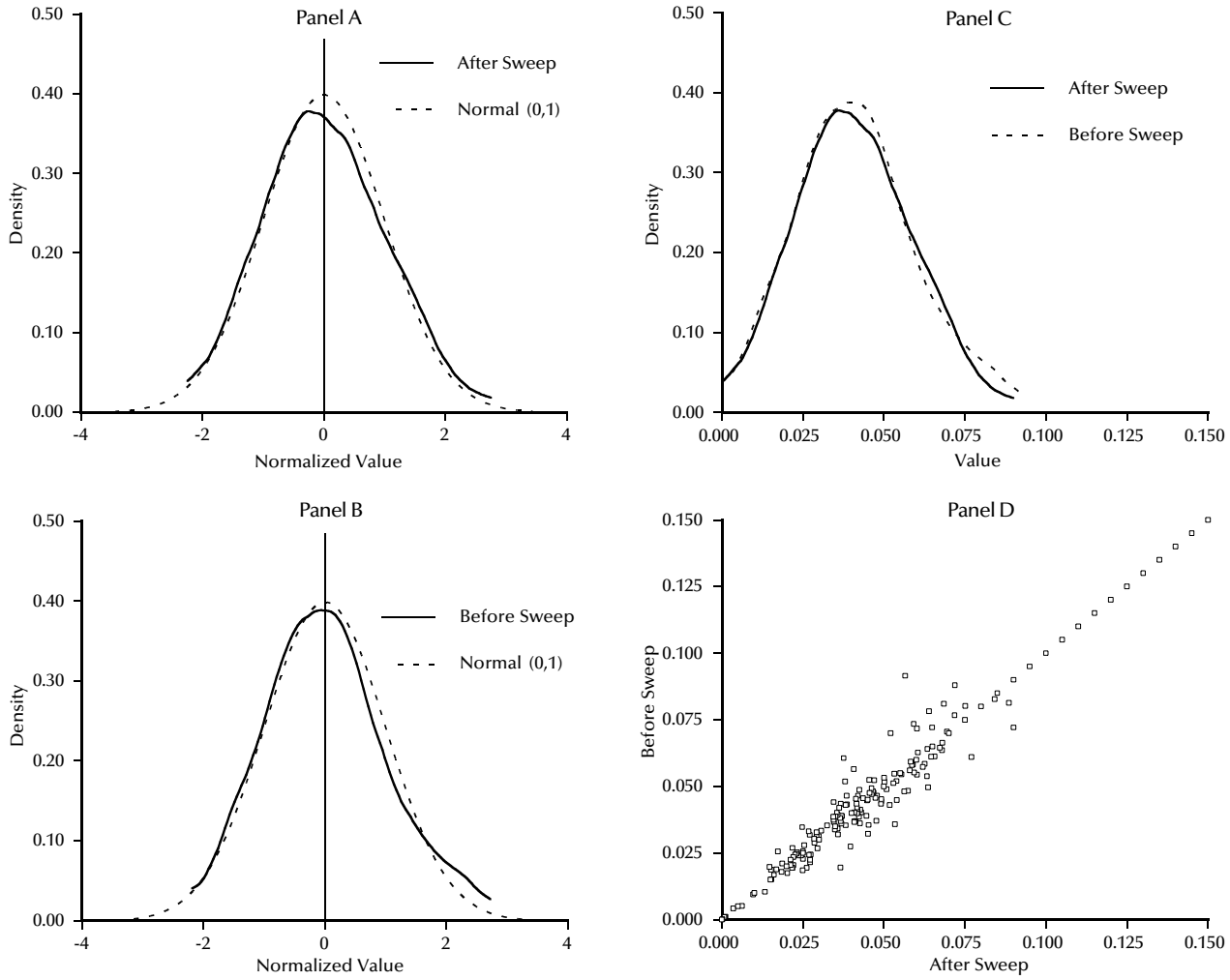
Data for the 458 banks that changed status

[23] The ongoing tuning and expansion of deposit-sweep programs is discussed in O'Sullivan (1998).

[24] Note that these banks differ with respect to the number of periods between the "before" and "after" dates, and the first and last periods in which data were reported. Twelve of the 680 identified sweeping banks are omitted (the figures in the text sum to 668) because data were not available for periods before and after the implementation of their sweep programs.

Figure 8

Vault Cash/(Reported Net Transaction Deposits + Sweeps)
Banks E-bound Before and After Sweep, Obs=155



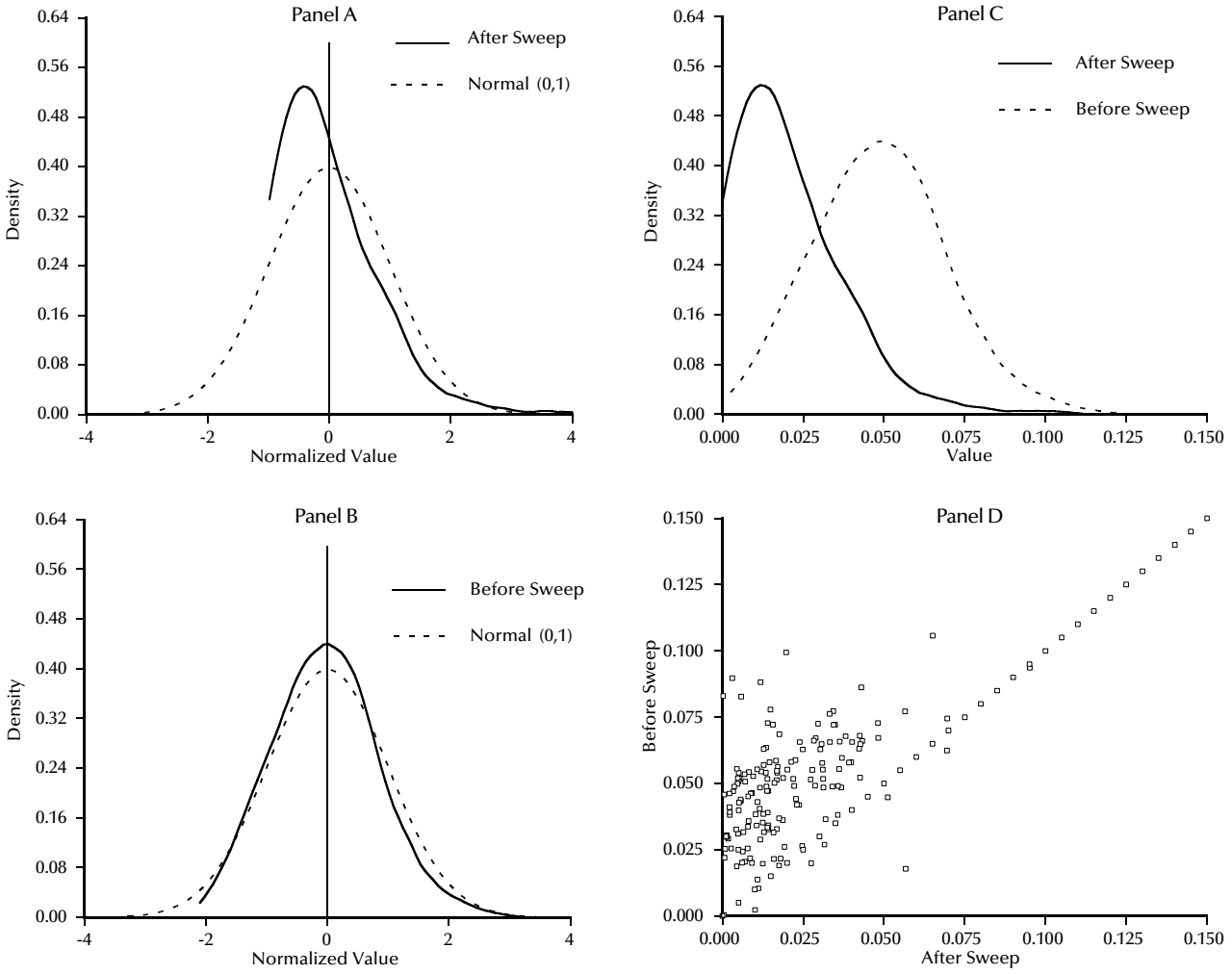
from economically bound to economically non-bound provide evidence for a lower boundary for *rr**. Scatter plots and smoothed density functions of the ratios VC/(NT + SWP) and RB/(NT + SWP) are shown in Figures 6 and 7, respectively, for the reserve-maintenance periods immediately before and after implementation of deposit-sweeping activity (the normal density is included for reference).[25]

- For vault cash, Figure 6, the *similarity* of the "before" and "after" distributions is striking. The means are approximately the same in both cases—4.5 percent for the "before" distribution and 4.6 percent for the "after" distribution—and the densities have similar dispersion. The Kolmogorov-Smirnov statistic fails to reject both the normality of the two distributions and their equality. For normality, the values of the test statistics are $(458)^{1/2} \times 0.0446 = 0.954$ for the "before" distribution and $(458)^{1/2} \times 0.0241 = 0.516$ for the "after" distribution. For equality, the value of the statistic is $[(458 \times 458)/(458 + 458)]^{1/2} \times 0.0611 = 0.925$. In all cases, the 5 percent critical value is 1.36.

[25] The densities are calculated by the RATS program KERNEL.SRC, which computes a nonparametric estimate of the unconditional distribution using the Epanechnikov kernel. We also have examined these ratios during the 5th, 10th, 15th, 20th, and 25th periods after the intensity of sweep activity stabilized. Those densities and scatter plots are nearly identical to the ones shown.

Figure 9

Deposits at the Federal Reserve/(Reported Net Transaction Deposits + Sweeps)
Banks E-bound Before and After Sweep, Obs=155



The Jarque-Bera test also suggests normality. Values of the statistic for the "before" and "after" distributions, respectively, are 5.54 (p-value 0.0628) and 4.89 (p-value 0.0866).

- For deposits at Federal Reserve Banks, Figure 7, the *difference* between the "before" and "after" distributions is striking.[26] The means differ: 4.2 percent for the "before" distribution and 1.2 percent for the "after" distribution (the median for the "after" distribution is 0.8 percent). The Kolmogorov-Smirnov statistic fails to reject normality of the "before" distribution, with a value of $(458)^{1/2} \times 0.031 = 0.663$. Normality of the "after" distribution is easily rejected, with a value of $(458)^{1/2} \times 0.173 = 3.70$. (In all cases, the 5 percent critical value is 1.36.) The Jarque-Bera statistic yields similar results for normality, with values of 2.03 (p-value 0.363) and 5059.7 (p-value of 0).

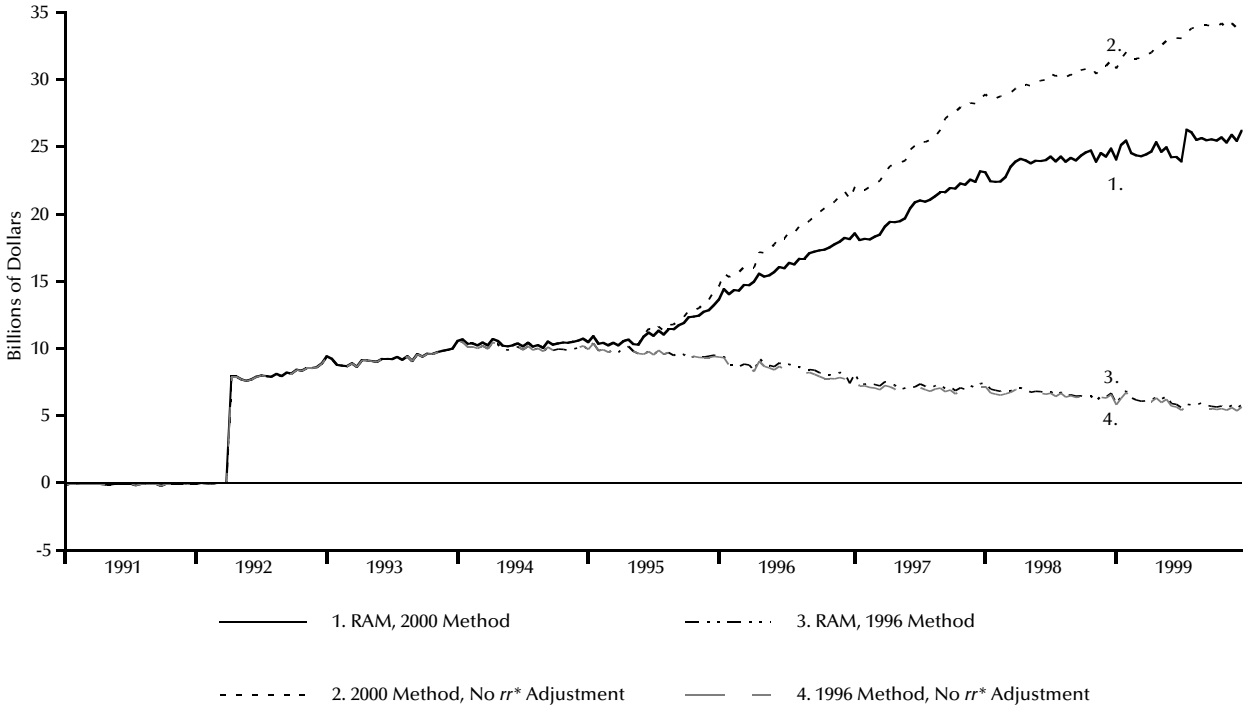
These distributions suggest that the mean of *rr** likely is not less than 5.8 (= 4.6 + 1.2) percent.

Data for the 155 economically bound banks that remained bound after implementing sweep programs provide evidence in favor of an upper boundary for *rr**. Scatter plots and smoothed density functions of the ratios VC/(NT + SWP) and

[26] Note that the inclusion of deposits at the Federal Reserve used to satisfy required clearing balance contracts gives the distributions thick right tails.

Figure 10

RAM, 1991-99



RB/(NT + SWP) are shown in Figures 8 and 9, respectively, for the reserve-maintenance periods immediately before and after implementation of deposit-sweeping activity.

- For the vault-cash ratio, the means of the "before" and "after" distributions are equal, at 4.1 percent. Normality of the distributions is not rejected, with Kolmogorov-Smirnov test statistics equal to 1.03 and 0.980, respectively, and equality is not rejected with a value of 0.040. (In all cases, the 5 percent critical value is 1.36.) The Jarque-Bera statistic also does not reject normality, with values of 2.04 (p-value 0.361) and 0.719 (p-value 0.698).
- For deposits at Federal Reserve Banks, the means of the "before" and "after" distributions are 5.0 and 2.1 percent, respectively. Normality of the "before" distribution is not rejected with a statistic of 1.11, but normality of the "after" distribution is rejected with a value of 1.74. Normality of both distributions is rejected by the Jarque-Bera statistic, however, with values of 1752.4 (p-value 0) and 4187.2 (p-value 0).

These data suggest that the mean of *rr** likely is not more than 6.2 (= 4.1 + 2.1) percent.

These statistics suggest that, in the absence of statutory reserve requirements, a typical bank in our sample likely would maintain approximately a 1 percent ratio of deposits at Federal Reserve Banks (including deposits used to satisfy clearing-balance contracts) to total net transaction deposits (including any amounts reclassified as MMDA). Hence, we conclude that a reasonable estimator for *rr** for a Case 4 bank is the sum of 1 percent plus the bank's vault-cash ratio during the reserve-maintenance period immediately before the period (or sequence of periods) during which the bank began (or changed the intensity of) its deposit-sweeping activity. Applying this rule to our sample of 680 identified sweeping banks, we estimate *rr** for 454 banks where, during the reserve-maintenance period immediately prior to beginning sweep activity, (i) the bank is classified as economically bound and (ii) the level of required reserves is less than the sum of vault cash plus 1 percent of transaction deposits plus sweeps:

$$\left.\frac{RR}{NT+SWP}\right|_{\tau} < \left.\frac{VC}{NT+SWP}\right|_{\tau} + 0.01 \ ,$$

where RR denotes the bank's required reserves, VC its vault cash, and SWP the estimated amount swept. The mean of these *rr** estimates is 5.79

FEDERAL RESERVE PUBLICATIONS AND DEPOSIT-SWEEP PROGRAMS

During the 1990s, Federal Reserve publications have documented the spread of deposit-sweeping software through the U.S. banking industry. The July 1994 Humphrey-Hawkins Act monetary-policy report introduced deposit-sweep programs in a single sentence. The July 1995 report noted that approximately $12 billion of deposits were involved in sweep activity and, as a result, that deposits at Federal Reserve Banks had decreased by about $1.2 billion. It also raised concern regarding an increase in federal funds rate volatility if deposits decreased further. The July 1996 report included a special appendix on the operation of sweep programs. The February 1997 report noted that the aggregate amount of deposits affected by sweep programs had increased to approximately $116 billion, compared with $45 billion in 1995. The July 1997 report noted the introduction of deposit-sweep programs for household demand deposits and noted that some banks were increasing the size of their clearing balance contracts when sweep programs reduced their required reserves. Subsequent reports have repeated these themes, along with an appeal that the Congress allow the Federal Reserve to pay interest on reserve balances (Meyer, 1998, 2000). In addition, deposit-sweep activity also has been highlighted in the annual reports of the Open Market Desk (see, for example, Hilton 1999, and Bennett and Hilton, 1997) and in the *Federal Reserve Bulletin* (Edwards, 1997).

percent, exactly the lower boundary discussed above, with a standard deviation of 1.96.

As of December 1999, after numerous mergers, our panel contained 649 active banks. Of these, 269 were classified as Case 4, 199 as Case 3, 60 as Case 2, and 121 as Case 1. The mean of the estimated *rr** for the 269 banks classified as Case 4 is 5.62 percent.

RAM

To illustrate the importance of our adjustments for deposit-sweeping activity and for banks falling below frictional levels of reserve demand (the *rr** correction, in Case 4), four alternative RAM series are shown in Figure 10.[27]

- Our preferred measure, which includes the effects of deposit-sweeping activity and *rr**, is labeled "1. RAM, 2000 method." This measure suggests that bank reserves in December 1999 were lower by $25.8 billion, relative to what might be expected in the absence of deposit-sweeping software.
- The series labeled "2." is the same calculation as "1." except that it ignores the *rr** adjustment. That is, it assumes for each bank that the amount of reserves freed by deposit-sweeping activity equals the reduction in required reserves. Our analysis shows, however, that deposit-sweeping software often is able to reduce a bank's required reserves to a level below the reserves necessary for the bank's day-to-day business. This measure suggests that banks' required reserves in December 1999 were lower by $34.1 billion, relative to what might be expected in the absence of such software.
- The series labeled "3." is RAM according to the method of Anderson and Rasche (1996b). This series ignores deposit-sweeping activity.
- The series labeled "4." is the same as "3." except that it adjusts for *rr**-type behavior. The very small difference between series "3." and "4." ($1.9 billion in December 1999) emphasizes that a correct RAM adjustment must include the effects of *interaction* between reductions in reserve requirements and banks realizing that their required reserves have fallen below the amount necessary for day-to-day business.

SUMMARY AND CONCLUSIONS

This analysis has examined the extraordinary

[27] These estimates differ from reserve measures published by the Federal Reserve Board. In that data, total and required reserves (adjusted for changes in reserve requirements and seasonal variation) both decreased from January 1994 to December 1999 by $19 billion. Note that the Board's measure does not include "surplus" vault cash, that is, vault cash held by depositories but not used to satisfy reserve requirements. The Board's measures also include an adjustment for the effect of changes in the low-reserve tranche between January 1995 and December 1999 of approximately $700 million (during this period, decreases in the size of the tranche increased required reserves).

unwinding of statutory reserve requirements in the United States since January 1994. Based on the statistical results in Anderson and Rasche (1996b), we selected a panel of 1231 banks whose demand for reserves likely is responsive to changes in statutory reserve requirements. For these banks, we estimate that deposit-sweeping activity has reduced required reserves in December 1999 by $34.1 billion. Adjusting for banks where the new lower level of required reserves is less than the bank's necessary day-to-day operating balances, we estimate that deposit-sweeping activity has reduced total bank reserves, as of December 1999, by $25.8 billion relative to the amount that would have been held in the absence of such activity.

Our analysis suggests that the willingness of bank regulators to permit use of deposit-sweeping software has made statutory reserve requirements a "voluntary constraint" for most banks. That is, with adequately intelligent software, many banks seem easily to be able to reduce their transaction deposits by a large enough amount that the level of their required reserves is less than the amount of reserves that they require for day-to-day operation of the bank. For these banks at least, the economic burden of statutory reserve requirements is zero.

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Federal Reserve Bank of St. Louis
Post Office Box 442
St. Louis, Missouri 63166-0442