Financial Market Evolution and the Interest Sensitivity of Output

by Beverly Hirtle and Jeanette Kelleher

Financial markets in the United States have undergone extensive changes in the past three decades. Financial deregulation, increased access to debt and equity markets for large classes of borrowers and investors, a substantially greater degree of internationalization, and innovations in the banking, securities, and financial derivative sectors have all altered the way in which financial markets operate and affect the rest of the economy. One important question emerging from these developments is whether the evolution of the financial sector has altered how monetary policy is transmitted, that is, the ways in which the Federal Reserve's policy initiatives work through various sectors of the economy to affect aggregate output and growth.

This article examines one aspect of the policy transmission mechanism, the relationship between interest rates and the growth of output, and attempts to quantify changes in that relationship over the period of recent financial market evolution. Using a simple empirical technique, we examine the sensitivity of the economy to movements in interest rates, that is, the degree to which changes in the level of interest rates ultimately affect economic activity. The basic goal of the analysis is to identify the direction of any systematic changes in the interest sensitivity of the economy over this time.

Our primary finding suggests that aggregate real gross national product may have become less sensitive to movements in short-term interest rates during the last three decades. According to our estimates, however, the rate of this decline has not been uniform over the entire period. Instead, our results imply that the interest sensitivity of output decreased during the 1950s, 1960s, and 1970s, and then leveled off and possibly rose again during the 1980s. This pattern emerges consistently in our analysis, even following modifications of the basic empirical specification such as controlling for other macroeconomic variables and allowing the degree of interest sensitivity to be affected by both inflation and changes in Federal Reserve regime.

Financial deregulation and interest sensitivity

The theoretical effect of financial deregulation on the interest sensitivity of the economy is ambiguous. On the one hand, certain types of financial deregulation have removed or limited the impact of quantity credit rationing, forcing monetary policy to work more exclusively through the direct effects of interest rates on business and household spending decisions and tending to reduce the measured impact of interest rate movements on real economic activity. On the other hand, secular changes in financial markets and in the degree of access to interest-sensitive financial assets and liabilities may have exposed a broader range of economic agents more directly to interest rate fluctuations. To the extent that a larger segment of borrowers and lenders may now be directly affected by interest rate variations, aggregate economic output will appear to be more interest sensitive. The net impact of these changes on various sectors of the economy can only be assessed empirically.[1]

[1]See Paul Bennett, "The Influence of Financial Changes on Interest Rates and Monetary Policy: A Review of Recent Evidence," in this issue of the *Quarterly Review* for another discussion of the effect of financial market evolution on the interest sensitivity of output.

The factors tending to lead to a decrease in the sensitivity of economic activity to interest rate movements have for the most part acted by curbing or eliminating some form of quantity credit rationing as a channel for monetary policy. For instance, innovations in commercial bank funding practices during the 1960s and 1970s — including the development of the market for negotiable certificates of deposit, the increased prevalence of one-bank holding companies and foreign branches, and the general relaxation of deposit rate ceilings — have increased the ability of commercial banks to fund themselves during periods of tight monetary policy and may have reduced the need for banks to engage in quantity credit rationing.[2] Parallel with developments in the commercial banking sector, the repeal of the Regulation Q ceilings and the deregulation of the thrift industry since the 1970s have greatly reduced thrift disintermediation as a source of restraint on the housing market.[3] Taken as a whole, these innovations in the funding practices of financial institutions have tended to limit the extent to which credit is rationed during periods of monetary tightness.

The impact of bank loan rationing may also have been reduced by the growth of alternative credit markets such as the commercial paper market and by the generally greater access to all debt markets for a large number of corporate borrowers. Mirroring this increased funding availability, the loan commitment market has given a growing share of corporate borrowers protection against bank credit rationing (at least in the near term) and therefore may have contributed to the diminished importance of bank loan rationing as a monetary policy transmission channel.[4] Both of these developments have tended to reduce the extent to which bank loans represent a "special" source of credit under the indirect influence of the Federal Reserve.

While the effects of financial changes in some sectors have probably tended to reduce the interest sensitivity of output, other financial market developments may have acted in the opposite direction. The interest sensitivity of the economy may have been increased by the growing exposure of certain sectors of the economy to fluctuations in interest rates. For instance, higher leverage in the corporate sector may make business output and investment decisions more susceptible to increases in interest rates.[5] In addition, the greater international integration of both financial and real sectors of the economy may mean that the channels of monetary policy acting through exchange rates and capital markets are now stronger.

Given these offsetting financial market developments, an empirical approach is necessary to determine the net effect on the interest sensitivity of output. It is quite possible that the impact of these developments has varied not only across different sectors of the economy, but also over time, as the role played by particular financial market developments has grown or diminished in importance. For this reason, it seems important to examine the interest sensitivity of the economy in a framework that allows for differential effects over time.

Previous empirical work

A number of recent papers have attempted to measure the interest sensitivity of various sectors of the economy and to determine how these sensitivities have changed over time. Relying on a variety of empirical techniques and reaching somewhat disparate conclusions, these papers have assessed the effects of financial market developments on the interest sensitivity of particular economic sectors and then used these sectoral results to make an inference about the overall interest sensitivity of the economy.

Akhtar and Harris, for instance, estimate sectoral equations with specially constructed interest rate measures and, controlling for periods of credit rationing, find an increased interest sensitivity in the producers' durable equipment and consumer durables sectors but a decreased sensitivity of housing activity to changes in interest rates.[6] On the basis of these findings, Akhtar and Harris conclude that the link between monetary policy variables (including exchange rates) and aggregate output is probably stronger now than in the period from 1960 to the mid-1970s.

Using modifications of equations from the Federal Reserve Board's MPS model, Benjamin Friedman examines the response of four economic sectors to movements in real interest rates and evaluates the

[2]For a more complete discussion of these developments, see Donald D. Hester, "Innovations and Monetary Control," *Brookings Papers on Economic Activity*, 1:1981, pp. 141-89; and Albert M. Wojnilower, "The Central Role of Credit Crunches in Recent Financial History," *Brookings Papers on Economic Activity*, 2:1980, pp. 277-326.

[3]See John Ryding, "Housing Finance and the Transmission Mechanism of Monetary Policy," in this issue of the *Quarterly Review* for a detailed analysis of the effects of financial market evolution and housing finance deregulation on the sensitivity of the housing sector to monetary initiatives.

[4]See Beverly Hirtle, "Loan Commitments and the Transmission of Monetary Policy," in *Studies on Financial Changes and the Transmission of Monetary Policy*, Federal Reserve Bank of New York, May 1990, pp. 98-117, for a more detailed discussion of the loan commitment market and its impact on monetary policy transmission.

[5]See Richard Cantor, "A Panel Study of the Effects of Leverage on Investment and Employment" in this issue of the *Quarterly Review* for a discussion of the role of corporate leverage on firms' investment, employment, and production decisions.

[6]M. A. Akhtar and Ethan S. Harris, "Monetary Policy Influence on the Economy: An Empirical Analysis," Federal Reserve Bank of New York *Quarterly Review*, Winter 1987, pp. 19-31.

change in this response since the mid-1970s.[7] He finds that the elimination of credit rationing in the housing finance market has reduced the impact of a monetary policy tightening on activity in that sector, although there is no evidence of a change in the sector's interest sensitivity in periods of no credit rationing. In addition, Friedman's results suggest an increase in interest sensitivity in business fixed investment and a decline in the interest sensitivity of consumer spending as well as imports and exports. On the basis of the findings for these individual sectors, Friedman concludes that the net impact of real interest rates on aggregate output has been unchanged by financial market deregulation.

George Kahn uses vector autoregressions to examine changes in the impact of nominal interest rates on aggregate GNP and various sectors.[8] His approach differs from that of Friedman and of Akhtar and Harris in that he does not control for periods of credit rationing. Estimating his equations over two periods, Kahn finds that both residential investment and consumption are less interest sensitive in the 1980s than in the period from 1955 to 1979, while the impact of an increase in interest rates on net exports has strengthened and changed direction, switching from a small positive effect to a large negative one. His results on business fixed investment are inconclusive. On the basis of this evidence and a direct estimate of his equation on aggregate GNP, Kahn concludes that the interest sensitivity of output in the 1980s has declined since the period from 1955 to 1979.

Barry Bosworth reaches a similar conclusion using a substantially different approach.[9] Noting that adjustable rate mortgages (ARMs) have been prevalent in Canada for a number of years and that Canadian housing investment is less sensitive to movements in interest rates than U.S. residential investment, Bosworth argues that the housing sector in the United States is likely to become less interest sensitive as ARMs become more common. Combining this analysis with an examination of business investment and foreign trade, Bosworth concludes that monetary policy lags have lengthened and become more uncertain as a result of institutional changes in financial and product markets.

As this brief review suggests, there is no clear-cut consensus about the impact of financial market developments on the overall interest sensitivity of the economy. This lack of consensus may in part be explained by the different interest rate measures employed by the authors in their empirical analyses. Friedman examines the sensitivity of output in various sectors to changes in real interest rates, while the bulk of the analysis in Akhtar and Harris and in Bosworth focuses on nominal interest rate movements. Kahn uses the nominal federal funds rate as a measure of interest rates in his estimates.

More probably, however, the differing conclusions about the overall interest sensitivity of the economy derive from the relatively informal way in which most of these papers combine the results from individual sectors to reach a conclusion about aggregate GNP. Of the four papers, only Kahn's makes a direct empirical examination of the effect of interest rates on aggregate output. Although the disaggregate approach taken by Friedman, Bosworth, and Akhtar and Harris has the advantage of providing insight into the differential effects of monetary policy across sectors, it is less well suited to assessing the net change in interest sensitivity for the economy as a whole.

Empirical approach

In this section we adopt a fairly general approach to measuring changes in the sensitivity of output to interest rate fluctuations. Specifically, we estimate an equation relating the growth of real GNP to the level of nominal interest rates and the stance of fiscal policy. This equation has the general form:

$$\log(GNP_t/GNP_{t-1}) = \alpha_0 + \alpha_1 \log(GNP_{t-1}/GNP_{t-2}) + \alpha_2 FISCAL_t + \alpha_3 r_t + \epsilon_t,$$

where GNP_t is real gross national product, $FISCAL_t$ is a measure of the stance of fiscal policy (higher values of FISCAL represent tighter fiscal policy),[10] and r_t is the three-month Treasury bill rate (see Box). The equations are estimated on quarterly data from 1957 to 1989.[11]

[7]Benjamin Friedman, "Changing Effects of Monetary Policy on Real Economic Activity," in *Monetary Policy in the 1990s*, Federal Reserve Bank of Kansas City, 1989.

[8]George A. Kahn, "The Changing Interest Sensitivity of the U.S. Economy," Federal Reserve Bank of Kansas City *Economic Review*, November 1989, pp. 13-34.

[9]Barry Bosworth, "Institutional Change and the Efficacy of Monetary Policy," *Brookings Papers on Economic Activity*, 1:1989, pp. 77-110.

[10]$FISCAL_t$ is the eight-quarter change in the ratio of the full employment government budget surplus or deficit to nominal GNP. We use the midexpansion trend measure of the federal government budget surplus or deficit, calculated by the Bureau of Economic Analysis (BEA), to represent the full employment budget position. This measure was available from 1955 to 1988, when it was discontinued by the BEA. Beginning in 1970, the BEA calculated an alternative full employment budget deficit series based on a 6 percent unemployment rate trend GNP measure. Although the levels of the two series are different, the changes are very similar, so the changes in the 6 percent unemployment rate series are appended to the midexpansion trend level to extend the series into 1989.

[11]All equations are estimated by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value to account for possible simultaneity bias.

Box: Selection of the Interest Rate Measure

The interest rate variable used in our estimates is the nominal three-month Treasury bill yield. In making this selection, we considered whether a nominal or real interest rate was the appropriate variable to use in examining the impact of financial market evolution on the interest sensitivity of real output. On the one hand, it is usually assumed that real interest rates affect the production, investment, savings, and spending decisions of firms and individuals in the economy, making real interest rates the correct choice for the equation. On the other hand, nominal interest rates may be more appropriate because they are pivotal in many of the monetary transmission channels affected by financial market evolution. For instance, the Regulation Q ceilings, which triggered rationing in the housing finance market, were expressed in nominal terms. In addition, most interest-sensitive household and corporate assets and liabilities are denominated in nominal terms, implying that household and corporate cash flows vary with movements in nominal rates.

Because these and other monetary policy channels work through movements in nominal interest rates, it seemed reasonable to use nominal rates in attempting to measure changes in interest sensitivity. As a test of this assumption, we reestimated the basic and time-varying forms of the equation using real instead of nominal interest rates. These results are reported in the table. For this purpose, real interest rates were calculated as the nominal rate minus expected inflation, where expected inflation was measured as the percent change in the consumer price index (CPI) over the most

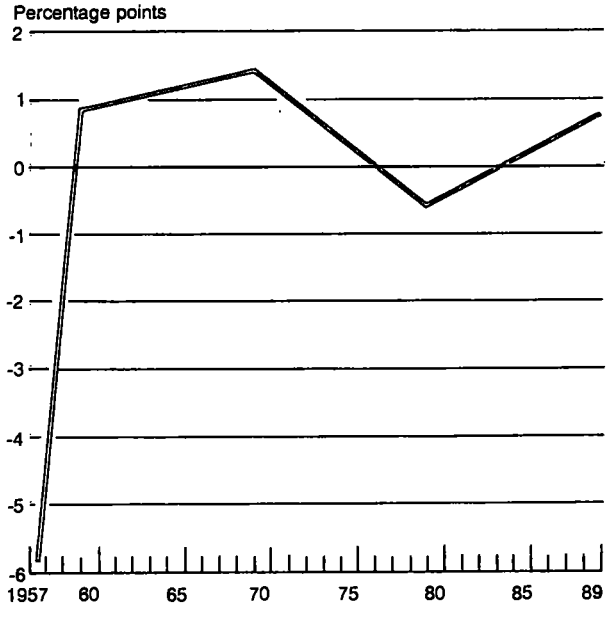
Interest Sensitivity of Real GNP: Real Interest Rates

$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_2 FISCAL_t + \alpha_3 r_t + \epsilon_t$$

	Basic Equation	Time-varying Equation	
	α_3 = Constant	$\alpha_3 = D_{50}(\beta_{50}+\gamma_{50}t) + D_{60}(\beta_{60}+\gamma_{60}t) + D_{70}(\beta_{70}+\gamma_{70}t) + D_{80}(\beta_{80}+\gamma_{80}t)$	
Constant	1.957 (.456)	1.392 (.702)	
Lagged dependent	.274 (.085)	.278 (.130)	
Fiscal policy	−58.970 (26.398)	−64.290 (29.413)	
Interest rate			
Constant	.040 (.171)	β	γ
1957-59		−8.157 (12.909)	.439 (.670)
1960-69		.407 (1.390)	.011 (.031)
1970-70		3.237 (1.928)	−.037 (.021)
1980-89		−2.801 (2.138)	.024 (.018)
Significance level of F-test for exclusion of time-varying coefficients		.309	

Notes: The variable $\%GNP_t$ equals $400*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average three-month Treasury bill rate during the quarter minus the four-quarter CPI inflation rate. $FISCAL_t$ is the eight-quarter change in the ratio of the full employment government budget surplus or deficit to nominal GNP. The variables D_{50}, D_{60}, D_{70}, and D_{80} are dummies for the years 1957-59, 1960-69, 1970-79, and 1980-89, respectively. The equations are estimated from 1957-I to 1989-IV by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value. The numbers in parentheses are standard errors.

Interest Sensitivity of Aggregate Real GNP: Piecewise Linear Specification Using Real Interest Rates



Note: Line plotted shows response of long-run real GNP growth to a permanent 1 percentage point increase in the real three-month Treasury bill rate.

Box: Selection of the Interest Rate Measure *(continued)*

recent four quarters.†

Clearly, real interest rates do not perform well in these equations. In the basic form of the equation (column 1 of the table), the interest rate coefficient has the wrong sign and is not a significant determinant of GNP growth. When the coefficient on interest rates is allowed to vary over time, the implied pattern of interest sensitivity varies from positive to negative (see chart) and the coefficients are not statistically significant. Overall, then, it does not appear that real interest rates are the correct interest rate measure for this specification of the equation.

†We also tried estimates using a forecast of inflation over the next quarter constructed from a single equation autoregressive model; substantially similar results were obtained.

This specification is very general in the sense that no attempt is made to control for the structural factors that might influence the relationship between real GNP and nominal interest rates. This lack of structure is deliberate, since the aim of this exercise is to measure the *net* effect of financial market evolution on the interest sensitivity of output. The notion is that by limiting the set of additional explanatory variables, the coefficient estimate on the interest rate measure, r_t, will capture the aggregate effect of the various channels of monetary policy on output. We include a measure of fiscal policy tightness, however, to control for the impact of fiscal policy changes on the relationship between interest rates and real output.

The equation specified above is appropriate only if the economic regime is stable throughout the entire sample period. The primary hypothesis of this work, however, is that the relationship between real economic activity and interest rates has evolved over time. In order to capture these effects, we estimate various alternative forms of the equation that allow the interest rate coefficient, α_3, to vary over time.

The most general of these specifications is a piecewise linear structure designed to allow the growth path of the interest rate coefficient to shift at the end of each calendar decade in the sample. That is, the interest rate coefficient is allowed to move along a linear path over time, but the slope of the path shifts at the end of each decade. This specification can be expressed as:

$$\alpha_3 = D_{50}(\beta_{50} + \gamma_{50}t) + D_{60}(\beta_{60} + \gamma_{60}t) + D_{70}(\beta_{70} + \gamma_{70}t) + D_{80}(\beta_{80} + \gamma_{80}t),$$

where D_{50}, D_{60}, D_{70}, and D_{80} are dummy variables for the years 1957-59, 1960-69, 1970-79, and 1980-89, respectively; t is a time trend; and the β and γ coefficients are the intercept and slope coefficients of the linear growth paths for each of the four decades.[12] Although this specification restricts the growth path of α_3 to be linear *within* any calendar decade, it provides a straightforward means of testing for changes in the growth path *between* decades.

In addition to this piecewise linear structure, some alternative time-varying specifications are estimated. These specifications include linear, quadratic, and logarithmic growth paths:

Linear: $\alpha_3 = \beta_0 + \beta_1 t$

Quadratic: $\alpha_3 = \beta_0 + \beta_1 t + \beta_2 t^2$

Logarithmic: $\alpha_3 = \beta_0 + \beta_1 \log(t)$.

These specifications are more restricted than the piecewise linear specification in that they place more structure on the type of curvature allowed in the growth path of α_3. Nevertheless, the quadratic form in particular represents an interesting base of comparison since its inflection point is unrestricted and can be compared with the arbitrary turning points selected for the piecewise linear specification.

Estimation results: the basic GNP equation

As a first step in examining the interest sensitivity of economic activity, we estimated a basic form of the GNP equation in which the interest effect is assumed to be constant over time. These estimates are con-

Footnote 11 continued

Hausman specification tests on the basic form of the model strongly reject the exogeneity of the three-month Treasury rate, making instrumental variables the appropriate technique. The estimates were also performed using the first two lags and the second through sixth lags of the interest rate measure as instruments without significantly affecting the results. In the various time-varying specifications, the lagged interest rates are interacted with the appropriate time trend variables to create a set of instrumental variables.

[12]The actual estimation procedure is constrained so that the piecewise linear structure is continuous at the three breakpoints between the decades. This constraint means that only one intercept parameter and the four slope parameters are actually estimated; the remaining intercept parameters can be derived from these estimates.

tained in the first column of Table 1. Overall, the results are consistent with our expectations about the effects of the explanatory variables on GNP growth. The coefficient on lagged GNP growth is positive and statistically significant, and indicates that approximately 24 percent of any shock to GNP growth persists from quarter to quarter. The negative parameter estimate on the fiscal policy variable is consistent with the idea that tighter fiscal policy leads to slower GNP growth, although the coefficient is only marginally significant. Most important for this exercise, the coefficient on the interest rate variable is negative and statistically different from zero. The parameter estimate implies that a 1 percentage point increase in the three-month Treasury bill rate would decrease real GNP growth by nearly 1/2 of 1 percentage point (for example, from 2.0 to 1.5 percent).[13]

Table 1

Interest Sensitivity of Real GNP

$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_2 FISCAL_t + \alpha_3 r_t + \epsilon_t$$

	Basic Equation	Time-varying Equation
	α_3 = Constant	$\alpha_3 = D_{50}(\beta_{50} + \gamma_{50}t) + D_{60}(\beta_{60} + \gamma_{60}t) + D_{70}(\beta_{70} + \gamma_{70}t) + D_{80}(\beta_{80} + \gamma_{80}t)$
Constant	4.338 (.884)	9.482 (1.841)
Lagged dependent	.244 (.083)	.233 (.087)
Fiscal policy	−50.363 (26.270)	−31.101 (28.712)
Interest rate		
Constant	−.365 (.122)	β γ
1957-59		−5.442 (1.455) .162 (.073)
1960-69		−2.571 (.937) .019 (.012)
1970-79		−2.321 (.746) .015 (.007)
1980-89		−.427 (.602) −.0038 (.0025)
Significance level of F-test for exclusion of time-varying coefficients		.003

Notes: The variable $\%GNP_t$ equals $400*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average three-month Treasury bill rate during the quarter. $FISCAL_t$ is the eight-quarter change in the ratio of the full employment government budget surplus or deficit to nominal GNP. The variables D_{50}, D_{60}, D_{70}, and D_{80} are dummies for the years 1957-59, 1960-69, 1970-79, and 1980-89, respectively. The equations are estimated from 1957-I to 1989-IV by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value. The numbers in parentheses are standard errors.

In this specification of the GNP growth equation, the interest rate effect is forced to be constant for the entire sample period. If financial market developments have caused the interest sensitivity of output to change over time, however, then this specification is inappropriate. The second column of Table 1 contains estimates of an alternative version of the model in which the interest rate parameter is allowed to follow a piecewise linear growth path over time. If the impact of interest rate movements has changed systematically since the late 1950s, then we should be able to find evidence of it in this alternative specification.

In Table 1, the subcolumns labeled "β" and "γ" contain the intercept and slope coefficients of the time path of the interest rate parameter over each of the four calendar decades in the sample. If the original specification of the equation with the constant interest rate parameter is correct, then we would expect all of the intercept coefficients (the parameters reported in the "β" column) to be equal to one another, and all of the slope coefficients (the parameters reported in the "γ" column) to be equal to zero. If the effect of interest rates has evolved over time, however, then there should be significant variation among the "β" and "γ" parameters.

The estimates in Table 1 strongly imply that the interest rate coefficient has not been stable over the sample period. As a group, the "γ" slope coefficients are significantly different from zero and the "β" intercept coefficients vary significantly from one decade to another.[14] These results imply both that the effect of interest rate movements on GNP growth has evolved over time and that the pace of this evolution has varied across the decades.

This last result is perhaps easiest to discuss when it is presented graphically. The interest rate effect implied by the estimates in Table 1 is illustrated in Chart 1. The values plotted in this chart represent the impact of a 1 percentage point increase in the interest rate variable on the GNP growth rate. For instance, a value of −1.5 percent on these figures indicates that a 1 percentage point increase in the interest rate is associated with a 1.5 percentage point decline in the GNP

[13]The impact of an increase in interest rates is the implied effect of a permanent 1 percentage point increase in interest rates on the long-run rate of GNP growth, an effect which is calculated by dividing the interest rate coefficient α_3 by one minus the coefficient on the lagged dependent variable α_1.

[14]The hypothesis that the four "γ" slope coefficients are equal to zero is strongly rejected. The F-statistic of this hypothesis is 4.267, which is significant at the .3 percent level (with 4 and 124 degrees of freedom). The hypothesis that the four "β" intercept coefficients are the same is also strongly rejected, with an F-statistic equal to 3.600, which is significant at the 1.5 percent level (with 3 and 124 degrees of freedom).

growth rate (for example, from 3.5 to 2.0 percent). Reading across the chart gives the estimated pattern of this impact between 1957 and 1989.

As the chart makes clear, the estimated interest sensitivity of real GNP changed considerably between 1957 and 1989. The impact of a given change in interest rates declined between the 1950s and the 1970s and then leveled off during the 1980s.[15] Overall, the impact of a change in interest rates is estimated to be significantly smaller by the end of the 1980s than it had been two decades earlier.

Interest sensitivity in the 1950s

One somewhat striking result in Chart 1 is the sharp decline in interest sensitivity during the three years of the 1950s included in the sample period (1957 to 1959). Because of the strength of this result and in lieu of an obvious explanation stemming from financial market developments, we examine the decline more closely to ensure that it does not represent some source of bias in the estimates of the interest sensitivity parameters for the remaining decades in the sample.

A possible source of difficulty with the estimates of interest sensitivity for the 1950s is the fact that only the last three years of the decade are included in the sample. This constraint occurs because the particular fiscal policy variable used in the estimates is available only beginning in 1957. To see whether the short sample period in the 1950s is responsible for producing the estimated sharp decline in the interest sensitivity parameter during this period, we reestimated the basic equation, omitting the fiscal policy variable, FISCAL, and extending the sample period back to the first quarter of 1950. These estimates are contained in Table 2.

For comparison with the results in Table 1, the first column of Table 2 contains the equation omitting FISCAL estimated over the original 1957-89 sample period, while the second column contains estimates over the broader 1950-89 sample. As Chart 2 illustrates, omitting the fiscal policy variable from the equation has little effect on the interest sensitivity parameters in the shorter sample period; both the estimates including the variable (the long-dashed line in Chart 2) and the estimates excluding it (the short-dashed line) exhibit the same sharp decline in interest sensitivity during the 1957-59 period.

When the sample is extended back to 1950, this decline is still evident, although the change in slope between the 1950s and the 1960s is somewhat less pronounced. The results for the 1970s and 1980s are not much affected by the extension of the sample to the early 1950s. Overall, the basic finding with the extended sample is qualitatively unchanged. The interest sensitivity of real output (the solid line in Chart 2) continues to decrease substantially starting in the 1950s, with the rate of decline appearing to lessen somewhat during the 1960s and 1970s and to level off during the 1980s.

Accounting for alternative economic variables

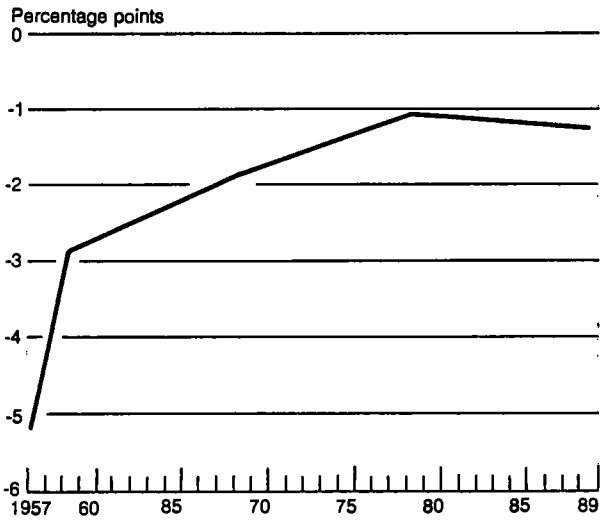
At first glance, the results in Charts 1 and 2 suggest that movements in interest rates had an extremely strong impact on GNP growth, particularly in the early part of the sample. Although the implied interest effect during this period is very large, recall that our estimates do not control for the influence of other variables in the economy and that our calculated interest effect therefore reflects the impact of all other factors on real GNP growth. The comparatively large size of the

[15] In statistical terms, the hypothesis that the "γ" slope coefficients are the same during the periods 1957-59 and 1960-69 is rejected with moderate statistical significance: the t-test value for this hypothesis is 1.809, which is significant at the 7.3 percent level (with 124 degrees of freedom). But the hypothesis that the "γ" slope coefficients are the same during the periods 1960-69 and 1970-79 cannot be rejected: the t-test value for this hypothesis is only .306. In addition, the hypothesis that the slope coefficients are both equal to zero is rejected at the 3.0 percent significance level.

Finally, as Table 1 shows, the "γ" slope coefficient during the 1980s is not significantly different from zero, consistent with the assertion that the sensitivity of GNP to interest rate variations did not change further during this period.

Chart 1

Interest Sensitivity of Aggregate Real GNP: Piecewise Linear Specification



Note: Line plotted shows response of long-run real GNP growth to a permanent 1 percentage point increase in the three-month Treasury bill rate.

implied interest effect in the early part of the sample can be interpreted in part as reflecting the influence of these other factors. The important fact to note from our estimates is not the *level* of the interest effects but their *movement* over time.

In fact, however, if important variables are omitted from our equations, then the time pattern of the interest sensitivity parameters might be biased by the influence of these omitted variables. To test the robustness of our results, we estimate alternative versions of the equation that control for a variety of possible omitted factors. If the pattern of interest sensitivity is not significantly altered when these other variables are included in the specification, we may infer that these alternative factors are not unduly influencing the results.

The additional variables tested as omitted explanatory factors are divided into two categories. The first category represents variables that act as predictors of future GNP growth. These variables include the lagged percent change in leading indicators and, proxying for the yield curve, the lagged spread between the ten-year and three-month Treasury rates. The second category of additional explanatory factors includes variables that control for alternative economic influences. These variables are the inflation rate, the lagged growth rate of M2, and as a more general test, a shifting intercept term.[16]

When these additional variables are held constant in the GNP equation, the interest rate coefficients capture the marginal impact of interest rate movements — that is, the influence of interest rates on the unpredicted or residual part of GNP growth. If the coefficient estimates reported in Table 1 are biased by the omission of important variables, then we would expect that the estimated impact of interest rate movements on the unpredicted part of GNP growth would be significantly different from the estimates derived from the equation omitting these alternative variables. If, however, the estimates in the two sets of regressions are substantially similar, then we can conclude that the coefficients are not significantly biased.

These alternative estimates are reported in Table 3 and illustrated in Chart 3. Looking first at the coefficients estimates for the two sets of alternative economic variables, note that the parameter estimates are consistent with our expectations and are significantly

[16]Since it is a contemporaneous variable, the inflation rate is potentially endogenous, so the first lag is used as an instrument for its contemporaneous value in the two-stage squares estimation.

Table 2

Interest Sensitivity of Real GNP: Regressions Beginning in 1950

$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_3 r_t + \epsilon_t$$

Time-varying Equations

$$\alpha_3 = D_{50}(\beta_{50} + \gamma_{50}t) + D_{60}(\beta_{60} + \gamma_{60}t) + D_{70}(\beta_{70} + \gamma_{70}t) + D_{80}(\beta_{80} + \gamma_{80}t)$$

	1957-89			1950-89		
Constant		9.959 (1.768)			9.147 (1.537)	
Lagged dependent		.243 (.087)			.382 (.074)	
Interest rate		β	γ		β	γ
	1957-59	−5.475 (1.462)	.158 (.074)	1950-59	−3.718 (.865)	.064 (.026)
	1960-69	−2.711 (.930)	.020 (.012)	1960-69	−2.943 (.776)	.025 (.011)
	1970-79	−2.554 (.706)	.017 (.006)	1970-79	−2.360 (.654)	.016 (.006)
	1980-89	−.353 (.602)	−.0049 (.0058)	1980-89	−.264 (.601)	−.0052 (.0056)
Significance level of F-test for exclusion of time-varying coefficients		.002			.002	

Notes: The variable $\%GNP_t$ equals $400*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average three-month Treasury bill rate during the quarter. The variables D_{50}, D_{60}, D_{70}, and D_{80} are dummies for the years 1957-59 or 1950-59, 1960-69, 1970-79, and 1980-89, respectively. The equations are estimated by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value. The numbers in parentheses are standard errors.

different from zero, although at only moderate significance levels for all but the leading indicators variable. The results suggest that the lagged growth in the leading indicators is a very accurate predictor of eventual real GNP growth and that the increases in the slope of the yield curve and the growth rate of M2 are associated with higher GNP growth. Higher rates of inflation, however, appear to be associated with slower GNP growth. Although these variables have at least marginally significant predictive power in the GNP equation, allowing the intercept term to shift at the end of each decade does not appear to contribute to the equation's ability to explain the growth of GNP.[17]

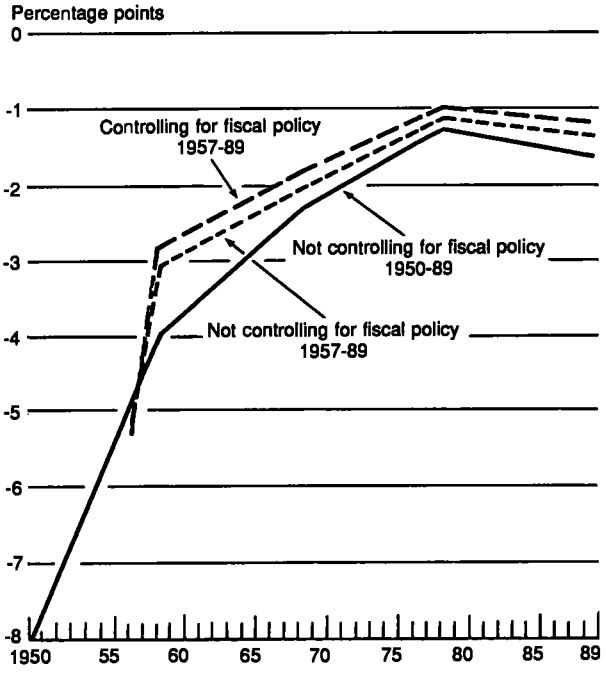
With the exception of the shifting intercept term, then, each of the four additional economic variables is able to explain some part of GNP growth. Even after controlling for the effects of other economic factors in this manner, however, it is still possible to identify a time-varying interest sensitivity. As Chart 3 illustrates, the basic time pattern of interest sensitivity remains in these alternative specifications of the GNP equation, although the level of the effect is altered. A comparison of Charts 1 and 3 reveals that the implied interest effects are somewhat smaller when inflation, the yield curve, and M2 growth are included in the specification, are somewhat larger when the intercept term is allowed to shift, and are significantly smaller when the leading indicator index is included as an explanatory variable.

The time-varying parameters describing the evolution of interest sensitivity continue to be statistically significant in most of these alternative specifications, reinforcing the conclusions based on our initial estimates. The exception to this finding is the specification controlling for leading indicators, which produces estimates of the time-varying interest sensitivity parameters that are not significantly different from zero. Despite the lack of statistical significance, however, the actual estimates in this case produce a time pattern of interest sensitivity that at least resembles the pattern produced by our initial estimates.

[17]The hypothesis that the four intercept coefficients are equal cannot be rejected. The F-statistic for this hypothesis is 1.072, which is significant at the 36.4 percent level (with 3 and 121 degrees of freedom).

Chart 2

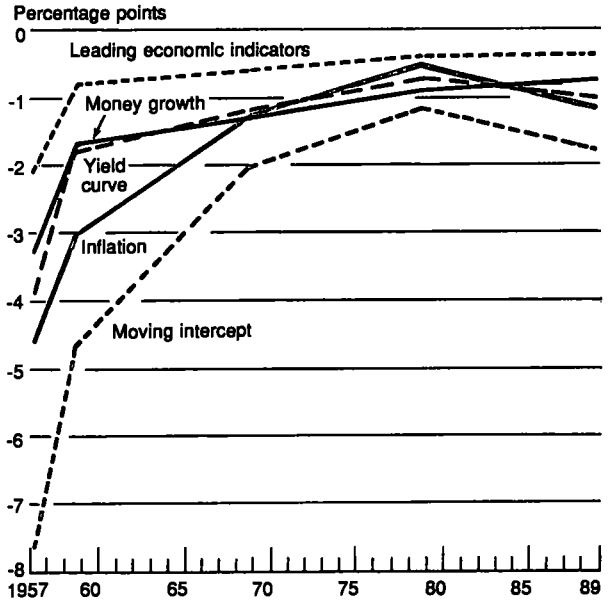
Interest Sensitivity of Aggregate Real GNP: Piecewise Linear Specification Beginning in 1950



Note: Lines plotted show response of long-run real GNP growth to a permanent 1 percentage point increase in the three-month Treasury bill rate.

Chart 3

Interest Sensitivity of Aggregate Real GNP: Controlling for Alternative Economic Factors



Note: Lines plotted show response of long-run real GNP growth to a permanent 1 percentage point increase in the three-month Treasury bill rate.

Alternative time-varying specifications

It is interesting to compare the basic piecewise linear estimates in Table 1 to some alternative time-varying interest sensitivity models. These estimates are presented in Table 4. The three equations contained in this table allow the interest rate coefficient, α_3, to vary with linear, quadratic, and logarithmic time trends. In each specification, the time-varying parameters are statistically significant and imply that the interest sensitivity of GNP declines over the sample period.

The patterns of interest sensitivity from these alternative models are presented in Chart 4. The quadratic and logarithmic trend specifications produce estimated time patterns broadly similar to those suggested by the piecewise linear estimates. The primary difference between the results of quadratic and logarithmic forms of the model and those of the piecewise linear specification is that the quadratic and logarithmic forms do not exhibit the same sharp decline in interest sensitivity during the 1950s.

Interestingly, however, the results of the quadratic estimation demonstrate the same flattening of the interest effect curve during the 1980s as was found in the piecewise linear estimates. The inflection point of the

Table 3

Interest Sensitivity of Real GNP: Additional Economic Factors as Determinants of GNP

$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_2 FISCAL_t + \alpha_3 r_t + \alpha_4 FACTOR + \epsilon_t$$

	Additional Economic Variable									
	Leading Indicators		Yield Curve		Inflation Rate		Money Growth		Shifting Intercept	
$\alpha_3 = D_{50}(\beta_{50}+\gamma_{50}t) + D_{60}(\beta_{60}+\gamma_{60}t) + D_{70}(\beta_{70}+\gamma_{70}t) + D_{80}(\beta_{80}+\gamma_{80}t)$										
Constant	5.249		7.028		10.904		5.529			
	(1.569)		(2.428)		(1.955)		(2.745)			
1957-59									13.973	
									(3.950)	
1960-69									11.725	
									(2.725)	
1970-79									9.423	
									(1.906)	
1980-89									11.516	
									(3.379)	
Lagged dependent	.038		.175		.192		.152		.263	
	(.079)		(.092)		(.088)		(.094)		(.093)	
Fiscal policy	−4.254		−28.329		−14.692		−21.787		−17.289	
	(24.523)		(27.699)		(29.664)		(28.196)		(31.661)	
Additional economic factor	.918		.676		−.507		.359			
	(.149)		(.439)		(.280)		(.193)			
Interest rate	β	γ	β	γ	β	γ	β	γ	β	γ
1957-59	−3.091	.118	−4.699	.163	−4.681	.108	−3.926	.125	−7.463	.201
	(1.239)	(.062)	(1.499)	(.071)	(1.497)	(.078)	(1.631)	(.074)	(2.475)	(.107)
1960-69	−.817	.0038	−1.662	.011	−3.212	.034	−1.555	.0067	−4.414	.048
	(.792)	(.0104)	(1.093)	(.013)	(.979)	(.014)	(1.052)	(.0137)	(1.606)	(.023)
1970-79	−.870	.0047	−1.640	.010	−2.203	.018	−1.733	.0096	−2.494	.016
	(.631)	(.0055)	(.858)	(.007)	(.737)	(.007)	(.775)	(.0069)	(.864)	(.008)
1980-89	−.434	.00036	−.058	−.0055	.942	−.014	−1.094	.0032	.258	−.011
	(.501)	(.00484)	(.626)	(.0918)	(.969)	(.008)	(.676)	(.0067)	(.940)	(.093)
Significance level for F-test for exclusion of time-varying coeffcients	.202		.063		.001		.046		.052	
Significance level for F-test for time-varying intercept term									.364	

Notes: The variable $\%GNP_t$ equals $400*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average three-month Treasury bill rate during the quarter. $FISCAL_t$ is the eight-quarter change in the ratio of the full employment budget surplus or deficit to nominal GNP. The variables D_{50}, D_{60}, D_{70}, and D_{80} are dummies for the years 1957-59, 1960-69, 1970-79, and 1980-89, respectively. The variable $FACTOR_t$ is one of four additional economic factors, either the percent change in the index of leading indicators in the previous quarter, the lagged four-quarter growth rate of M2, the spread between the ten-year Treasury bond and the three-month Treasury bill rates (yield curve), or the four-quarter CPI inflation rate. The equations are estimated from 1957-I to 1989-IV by two-stage least squares using the first lag of the interest rate and alternative macroeconomic variables as instruments for their contemporaneous values. The numbers in parentheses are standard errors.

quadratic form occurs during the fourth quarter of 1982, a finding consistent with the implication of the piecewise linear estimation that the interest sensitivity of output was relatively constant during this period.

The role of changes in monetary policy regime

The estimates presented in Table 1 and Chart 1 suggest that, unlike the previous three decades, the 1980s have seen little net change in the interest sensitivity of real GNP. Aside from financial market developments, at least two explanations of this recent stability are possible. The first explanation involves the regime change at the Federal Reserve between 1979 and 1982. When monetary aggregates displaced interest rates as the primary monetary policy target, perceptions about interest rate variations may have been modified in such a way that the net response of output to changes in interest rates was altered. To the extent that this change in perception resulted in financial market innovation, of course, the regime shift represents another facet of the financial market evolution that is the focus of this analysis. If, however, the regime change at the Fed brought about changes in other aspects of the economy, then these changes could be influencing our results.

To test the regime change hypothesis, we reestimated the basic and time-varying forms of the model, this time allowing the coefficient on interest rates to vary with a proxy for the Federal Reserve regime. We used the within-quarter standard deviation of the weekly average federal funds rate for this proxy. Although this variable does not measure regime change per se, it does reflect shifts in the emphasis between interest rates and monetary aggregates as intermediate monetary targets.

Estimates of the basic form of the equation and estimates of the time-varying model, both controlling for fed funds rate variability, appear in the first and second columns of Table 5, respectively. In both versions of the equation, the variability of the fed funds rate does not have significant explanatory power, suggesting that it has little measurable effect on the interest sensitivity of

Table 4

Interest Sensitivity of Real GNP: Alternative Time-varying Specifications

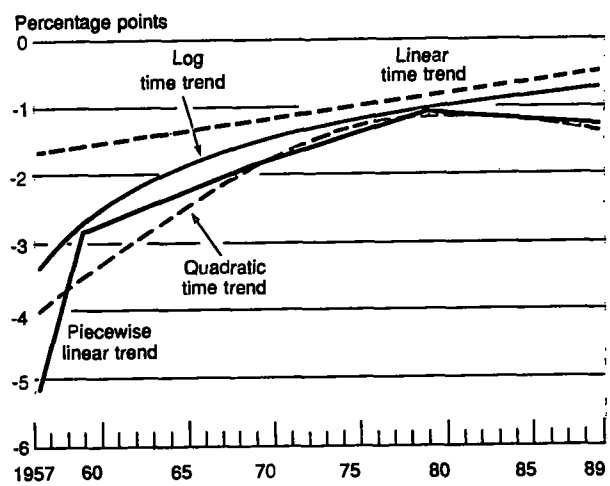
$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_2 FISCAL_t + \alpha_3 r_t + \epsilon_t$$

	Linear	Quadratic	Log
	$\alpha_3 = \beta_0 + \beta_1 t$	$\alpha_3 = \beta_0 + \beta_1 t + \beta_2 t^2$	$\alpha_3 = \beta_0 + \beta_1 \log(t)$
Constant	6.577	9.511	8.213
	(1.215)	(1.706)	(1.401)
Lagged dependent	.230	.246	.225
	(.084)	(.086)	(.085)
Fiscal policy	−38.106	−25.694	−33.705
	(26.841)	(27.902)	(27.006)
Interest rate Constant	−1.334	−3.451	−4.226
	(.374)	(.886)	(1.055)
TIME	.0070	.046	
	(.0025)	(.015)	
TIME squared		−.00021	
		(.00008)	
Log TIME			.743
			(.201)
Significance level of F-test or t-test on exclusion of time-varying coefficients	.007	.001	.000

Notes: The variable $\%GNP_t$ equals $400^*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average three-month Treasury bill rate during the quarter. $FISCAL_t$ is the eight-quarter change in the ratio of the full employment government budget surplus or deficit to nominal GNP. TIME is a linear time trend beginning in 1955-I. The equations are estimated from 1957-I to 1989-IV by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value. The numbers in parentheses are standard errors.

Chart 4

Interest Sensitivity of Aggregate Real GNP: With Alternative Time Trend Specifications



Note: Lines plotted show response of long-run real GNP growth to a permanent 1 percentage point increase in the three-month Treasury bill rate.

GNP. Moreover, the time-varying interest effects are still strongly evident in this specification of the model, with point estimates generally similar to those in Table 1. To the extent, then, that fed funds rate variability is an adequate proxy, our results appear not to be driven by the 1979-82 regime shift at the Federal Reserve.

Another test of the impact of the 1979-82 Federal Reserve regime shift can be derived from long-term Treasury rates. As discussed above, one alternative explanation for the estimated decline in interest sensitivity is that this decline simply reflects the adaptation of the economy to the more volatile short-term interest rates generated by the change in Federal Reserve operating procedure. The volatility of long-term interest rates was presumably less affected by the move to monetary growth targeting, suggesting that the sensitivity of the economy to movements in these long-term interest rates might not have changed significantly. If, however, we find a time pattern of long-term interest rate sensitivity similar to that found for short-term rates, then we can take this as evidence that our basic results are not driven by the Federal Reserve regime shift.

Table 6 and Chart 5 present estimates of the basic

Table 5

Interest Sensitivity of Real GNP: Fed Funds Rate Variability as a Determinant of Sensitivity

$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_2 FISCAL_t + \alpha_3 r_t + \epsilon_t$$

	Basic Equation	Time-varying Equation	
	$\alpha_3 = \delta_0 + \delta_1 \sigma_t$	$\alpha_3 = \delta\sigma_t + D_{50}(\beta_{50} + \gamma_{50}t) + D_{60}(\beta_{60} + \gamma_{60}t) + D_{70}(\beta_{70} + \gamma_{70}t) + D_{80}(\beta_{80} + \gamma_{80}t)$	
Constant	4.129	10.285	
	(1.300)	(2.811)	
Lagged dependent	.243	.223	
	(.084)	(.090)	
Fiscal policy	−50.565	−36.111	
	(26.450)	(29.681)	
Interest rate			
Constant	−.308		
	(.275)		
Fed funds variance	−.039	.097	
	(.161)	(.255)	
		β	γ
1957-59		−6.967	.226
		(1.917)	(.088)
1960-69		−2.894	.022
		(1.421)	(.017)
1970-79		−2.396	.014
		(.796)	(.007)
1980-89		−.868	−.0015
		(1.266)	(.0083)
Significance level of F-test for exclusion of time-varying coefficients		.004	

Notes: The variable $\%GNP_t$ equals $400*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average three-month Treasury bill rate during the quarter. $FISCAL_t$ is the eight-quarter change in the ratio of the full employment government budget surplus or deficit to nominal GNP. σ_t is the within-quarter variance of the weekly average federal funds rate. The variables D_{50}, D_{60}, D_{70}, and D_{80} are dummies for the years 1957-59, 1960-69, 1970-79, and 1980-89, respectively. The equations are estimated from 1957-I to 1989-IV by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value. The numbers in parentheses are standard errors.

Table 6

Interest Sensitivity of Real GNP: Ten-Year Treasury Bond Rate

$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_2 FISCAL_t + \alpha_3 r_t + \epsilon_t$$

	Basic Equation	Time-varying Equation	
	α_3 = Constant	$\alpha_3 = D_{50}(\beta_{50} + \gamma_{50}t) + D_{60}(\beta_{60} + \gamma_{60}t) + D_{70}(\beta_{70} + \gamma_{70}t) + D_{80}(\beta_{80} + \gamma_{80}t)$	
Constant	3.531	10.680	
	(.969)	(2.874)	
Lagged dependent	.261	.212	
	(.083)	(.086)	
Fiscal policy	−59.619	−63.098	
	(26.096)	(27.042)	
Interest rate			
Constant	−.204	β	γ
	(.116)		
1957-59		−4.664	.135
		(1.367)	(.059)
1960-69		−2.239	.014
		(.959)	(.010)
1970-79		−2.289	.014
		(.932)	(.007)
1980-89		−.857	.00013
		(.521)	(.00488)
Significance level of F-test for exclusion of time-varying coefficients		.017	

Notes: The variable $\%GNP_t$ equals $400*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average ten-year Treasury bill rate during the quarter. $FISCAL_t$ is the eight-quarter change in the ratio of the full employment government budget surplus or deficit to nominal GNP. The variables D_{50}, D_{60}, D_{70}, and D_{80} are dummies for the years 1957-59, 1960-69, 1970-79, and 1980-89, respectively. The equations are estimated from 1957-I to 1989-IV by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value. The numbers in parentheses are standard errors.

and time-varying specifications of the GNP equation using the ten-year Treasury bond yield as the interest rate measure. Just as the equations using the three-month Treasury rate demonstrated the variable influence of short-term interest rates, these estimates imply that the influence of long-term Treasury rate movements has not been stable over time.[18] Moreover, as Chart 5 reveals, the implied time pattern of interest sensitivity to movements in the long-term Treasury rate is quite similar to that for the short-term Treasury rate. Together with the estimates that control for fed funds rate variability, these estimates suggest that the time pattern of interest sensitivity is not generated by the 1979-82 Federal Reserve regime change.

The role of inflation

A second potential explanation of the pattern of interest sensitivity during the 1980s concerns inflation. It is possible that the high inflation of the late 1970s somehow altered the response of output in various economic sectors to changes in nominal interest rates, perhaps by affecting the way expectations were formed or by bringing about institutional changes in pricing and indexation. If this is the case, then our estimates could be confounding the effects of inflation with those of financial market evolution.

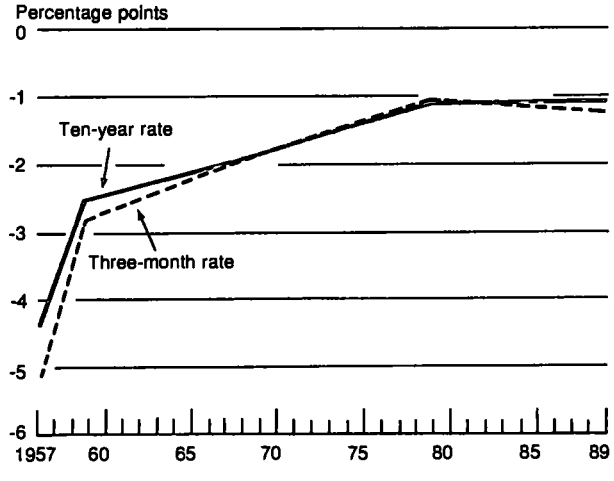
To control for the effects of inflation, we allowed the coefficient on interest rates to vary with the rate of inflation in the basic and piecewise linear forms of the equation.[19] The resulting estimates are contained in

[18]The hypothesis that the four "γ" coefficients are equal to zero, implying a constant interest rate coefficient, is strongly rejected. The F-statistic for this hypothesis is 3.127, which is significant at the 1.7 level (with 4 and 124 degrees of freedom).

[19]We used the four-quarter change in the CPI as a measure of the rate of inflation. Note that these estimates are distinct from those discussed earlier that had inflation entering the equation as an independent explanatory variable. In that specification, the rate of

Chart 5

Interest Sensitivity of Aggregate Real GNP: With Ten-Year and Three-Month Treasury Rates



Note: Lines plotted show response of long-run real GNP growth to a permanent 1 percentage point increase in the three-month or ten-year Treasury bill rate.

Table 7

Interest Sensitivity of Real GNP: Inflation as a Determinant of Sensitivity

$$\%GNP_t = \alpha_0 + \alpha_1 \%GNP_{t-1} + \alpha_2 FISCAL_t + \alpha_3 r_t + \epsilon_t$$

	Basic Equation	Time-varying Equation	
	$\alpha_3 = \delta_0 + \delta_1 \pi_t$	$\alpha_3 = \delta\pi_t + D_{50}(\beta_{50} + \gamma_{50}t) + D_{60}(\beta_{60} + \gamma_{60}t) + D_{70}(\beta_{70} + \gamma_{70}t) + D_{80}(\beta_{80} + \gamma_{80}t)$	
Constant	3.412 (1.035)	8.603 (1.923)	
Lagged dependent	.205 (.086)	.193 (.090)	
Fiscal policy	−43.156 (26.444)	−12.778 (30.364)	
Interest rate			
Constant	.017 (.249)		
Inflation	−.036 (.020)	−.058 (.032)	
		β	γ
1957-59		−4.654 (1.528)	.143 (.074)
1960-69		−2.206 (.968)	.021 (.012)
1970-79		−2.120 (.751)	.021 (.007)
1980-89		1.457 (1.192)	−.016 (.009)
Significance level of F-test for exclusion of time-varying coefficients		.002	

Notes: The variable $\%GNP_t$ equals $400*(GNP_t/GNP_{t-1})$, where GNP is real gross national product. The variable r_t is the average three-month Treasury bill rate during the quarter. $FISCAL_t$ is the eight-quarter change in the ratio of the full employment government budget surplus or deficit to nominal GNP. π_t is the four-quarter CPI inflation rate. The variables D_{50}, D_{60}, D_{70}, and D_{80} are dummies for the years 1957-59, 1960-69, 1970-79, and 1980-89, respectively. The equations are estimated from 1957-I to 1989-IV by two-stage least squares using the first lag of the interest rate variable as an instrument for its contemporaneous value. The numbers in parentheses are standard errors.

Table 7 and illustrated in Chart 6. As the estimates in Table 7 demonstrate, the rate of inflation has a marginally significant effect on the interest rate sensitivity parameter, suggesting that in periods of high inflation, the impact of monetary policy through a change in interest rates is strengthened. Moreover, the time-varying coefficients of the piecewise linear specification continue to be highly significant even after this modification.

As illustrated in Chart 6, the time pattern of interest sensitivity is altered somewhat by controlling for inflation. This chart shows the estimated interest sensitivity when actual inflation is taken into account (the solid line) and when inflation is held fixed at its sample mean (the dashed line). This second series represents the marginal trend in interest sensitivity after controlling for inflation and can be compared to the line in Chart 1.

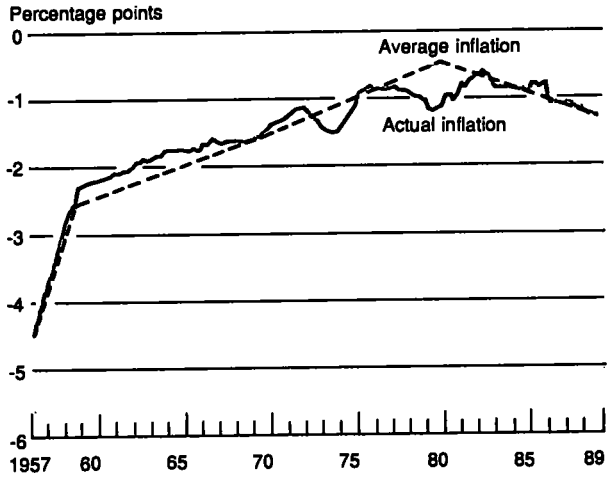
The apparent effect of inflation in this specification is to introduce some cyclical variation into the time pattern of the overall measure of interest sensitivity. Periods of high inflation, such as the early and late 1970s, also appear to be periods of temporarily increasing interest sensitivity. The overall trend, however, is towards a decline of the interest rate impact on real output.

By holding the rate of inflation constant, we can derive the marginal trend in interest sensitivity from our estimates. As a comparison with Chart 1 reveals, the time-related marginal trend in this interest sensitivity (the dashed line in Chart 6) is essentially unchanged by controlling for inflation. As in the earlier estimates, this component of the estimated interest sensitivity decreases from the 1950s to the 1970s. Unlike the previous estimates, however, the estimates controlling for inflation show the slope of the marginal trend line to be more distinctly (and in a statistical sense, significantly) negative during the 1980s. Thus, controlling for inflation alters the prior findings somewhat in that it appears to identify an underlying drift towards an increased interest sensitivity of GNP during the 1980s.

Footnote 19 (continued)
inflation acted to predict GNP growth directly; in this specification, the inflation rate determines the sensitivity of GNP growth to interest rate movements.

Chart 6

Interest Sensitivity of Aggregate Real GNP: Piecewise Linear Specification with Interacted Inflation



Note: Lines plotted show response of long-run real GNP growth to a permanent 1 percentage point increase in the three-month Treasury bill rate.

Comparison with previous research

It is revealing to compare the outcome of our analysis with the findings of Friedman, Bosworth, Kahn, and Akhtar and Harris, all of whom attempt to measure changes in the interest sensitivity of output over the past three decades. As noted earlier, these authors examine the interest sensitivity of activity in several major economic sectors and use their findings about individual sectors to draw conclusions about the interest sensitivity of the aggregate economy. Friedman concludes that there has been little net change in the ability of the Federal Reserve to affect real economic activity through movements in interest rates, while Akhtar and Harris find that the influence of interest rates (net of credit rationing effects) and exchange rates on aggregate output in the mid- to late 1980s was probably stronger than in the period from 1960 to the mid-1970s. From both aggregate and sectoral evidence, Kahn concludes that the interest sensitivity of the economy has actually declined. Bosworth argues that monetary policy lags may have become longer and more uncertain, possibly lessening the shorter run relationship between interest rates and economic activity.

Our results agree most closely with Kahn's findings. Focusing on the results we derived by controlling for inflation, note that our estimate of the interest sensitivity of output at the end of the 1980s is at a level similar to that first reached during the early to mid-1970s (see Chart 6), although it is greater (in absolute value) than its value in the early 1980s. Overall, however, the net interest impact derived from our estimates appears to be somewhat less than that prevailing during the 1960s.

Conclusion

To the extent that our estimates of the interest sensi-

tivity of output are actually reflecting the effects of financial market evolution since the late 1950s, we can conclude that these developments tended to reduce the interest sensitivity of output through the 1970s but may have acted to increase this sensitivity during the 1980s. This finding has some intuitive appeal since the evolution of interest sensitivity corresponds in a general way to the hypothesized effects of various financial market developments. For instance, our estimates suggest that the interest sensitivity of output declined during the 1960s and 1970s, a period during which the development of bank funding markets, deregulation of deposit rate ceilings, and increased access to nonbank credit markets are assumed to have reduced the incidence of quantity credit rationing and thereby diminished the impact of interest rate variations on GNP. Similarly, we find that during the 1980s—the period in which increases in leverage and the internationalization of financial markets are hypothesized to have led to a more potent monetary policy—our measure of interest sensitivity increased. Although it is probably overstating the case to draw a close association between particular financial market developments and the results of our simple estimation procedure, it is nonetheless reassuring to find at least a broad correspondence between these developments and the results presented here. While our aggregate approach makes it difficult to identify precisely the effects of financial market evolution, our findings suggest that there have been measurable changes in the relationship between interest rates and real output over the past three decades.