Preliminary SAVE

Econometric Models and the Monetary Policy Process

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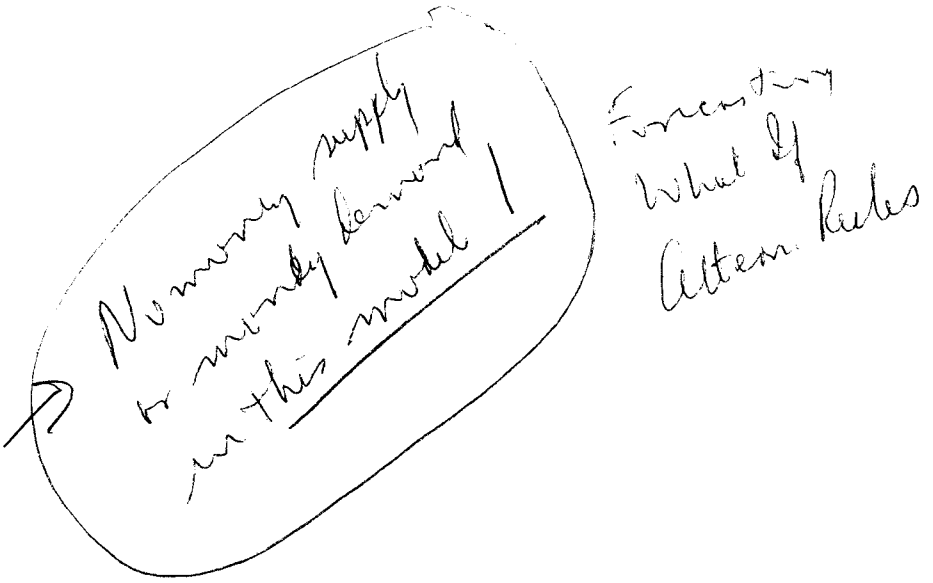

The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the staff, by the Board of Governors, or by the Federal Reserve Banks.

1. Introduction

Economic analysis is both a science and an art. Science enters through the use of sophisticated econometrics, rigorous theory, and high-speed computers. Art enters in order to deal with all the shortcomings of science. This paper is about the ongoing effort of the staff at the Federal Reserve Board to mix science and art in a sensible fashion in support of the monetary policymaking process at our institution.

More specifically, the paper addresses the use of econometric models in monetary policymaking. As we describe in the second section of this paper, there are many econometric models in use at the Federal Reserve Board. These models run the gamut from single-equation models describing individual markets to large-scale systems describing the U.S. economy as a whole. Even within the latter group of models, there are important distinctions among models: Some models take a structural approach while others are completely non-structural; some models focus on U.S. markets exclusively while others embed our economy in the world context.

As we describe in the third section of the paper, these models are used in a wide variety of activities at the Federal Reserve Board. One such activity is economic forecasting. A key objective of this section of the paper is to convey a realistic understanding of how the staff forecast is assembled and the role of models in that process. A central theme that emerges from this section of the paper is that models are rarely, if ever, used at the Federal Reserve without at least the *potential* for intervention based on judgment. Instead, our approach involves a mix of science and art, where "science" is meant to denote a rigid and unyielding adherence to model-based methods and "art" is meant to denote the selective

application of judgment guided by information not available to the model. Models are also used for other important activities at the Board aside from forecasting, including general policy analysis and the evaluation of monetary policy rules, and we describe in section 3 the role of models in these areas as well.

In section 4, we evaluate the strengths and weaknesses of the mixed approach to forecasting and policy analysis typically used at the Federal Reserve. We discuss the types of problems that motivate the reliance on the judgmental approach. However, we recognize that there are hazards inherent in the judgmental approach, and we review these risks and the manner in which they are addressed.

In section 5, we use the experience of the 1990-91 recession to illustrate some of the practical difficulties involved in economic forecasting and policy analysis. During that episode, an overwhelming volume of anecdotal evidence suggested that the economy was being held back by financial "headwinds," including an atypical reluctance of banks to lend—possibly associated with the implementation of new capital standards—and an unusual reluctance of households and businesses to spend, as they labored to improve the state of their balance sheets. Moreover, a nascent research literature (contributed to in part by Board authors) suggesting that such forces could be understood in the context of rigorous models, and that they might play an empirically important role in shaping the business cycle. However, standard macroeconometric models of the day—including the Board's—gave no role to such forces in the determination of real activity. In response to the anecdotal evidence and the research, the staff modified its analysis in a way that it never could have done had it

been locked into a doctrinaire view of the forecasting process Finally, we present some brief conclusions in section 6.

2. Macroeconomic models at the Federal Reserve Board

There is no one model that represents "the" official staff model of the Federal Reserve Board. Rather, many models are in use, each designed with a different purpose in mind. These models vary in complexity and scope, in their theoretical and empirical foundations, even in their formality. In this section, we present a brief overview of the major macroeconomic models in use at the Board. Our focus is on their general design; discussion of their roles in providing support to monetary policy is deferred until section 3.[1]

2.1 The MPS model

From the late 1960s until the beginning of this year, the MPS model was the Board's primary formal model of the U.S. economy.[2] It was a large-scale quarterly model, with about 125 stochastic behavioral equations and more than 200 identities. This model had a neoclassical steady-state: In the long run, all markets cleared and the marginal product of each factor of production (labor, capital and energy) was equilibrated to its relative price. The aggregate production technology was characterized as Cobb-Douglas, so the growth of output in the long run was a function of population growth and the growth of multi-factor productivity, both of which were assumed to be exogenous. However, the steady-state *level*

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[1]In this review, we make no claim to provide a comprehensive treatment of empirical macroeconomic work carried out at the Federal Reserve Board, let alone at the Federal Reserve Banks.

[2]See Brayton and Mauskopf (1985) for an overview of the structure and properties of the MPS model.

of production was influenced by a variety of additional factors, including marginal tax rates, transfer payments and other government policies, that altered both the after-tax rate of return on investment and the propensity to save. The latter role for fiscal policy arose because consumers were assumed to be non-Ricardian, and because the private saving rate depended on the composition of household income and ratio of property wealth to income.

By contrast, the short-run structure of the MPS model was Keynesian in spirit: Output and employment were largely determined by the level of aggregate demand because wages and prices were assumed to adjust only in a sluggish manner. As a result, both monetary and fiscal policy had significant effects on real activity in the short run.[3] The short-run dynamics of the model were quite complex, owing not only to the wage-price sector but also to the equations for household and business spending. These dynamics arose not from tightly specified theoretical models, but from estimated equations in which the level of an (often nonstationary) variable was regressed on a set of explanatory variables, selected on the basis of theory. Coefficients on explanatory variables typically were constrained to lie on low-order polynomial distributed lags; such restrictions were justified as a parsimonious way to capture a combination of adjustment costs and expectations formed from an autoregressive forecasting process. However, no attempt was made to identify expectations from intrinsic sources of sluggish adjustment.

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[3]Strictly speaking, the model was not superneutral owing to the various nonneutralities in the tax code. As a result, monetary policy had modest long-run effects on the capital-output ratio, and thus on the level of potential output. Otherwise, the MPS aggregate supply curve was vertical in steady-state.

2.2 The FRB/US model

Owing partly to dissatisfaction with the treatment of expectations in the MPS model, as well as a desire to update the theoretical basis of the model and to improve upon the econometric techniques used in estimation, staff began to work several years ago on developing a replacement. The result is the FRB/US model, which became fully operational earlier this year.[4] Like the MPS model, FRB/US is a relatively large quarterly model of the U.S. economy; it has roughly 30 stochastic behavioral equations and about 300 accounting and expectational identities.[5] In addition, FRB/US has a similar neoclassical steady-state structure. However, its short-run dynamic structure is considerably different from that of the older model. In particular, a great deal of effort has been directed toward disentagling expectations from other sources of dynamic behavior, in the context of an explicit theoretical structure. As a result, model users are able to examine the sensitivity of forecasts and policy simulations to different assumptions about the manner in which expectations are formed.

Most of the major behavioral equations in FRB/US are derived from formal specifications of optimizing behavior of forward-looking households, firms, and investors. In the case of asset prices, this approach gives rise to conventional arbitrage equations in which, for example, the yield on a bond of a given maturity equals a weighted average of expected

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[4]For an overview of the FRB/US model, see Brayton and Tinsley (1996).

[5]However, the effective size of the model is considerably smaller because many identities could be easily dropped or substituted out: A linearized version of the model that does just this—in order to economize on space for stochastic simulations under model-consistent expectations—has only 95 identities, of which 35 determine expectational variables.

future short-term interest rates, plus a term premium. Similarly, the value of corporate equities equals the present value of expected dividends.

In the other sectors of the model, where frictions such as staggered contracts, habit persistence, labor training, and investment planning and installation costs are significant, the derivation of behavioral equations is more complicated. Agents are assumed to solve an explicit cost minimization problem, in which the cost of deviating from a desired trajectory is balanced against a generalized specification of adjustment costs.[6] The resulting decision rules take the form of tightly parameterized error-correction equations. In these equations, the change in, say, consumption is a function of three factors: (1) the lagged deviation of actual spending from its desired, or target, level (as defined by the present value of expected future income); (2) lagged changes in actual consumption; and (3) a weighted sum of expected future changes in the path of target consumption, where the weights are determined by the estimated coefficients on the first two factors.[7]

Among the explanatory variables in these dynamic equations, are expectations of future variables. In order to estimate these equations, the staff must develop proxies for these expectations. In FRB/US, these proxies are computed using small-scale VAR models. The

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[6]Adjustment costs are approximated by a higher-order polynomial, rather than the conventional quadratic specification. This flexible functional form implies that it is costly to adjust not only the level of a decision variable, but also its growth rate, its acceleration, and so forth. By writing the cost minimization problem in this manner, one obtains decision rules in an error-correction format, where significant coefficients on lagged changes in the decision variable imply adjustment costs that are of an order higher than quadratic (Tinsley, 1993).

[7]The dynamic consumption equation is actually somewhat more complicated than suggested here, in that target spending depends on the composition as well as the level of permanent income (owing to aggregational and distributional effects), and the dynamic equation is modified to account for liquidity-constrained households.

result is a theory-based model that fits the historical data reasonably well. The model also provides considerable flexibility in the treatment of expectations. In addition to using the historical VAR system to generate expectations for policy simulations, expectations can also be generated in alternative ways, including: (1) VAR systems designed to be fully consistent with a particular characterization of policy; (2) full model-consistent expectations; and (3) variants of (1) and (2) in which agents must learn about key features of the model, such as the inflation goal of the monetary authorities. In the case of forecasting, the practice to date has been to project expectations using the historical VAR system.

Given the explicit treatment of expectations in the model, stability in simulations is guaranteed only if agents are assumed to expect both monetary and fiscal policy to be governed by explicit rules. The authorities can depart from these rules in the short run but not in the long run. Thus FRB/US incorporates explicit monetary policy reaction functions (typically variants of Taylor's rule), and fiscal rules that target an exogenous debt-to-GDP ratio by endogenously adjusting tax rates. In the case of the MPS model, such explicit characterizations of policy were not necessary (except in long-run simulations), owing to the adaptive treatment of expectations.

2.3 The Multi-Country model (MCM)

The MCM is a large-scale dynamic model of the world economy, with nearly 1400 equations. These equations are broken into country and regional blocks, so that there are separate specifications for each of the G-7 economies and Mexico, as well as ones for regional aggregates such as the "other" OECD economies, the newly industrialized economies, and OPEC (excluding Mexico). A typical country block for a G-7 economy has

about 35 behavioral equations and 100 identities; the general specification of these equations is fairly similar across countries.

The MCM has been in use at the Federal Reserve since the late 1970s, but has recently undergone a redesign (completed this year) similar in conceptual direction to that of FRB/US.[8] Like FRB/US, the new MCM treats expectations explicitly, setting them either in a model-consistent manner, or according to a small-scale VAR forecasting system.[9] The use of expectational mechanism is pervasive: Bond yields equal a weighted average of expected future short-term interest rates, the exchange rate is determined by an uncovered interest parity condition, consumption and investment depend on the expected real interest rate and the nominal wage rate depends on expectations of both future wage rates and unemployment.

The new MCM is neoclassical in its long-run structure, and it too employs explicit policy reaction functions that tie-down the long-run level (or growth) of the price level and of the indebtedness of the government. However, the treatment of adjustment costs is somewhat simpler, although dynamic equations are often written in an error-correction format. Parameter values are either estimated directly or taken from other econometric work to replicate the empirical behavior of different aspects of the individual countries.

2.4 The World model

Of all the models at the Federal Reserve Board, the world model probably has the best claim to being "the" official staff model. The World model is a hybrid that combines the

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[8]For an overview of the original MCM model, see Stevens, et al.(1984).

[9]For an introduction to some of the properties of the new MCM, see. Levin (1996)..

non-U.S. blocks of the MCM with the domestic equations of FRB/US.[10] The merger exploits the strengths of each of its components. (When FRB/US is simulated on its own, foreign output and inflation are essentially exogenous; when the MCM is simulated on its own, the treatment of the U.S. economy is less detailed.) At present, the treatment of expectations in the World model is more limited than in either of its components, in that only VAR-based expectations are possible. However, work is currently under way to produce a version of the combined model that can be simulated under full model-consistent expectations.

2.5 Other quarterly macroeconometric models

In addition to the large-scale macro models, the Federal Reserve staff also maintains other models of the aggregate economy, such as vector autoregression models (VARs). The standard VAR is small and only includes three or four variables, such as a measure of real activity, inflation, and a financial indicator. Given the low cost of exploring alternatives, many different specifications may be in use at any given time: Real activity can be measured by the unemployment rate, manufacturing capacity utilization, or the GDP gap; inflation can be measured using the CPI or the GDP chain-weight price index; financial conditions can be measured by the federal funds rate, M2 growth, or non-borrowed reserves. Such VARs are viewed as providing an atheoretical check on the dynamics generated by our structural models in response to various shocks.

In addition to these models, which are maintained by Federal Reserve staff, we also consult the models of several commercial vendors.

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[10]Prior to the creation of FRB/US, the World model (dubbed MOMBO) consisted of the linked MPS and old MCM models. The practice of combining the main domestic and international models goes back several years.

3. The uses of macroeconometric models in the monetary policy process

In this section, we shall describe the principal activities in which macroeconometric models are used in the monetary policymaking process. We shall focus on three distinct, but related, enterprises in which the models play a critical role: economic forecasting, the generation of impact multipliers for policy shocks and for changes in other exogenous variables, and the evaluation of alternative monetary policy rules. We will also provide a rationale for the approaches we have chosen to employ in these activities.

Before describing how macroeconometric models are used by the staff, we should point out that models play an often overlooked, but important, role as vehicles for communication. Because the specification of aggregate demand and aggregate supply embedded in the FRB/US model is a reasonable representation of the staff's conception of macroeconomic behavior, the model provides a framework for discussions about the structure of the economy and about the influence of monetary policy on key macroeconomic variables. In this role, the model helps enforce clarity and precision on the staff's macroeconomic analysis. It also enforces a degree of consistency on the staff over time in our communications with policymakers.[11]

To be sure, as is the case with the profession at large, there are differences of opinion among the policymakers (and among the staff) concerning the validity of the models in use at the Board as a complete description of the underlying structure of the economy. For some,

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[11] Unfortunately, econometric models seem to us to play a less prominent role in facilitating conversation between the staff and the outside economists. This no doubt importantly reflects the fact that academic economists, with only a few exceptions, gave up the enterprise of structural modelling about 20 years ago.

these differences center on the specification of particular behavioral relationships. But for others, there are fundamentally different views about the economic paradigm described by the model. Such differences of opinion explain why the staff has developed alternative models, and why not all discussion and research activity is carried out in the context of FRB/US. Nevertheless, the model provides policymakers with a clear view of the baseline framework employed by the staff in our macroeconomic analysis.

That said, there are limitations that could result from too rigid an adherence to the framework embodied by the model. We know with certainty that the model is misspecified—in some areas, probably by a great deal. The difficulty is that misspecification often is revealed only gradually over time. Indeed, some constructive tension always exists between the current specification of the model and the staff's evolving understanding of macroeconomic behavior based on our research efforts and those of others. For example, the treatment of expectations in the MPS model did not accurately reflect the staff's view of how the economy actually operates, especially the financial sector. The resulting divergence meant, for example, that the MPS gave a different accounting of how a multi-year fiscal package would affect the term structure of interest rates than the staff would have done. The bottom line is that while, under most circumstances, the model serves as a useful communication device, it cannot always be taken as a literal representation of the staff's "model."

In the subsequent discussion, we shall outline three broad approaches to carrying out macroeconomic analysis for policymaking. The first approach involves a large-scale macroeconometric model without intervention; the second involves using of a large-scale

model with intervention; and the third is explicitly judgmental. By the use of a large-scale model without intervention, we mean to connote a regime in which the model is not altered in any respect once it has been estimated.[12] Use of a large-scale model with intervention implies to us an activity in which the analyst may shift intercepts or apply other add-factors to residuals. A judgmental approach may incorporate information from one or more large- or small-scale models, but the analysis is not framed in terms of adjustments to a single system of equations. To be sure, the distinctions among these approaches are somewhat murky, especially for the latter two approaches. In effect, the Board staff employs all three of these approaches, but the activities in which they are used differ. At the risk of some oversimplification, the economic forecast is produced using a judgmental approach, the analysis of shocks to that forecast is conducted using an add-factored econometric model, and analysis of alternative policy rules usually involves an unadjusted model. We will attempt to provide a rationale for this eclectic approach.

3.1 Forecasting

The Board staff prepares a detailed forecast of the U.S. and foreign economies prior to each of the eight Federal Open Market Committee (FOMC) meetings held each year. The staff presents this forecast and the accompanying analysis in a policy document called the Greenbook. The projection interval typically is about two years in length. The forecast is designed to provide a baseline for Committee discussion and is the view of the staff and not of the members of the FOMC. It is quite common for Committee members to take issue with

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[12]We recognize that even this definition leaves some role for judgment to play a role; mainly, judgment would enter in from speculation, and possibly the unspecification, of the model.

either the particulars or the broad contours of the staff projection. Some Committee members may have different views about the economic outlook, even taking as given the policy assumptions underlying the staff forecast. Others may view the staff projection as plausible given the policy assumptions, but may regard the macroeconomic outcome as unsatisfactory given their policy objectives. Finally, there may be disagreements about other conditioning factors, such as foreign economic policies, fiscal policy, or oil prices. When there are obvious risks associated with the assumptions underlying the forecast or with key macroeconomic relationships, simulations of FRB/US, MCM, World, and commercial models are used to highlight the sensitivity of the forecast to these risks. (These activities are described in section 3.2.)

The baseline forecast presented in the Greenbook is referred to as a "judgmental" projection because it does not result from a mechanical run of any large-scale macroeconometric model nor is it derived directly by add factoring any such model. Until recently, we have not made much use of "pure" model forecasts. Instead, persistent patterns in equation errors (often regarded as evidence of structural change) were factors projected into the future judgmentally. Equation add-factors were also adjusted to reflect current quarter information. But during the major respecification project of the past several years, the staff has developed an automated time-series approach to forecasting model residuals.

By design, equation residuals in the new model are supposed to be white noise. But in practice, this property may not hold out of sample, perhaps owing to structural change. In addition, for some equations it does not even hold within the estimation period (although the

economic importance of this residual serial correlation is not great).[13] To take account of the predictable element of the errors in the projection, all residuals are analyzed using a simple time series model. For each equation, the model is fitted to the last 10 year's worth of data using weighted least-squares, where the weights decline geometrically as one moves back in time. (Roughly 50 percent of the weight is put on observations in the most recent three years.) These coefficient estimates are then adjusted using Thiel's mixed estimation procedure, where the best estimate of the "true" error model is defined to be a weighted average of the least-squares estimator and a Bayesian prior that the errors are white noise. The weights chosen in this procedure are a function of the variance-covariance matrix of the least-squares estimates, so that more weight is placed on the Bayesian prior if the time series model is estimated imprecisely. The final version of the model is then used to project the equation errors over the forecast period. This new algorithmic approach should allow practical consideration of a "pure" model forecast, though we have not yet accumulated enough experience with this technique to assess its usefulness in actual application. Consequently, we are still some distance away from being able to rely heavily on a pure model-based forecast.

The staff has also avoided framing the forecast in terms of add factors to our large-scale models. FRB/US is used as an input in the broader judgmental forecasting process, but it, like the MPS model, is not the principal vehicle for producing the forecast. In part, this

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[13]There are a few exceptions to this statement, most notably the bond rate and stock market equations. In these particular cases the residuals display a significant degree of serial correlation, which has been interpreted as a time-varying component of the term and equity premiums. Work is ongoing to develop economic models for these premiums.

reflects a concern that approaching the forecast as a collection of add factors would create too narrow and mechanical a focus in both the preparation and communication of the forecast. In developing the judgmental forecast, the staff considers a wide range of alternative specifications for key behavioral relationships, including those specifications embodied in FRB/US. In addition, the staff incorporates other non-model sources of information into its forecast. We evaluate the pros and cons of this approach in the next section of the paper. Before describing how FRB/US is employed as a tool in preparing the forecast, we review the institutional setting in which the forecast is produced, and then outline the judgmental forecasting process.

The judgmental forecasting process begins with a set of conditioning assumptions for monetary and fiscal policy and for some key variables that, to a first approximation, are exogenous to U.S. output, inflation, and interest rates. With respect to monetary policy, the point of departure for the staff forecast most often is an assumption that the nominal federal funds rate will remain unchanged over the next six to eight quarters. This procedure might seem less natural than one in which the staff projection was organized around developing a path for the federal funds rate that would minimize the losses associated with the "objective function" of the policymakers. In part, our approach reflects important institutional features of the Federal Reserve System. The FOMC is composed of the seven members of the Board of Governors and five of the twelve Reserve Bank presidents.[14] The Committee is a

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[14]The President of the Federal Reserve Bank of New York serves on the FOMC every year. Chicago and Cleveland serve in alternating years, and the other nine presidents serve one year out of every three. All presidents participate in Committee discussions, regardless of their current membership status.

deliberative body; therefore, issues surrounding the objectives, strategies, and tactics of monetary policy are open to discussion. The diversity of the Committee members' views makes it difficult to define clearly an "objective function" from which an "optimal" federal funds rate path could be derived. The role of the staff in this process is not to recommend policies but to provide the forecasts and analysis that will facilitate Committee deliberations and decisions. Strictly speaking, therefore, the staff forecast is not an unconditional forecast of the economic outlook. On the contrary, it is conditioned on a particular assumption about the path of monetary policy which, at the time of the forecast, may not appear to be the path most likely to be pursued. Of course, there are times when the economic forecast produced by an assumption of an unchanged federal funds rate is so at odds with the stated objectives of most policymakers that such a projection would not serve as a useful baseline for discussions. Under these circumstances, the forecast would be conditioned on an alternative path for the funds rate. In general, for each forecast, model multipliers on changes in the federal funds rate are applied to the staff forecast to allow the policymakers to judge how the projection would differ under alternative assumptions about interest rates.

Fiscal policy also is a key conditioning factor in the staff projection. To be sure, large portions of the federal budget are sensitive to output, incomes, inflation, and interest rates, and thus are endogenous to the forecast. The staff preserves this endogeneity by specifying its assumptions in terms of tax policy and discretionary spending, which are seen as largely exogenous over the two-year interval of the projection.

Other aspects of the forecast exhibit varying degrees of exogeneity. Foreign economic activity is sensitive to U.S. economic and financial conditions, but considerably less so than

most components of domestic spending. The same is true of the price of oil. For these inputs into the domestic forecast, feedbacks must be accounted for, though in general the effects are small. As with the monetary policy assumptions, when especially large risks are associated with these assumptions, model simulations are used to highlight the associated sensitivities of the staff forecast.

At the start of each FOMC forecast process. a forecast coordinator provides the forecast participants with these key conditioning assumptions as well as initial paths for output and inflation, which often are those of the most recent forecast. Given these conditioning assumptions and the economic and financial news that has become available since the previous forecast, economists covering various components of aggregate demand—consumption, fixed investment, inventories, government spending, and net exports—and aggregate supply—labor supply, capital services, and wage and price determination—adjust the projections for their sectors. These forecasts are then assembled by the coordinator into an overall economic forecast of aggregate output, income, inflation, and interest rates, along with projections of sectoral detail. This forecast is then relayed back to the sector analysts, who react to any changes in the endogenous variables of relevance to their sector and provide the coordinator with a new forecast. If necessary, further iterations occur until the process converges. "Solution" of this rather cumbersome judgmental system is tractable largely because the economic outlook generally does not change greatly from one meeting to the next. As a check on the process, FRB/US is used to ensure that the implications of incoming news for intermediate-term dynamics of the economy have been adequately taken into account.

Considerable effort in preparing the forecast is involved with filtering high-frequency data to establish the near-term forecast. Getting the correct starting point is important because much of the dynamics of spending and production in subsequent quarters depends on an appropriate assessment of the current cyclical state of the economy. Is underlying income growth strong? Is current production flowing mainly to final sales or to inventories? Are increases in final sales adding mainly to demands on domestic or foreign producers? Because the most recent statistical data are noisy, incomplete, and often contradictory, these questions are more difficult to answer than might be imagined.. Large-scale macroeconometric models, which rely primarily on quarterly time-series data, are not well suited to this activity. By contrast, the staff involved in the judgmental forecast exploit a vast array of econometric and statistical models in filtering and forecasting these high-frequency data. (See, Braun (1990) for an example of a model that pools data from the establishment and household surveys to produce a projection of current-quarter GDP.)

Board staff are continuously engaged in the interpretation of incoming data. We attempt to operate like a Kalman filter, extracting from the newly available information (say, a monthly retail sales report or a revised quarterly reading on GDP growth) that portion which is "news" in the formal sense. Conversations between the staff and the members of the Board often are conducted in terms of the implications of the incoming information for the Staff forecast. Large-scale models generally play little role in this near-term filtering exercise because baseline assumptions about the soon-to-be-released indicators are established in the course of each FOMC forecasting round, and it is a relatively (though not entirely) mechanical process to compare these assumptions with the just-announced data.

In addition to near-term filtering models, each sectoral economist maintains and consults a stable of econometric models relevant to his or her sector for guidance in the preparation of the longer-term forecast. These models typically encompass a range of plausible specifications—some are minor variations on a standard model, while others can represent quite different paradigms. For example, the economists covering business fixed investment maintain accelerator models, neoclassical investment models, putty-clay models, and models that incorporate various financial constraints on investment spending, such as corporate cash flow. The sensitivity of the forecasts of these models might also be examined with respect to the particulars of specification: for example, the forecast sensitivity of investment equations might be examined with respect to the choice of variables used to measure sales expectations and the cost of capital, or the lag length assumed to capture adjustment costs. This approach allows the judgmental forecasters a better understanding of both the risks associated with the forecast and the sources of those risks; this is information not easily filtered through the lens of a single large econometric model.

Although not used directly to produce the staff economic projection, the large macroeconometric model serves an important function in this process. FRB/US is simulated throughout the forecasting process and is updated for incoming data and changes in any assumptions about policy or exogenous variables. (The model uses the staff judgmental assumptions about fiscal policy, short-term interest rates, oil prices, the exchange rates, and foreign activity.) The results of these model runs are used at both the sectoral and aggregate level as an input to and a check on the judgmental projection. To flag any unusual discrepancies, the staff examines the add-factors required on the model equations to produce

the staff judgmental projection. These implicit judgmental add-factors can be compared with those produced by the algorithmic approach to provide a clear identification of those areas where tensions exist between the staff's judgment and that of the model. In addition, stochastic simulations of the model are used to generate confidence intervals around the model forecast. The position of the staff forecast relative to a 70 percent confidence interval around the model forecast provides an additional consistency check on the staff forecast.

FRB/US plays a more significant role in the development of the staff projection when there have been large changes in conditioning assumptions or in exogenous variables. Under these circumstances, the judgmental process of incremental adjustment to the forecast could not be counted on to converge quickly or accurately to a new solution path. As a consequence, the model can be used to establish a new baseline that can serve as the point of departure for the judgmental forecast when there have been large changes in policy assumptions or in the paths of exogenous variables, or extraordinary amounts of "news" received since the previous meeting. The next section describes how the models are used for these and other similar exercises.

3.2 Policy Simulations

While macroeconomic models play an important role in the development of the forecast at the Board, they may play an even more important role in addressing "what if" questions. This role is generally fulfilled through multiple simulations of a model in which baseline results are compared with those obtained when model structure or exogenous variables are altered. The range of questions that models are used to address is broad, and often includes issues well beyond the domain of monetary policy. Thus, while model

simulations are frequently used to gauge the macroeconomic consequences of hypothetical monetary policy actions, they also provide quantitative answers to such diverse questions as the dynamic response of the current account to an exogenous appreciation of the dollar, the effects of an increase in the minimum wage on inflation, and the effects of changes in fiscal policy on the term structure of interest rates, output, and capital accumulation. Just about any question of general macroeconomic interest is fair game, and it is only the amount of detail incorporated into the models themselves that limits their use in this regard.

3.2.1 Changes in conditioning assumptions

The policy simulations carried out at the Board can be divided into several categories. Simulations in the first category involve changes in the conditioning assumptions that underlie the staff economic projection. As noted above, the staff judgmental forecast is based on explicit assumptions for several key macroeconomic variables—the federal funds rate, federal spending and tax rates, oil prices, and foreign economic policies. A great deal of uncertainty surrounds these assumptions, and an important issue in any forecast is how the overall outlook would change if these variables were to evolve in a different manner. To this end, simulation exercises are routinely carried out to estimate the quantitative influence of plausible perturbations in these variables on aggregate output and inflation.

The evolution of alternative monetary policy settings is an important model activity. With the introduction of the forward-looking models, it has become necessary to be more specific about the ultimate purpose of the policy action. Specifically, is the shock to the funds rate a transitory event, or is it the start of a sustained policy to alter the long-run level of inflation? This question did not arise in the context of the older models because

expectations were adaptive. But in the new models, how agents interpret policy actions has an important effect on the dynamic response of output and inflation. If the change in interest rates is seen as transitory, the short-run response of the economy will be minimal. But if agents perceive the action as part of, say, a sustained disinflation policy, then the immediate response of long-term interest rates, inflation and output will be substantial. Generally, the practice in these simulations has been to assume that agents view such shocks as transitory. However, in experiments where the funds rate is raised or lowered for more than a year, this assumption implies that agents make a long string of forecast errors -- a statistically improbable event.

In exercises involving changes to other variables, monetary policy is typically treated in one of two ways. One approach treats monetary policy as exogenous, in the sense that the nominal federal funds rate is held at its baseline path. The rationale for this treatment is that it isolates the effect of the change in conditioning assumptions. The other approach treats the funds rate as endogenous, either by targeting nominal income, or by using an explicit Taylor-type reaction function, or by employing *ad hoc* search procedures to find values for the funds rate that return inflation or unemployment to their baseline paths. These exercises are routinely reported in Greenbooks and in other policy documents, and are often used by the staff to illustrate significant risks to the forecast.

3.2.2 Alternative policy strategies and risk analysis

A second category of model simulation involves the analysis of alternative strategies for monetary policy over a longer period. This type of exercise begins with the creation of a five-year (or longer) baseline. The baseline is set equal to the staff judgmental forecast as far

out as that forecast is available; beyond that, the baseline is generated using the model, based on time-series extrapolations of exogenous variables and explicit assumptions for fiscal and monetary policy. For example, fiscal policy assumptions might be based on Congressional Budget Office projections, while monetary policy could be chosen to keep inflation on some specified path. In addition, extended baselines typically incorporate certain "stylized facts" about the economy—drawn from a large body of econometric work within and outside the Federal Reserve System—that may or may not be embedded in the model itself. For example, multi-factor productivity, labor force participation and population might be constrained to grow at particular trend rates, and the model's price equation residuals could be adjusted to yield a particular value of the NAIRU.

With the baseline in place, the next task is to simulate the macroeconomic effects of alternative monetary policies. These alternative monetary policy strategies are discussed in the Bluebook—a staff document prepared for the FOMC with the goal of facilitating discussion of policy options and risks. The main focus of the Bluebook discussion is on the likely path of inflation under different strategies, and on the implications for policy of different risks to the outlook. In that regard, the old combined MPS-MCM model was used to compare the implications of alternative medium-term trajectories of inflation for the paths of output and interest rates.

Our new models allow consideration of the much richer context in which policy decisions must be made. For example, the question of policy credibility can now be formally addressed. Disinflation policies that are fully credible presumably have lower costs in terms of lost output and employment than ones that are discounted by the public, and FRB/US can

now be used to assess the likely empirical importance of such credibility effects. In particular, the model can be run first under the assumption that monetary policy is fully credible, and second under the assumption that agents only learn about the FOMC's long-run inflation target over time. In the second simulation, the cost of disinflation in terms of lost output will be higher than in the first. This type of analysis provides policymakers with a sense of the implications of credibility and expectations for the economic consequences of disinflation.

In a similar vein, changes in policy are likely to engender changes in the expectations formation process, and thus in the dynamic behavior of the economy, and FRB/US can be used to assess the importance of these effects as well. Although the alternative policy strategies that we had presented in the past were not radically different from historical policies, and thus would not be expected to invalidate the general flavor of simulations conducted under the assumption of adaptive expectations, the Lucas critique was a source of discomfort to all involved in the production and consumption of these simulations. In any event, we believe that the Lucas critique should have less force *vis-à-vis* FRB/US and the redesigned version of the MCM.

As noted earlier, model simulation results are also used by the staff to quantify risks in the economic and policy outlook. For example, we have investigated a hypothetical situation in which the NAIRU differs from that initially perceived by policymakers at the start of the simulation. The purpose of this exercise was to gauge how long it might take for such an error to become apparent, given that such an error almost certainly would be accompanied by transitory price shocks that would create signal extraction problems. Other examples of

risk analysis carried out by the staff include simulations of alternative policy responses to increases in the minimum wage, and the effects of changes in the real exchange rate.

3.2.3 Other examples of model-based analysis

Macroeconometric models have been used in many other ways to address important economic issues. Examples include: decomposing the sources of historical GDP forecast errors, by analyzing the relative contribution of equation errors made in different sectors (Stockton 1993); computing historical movements in the equilibrium real interest rate (Bomfim 1996); and estimating the size and persistence of unobserved shocks to aggregate demand and supply, based on observed movements in the term structure of interest rates. Outside of forecasting and the development of monetary policy scenarios, analysis of alternative fiscal policies is one of the most frequent uses of our large-scale models. Models have helped to shed light on two different aspects of fiscal policy—steady-state aggregate supply-side responses, and the dynamic effects of fiscal policy changes on aggregate demand.

With respect to aggregate supply, detailed models of the U.S. economy such as FRB/US incorporate many channels for fiscal policy to influence the long-run economy: marginal tax rates and investment subsidies affect the desired capital-output ratio and the labor force participation rate;[15] transfer policies alter the mix of household income and thus the private saving rate; and debt policies influence the aggregate saving rate because households are not Ricardian.

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[15]In FRB/US marginal tax rates have no effect on labor force participation, but they do in two of the commercial models (DRI and WUMM).

Large-scale macro models are also used to analyze the short-run effects of fiscal policy changes. Unlike the long-run aspects of fiscal policy, which are of only general interest to monetary policymakers, the dynamic response of the economy to a fiscal policy shock can be of immediate practical concern. One reason for this interest has been already discussed: The stance of fiscal policy, as given by the projected growth of federal spending and various tax rates, is an important conditioning assumption for the near-term outlook. But another reason concerns the behavior of bond and other asset prices. Because the level of government spending, taxation and debt influences the level of the equilibrium real interest rate, anticipated future changes in fiscal policy affect bond yields and equity prices in the present. Such expectational effects raise special issues for monetary control, because a credible program of fiscal austerity, if scheduled for a future date, can potentially be stimulative in the near term owing to the fall in bond rates that follows the announcement of the plan (see Taylor 1995). Under these conditions, keeping inflation constant may require raising short-term interest rates for a time. Such expectational effects were extremely difficult to account for in the old MPS and MCM models, but FRB/US and the new MCM are well designed for the analysis of such questions.

3.3 Evaluation of monetary policy rules

Much research undertaken at the Board over the past twenty years has involved the use of macroeconometric models to evaluate various proposed monetary policy rules. This might seem peculiar given our earlier acknowledgment that the policy process of the Federal Reserve is not driven by rules in any simple or mechanical sense. However, there is not any necessary tension here; indeed, Yellen (1996) and Meyer (1996) have laid out some of the

reasons that even a discretionary policymaker might wish to be apprised of the prescriptions of rules. The staff can play a useful role in this regard by assisting policymakers in using models to define, develop, and select rules with favorable characteristics.

In this section, we summarize a small but representative sample of work that has used macroeconometric models to evaluate monetary policy rules. These studies have addressed several broad issues. Some of these studies have attempted to sort out which variables policymakers should consider in adjusting the federal funds rate; at various times, the staff has looked at rules that are dependent on inflation, real output, nominal income, monetary aggregates, commodity prices, and financial variables such as the yield curve and exchange rate. This work has sometimes explored the implications of the degree of aggressiveness of policy in response to changes in these policy indicators. Models have also been used to examine issues involved in establishing the long-run objectives of monetary policy. Other work has taken the objectives of monetary policy as given, and has focused more on alternative strategies for achieving those objectives. Finally, some work has used a variety of macro models to explore the robustness of rules to alternative assumptions about the structure of the economy—in the tradition of McCallum (1984, 1988). The results of this work are transmitted to the Board and the FOMC by way of research papers, memoranda, and special briefings or seminars.

An example of the first type of study is provided in Brayton and Tinsley (1996), who use stochastic simulations of the MPS model to compare the effectiveness of four simple policies in minimizing the variability of prices and output. Each policy responds to fluctuations in a different indicator. Brayton and Tinsley consider four candidates (nominal

GDP, the GDP deflator, M2, and an index of commodity prices), and conclude that, by a fairly wide margin, nominal GDP is the best. Perhaps surprisingly nominal GDP ranks first in Brayton and Tinsley's assessment even if the policymaker is assumed to care only about stabilizing prices. The explanation for this result appears to lie in the fact that demand shocks feed into prices only with a lengthy lag; as a result, a policy that keys on the GDP deflator will tend to react too little and too late to demand shocks. In sum, according to Brayton and Tinsley, "output and price stability are more often compatible, rather than competing, intermediate-term objectives [p.312]."

Brayton, Levin, Tryon, and Williams (1996) build on the idea that any particular monetary policy rule will endow inflation with a certain variance around its target level, and will also endow output with a certain variance around potential. Moreover, any realistic econometric representation of the economy will imply that there exists an efficient policy frontier, consisting of policies that deliver the minimum variability of inflation for given variability of output. Brayton et al. provide an explicit empirical estimate of the location of this frontier given the structure of FRB/US. They also find that a policy rule estimated using data covering the period since 1980 appears to have been quite close to that frontier. By contrast, a policy based on mechanical application of Taylor's rule would have been relatively far from the frontier, because the responses to inflation deviations and output deviations would have been insufficiently vigorous.

An example of the second type of study is provided by Fuhrer and Moore (1995). These authors specify and estimate a small-scale rational expectations macroeconometric model of the U.S. economy. A key component of this model is a policy rule which

determines changes in the short-term nominal interest rate based on deviations of inflation from target, and deviations of output from output from potential. Fuhrer and Moore examine various possible settings for the parameters of this rule, and conclude that the settings that most closely match the historical behavior of the Federal Reserve strike a good balance among four competing policy objectives: minimizing the sacrifice ratio, minimizing the variance of the output gap, minimizing the variance of inflation deviations from assumed target, and minimizing the variance of the short-term nominal rate.[16]

Fuhrer and Madigan (1996) provide an example of research that has explored issues related to the long-run objectives of monetary policy. These authors use the Fuhrer-Moore model to examine whether the constraint at zero on nominal interest rates has implications for the optimal setting of the long-run inflation objective. They note that a central bank may find it desirable, in the course of a recession, to set the short-term nominal interest rate below the rate of inflation—in other words, to push the rate into negative territory in real terms. If the inflation rate is very low, the central bank may face a binding constraint on its ability to drive the real rate down, and thus on its ability to stabilize real activity. Summers (1991) cited this possibility as a reason for setting a *positive* rate of inflation as the objective of monetary policy. Based on simulations of the Fuhrer-Moore model, however, Fuhrer and Madigan conclude that, for most shocks typical of the post-war U.S. experience, the ability of the Federal Reserve to conduct countercyclical monetary policy in a low-inflation context would

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[16]The bulk of this paper actually is concerned with considerations related to the correlation between the output gap and various interest rates; for our purposes, however, the results described in the text are the more relevant portion of this paper.

not have been seriously impaired by the zero constraint on nominal interest rates. For severe shocks, however, this ability would indeed have been reduced.

Orphanides et al. (1996, in process) provide an example of work that has focussed on the strategy of monetary policy. This work aims to compare the performance of an "opportunistic" policy rule with a conventional rule, using a small-scale (ten equation) empirical macroeconometric model with rational expectations. Because the opportunistic rule is nonlinear in the state variables, the major macroeconomic variables of interest (such as the output gap and the deviation of inflation from its target) are not distributed according to the normal distribution even if the underlying shocks to the economy are normal. The paper illustrates some of the tradeoffs this situation makes available to policymakers. For example, there exist opportunistic policies that produce more diffuse inflation distributions than their conventional counterparts, but more concentrated output distributions. The ultimate objective of the paper is to assist policymakers in assessing alternative disinflation strategies.

Finally, Bryant, Hooper, and Mann (1993) offers an example of work intended to explore the robustness of rules to alternative assumptions about the structure of the economy. This volume represents the latest installment in a monumental effort to coordinate research efforts across a large number of large-scale models.[17] Board staff have played an important role in this project since its inception, and this volume was no exception (two of its three editors and several of its contributing authors being members of the staff). As with many other studies in this literature, the aim of this volume was to evaluate the success of

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[17]The earlier volumes in this series include Bryant, Henderson, et al. (1988), Bryant, Holtham, and Hooper (1998), and Bryant, Currie, et al. (1989).

alternative monetary policy rules in achieving certain policymaker objectives. The distinguishing features of this effort were that it involved extensive participation by eight different teams using large-scale macroeconomic models, and that each of these models placed the U.S. economy explicitly in a global context. One of the main findings of the study was that "either nominal-income targeting or real-GNP-plus-inflation targeting, in contrast to money targeting or exchange-rate targeting, best stabilizes national economies if the loss functions of policymakers ... stress a combination of [real variables such as output or employment] and nominal ultimate-target variables such as the rate of inflation or the price level [p.30]."

4. An evaluation of the relative merits of model-based and judgmental approaches to policy analysis

In this section, we evaluate the procedures used at the Board, which employ both judgment and models in developing forecasts and policy analysis. Macroeconometric models—both large- and small-scale—serve an extremely important function in the development of analysis for the monetary policy process. However, we do not see these models as being capable of completely supplanting the use of judgment in the preparation of this analysis. Nevertheless, there are some drawbacks and potential pitfalls to the approach we have taken, and we highlight those that we view as being most serious.

4.1 The weaknesses of models and their mechanical application in policy analysis

4.1.1 Identification and the Lucas Critique

A common criticism of large-scale structural models is the lack of adequate identification. These models typically contain many more variables than equations, and identification in such systems is obtained by a host of exclusion restrictions, some of which

are difficult to justify on theoretical grounds. Another common criticism of large-scale models involves the Lucas critique: Because such models are simply reduced-form representations of the economy, their structure will change when ever there is a significant shift in policy, and thus, these models are not well suited for analysis of the effects of changes in policy. These two arguments help explain why structural models fell out of favor with the profession during the 1970s and early 1980s.

In large measure, these criticisms motivated the development of FRB/US and the new MCM. For example, FRB/US attempts to deal with the identification issue by basing the specification of its dynamic equations on theory, and using explicit proxies for expectational variables in estimation. As for the Lucas critique, the model is often run under model-consistent expectations, implying that the dynamic properties of the model fully incorporate any changes in the behavior of agents that would be induced by a shift in policy.[18] Even under VAR-based expectations, agents' expectations in FRB/US cannot be continually biased because learning mechanisms ensure that. expectations are fully in accord with simulated outcomes in the long run. Still, one can conceive of policy experiments that would make the use of fixed VAR forecasting mechanisms problematic.[19] As a practical matter, we recognize

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[18]This statement assumes that the change in policy is not so great that it would induce a change in the structural parameters of the model. If one was interested in the effects of a hyperinflation on the behavior of the U.S. economy, FRB/US would probably not be a good guide, because in the real world there would presumably be a change in the adjustment costs embedded in the (fixed) coefficients of the wage and price equations.

[19]To address this problem, we plan to develop procedures whereby the expectational system can be made consistent with the behavior of the overall model under any specification of policy, by re-estimating the VARs using pseudo-data generated by stochastic simulations.

that myriad identification questions remain, and we have directed our research resources toward resolving those with the greatest possible policy consequences.

4.1.2 Problems analyzing changes in endogenous variables

Although the introduction of forward-looking expectations has alleviated some problems associated with the use of structural models, many difficulties still persist. In particular, the use of models to estimate the macroeconomic effects of changes in conditioning assumptions can be problematic. It is straightforward to use model simulations to estimate the response of real GDP or inflation to a change in a truly exogenous variable, or even a variable that is weakly exogenous, such as the price of oil. It is more complex to construct coherent experiments for shocks to variables that have a large endogenous component, such as the exchange rate or bond yields.

As a practical matter, identifying the source of these shocks, at times, can be extremely difficult, yet will be critical to setting up the appropriate experiment. Shocking long-term interest rates in the model in response to observing an unexplained rise bond yields will lead the model to signal future weakness in economic activity. However, such a prediction would be justified only if the rise in long-term interest rates was associated with an increase in term premiums. If, instead ,the observed rise was associated with expectations of higher output and inflation in the future (and thus higher short-term rates), the correct conclusion would be that the change should have the opposite effect. Although we are fully aware of the pitfalls involved in interpreting innovations in financial variables, using the model to estimate the effects of changes in these variables is fraught with difficulty.

4.1.3 Structural Change

Another problem that afflicts any large-scale macroeconometric model is structural change. Although the consequences may not be too serious if the evolution of the economy is gradual and the model is not used for long-run forecasting, the situation is much less favorable if structural changes occur abruptly and could not be contemplated by the model builders. For example, the end of Regulation Q and the innovations in the mortgage market have altered the dynamics of housing demand in ways that we are still struggling to understand. In these cases, the structure of the model may immediately become inadequate for describing behavior in the sector. Under some circumstances, it may be possible to alter the model's structure in an appropriate manner, especially if theory provides guidance for how the effect should be incorporated into the system. But if the quantitative effects of the event cannot be pinned down from theory, then the model builder may be stymied: The influence may not be estimable from historical data.

4.1.4 Consideration of Alternative Specifications

As was mentioned in the previous section, we believe that it is useful for the staff to be able to examine a range of econometric specifications—both structural and reduced-form—in carrying out policy analysis, rather than relying on a single specification enshrined in the "staff model." The examination of a range of specifications and behavioral models affords a more realistic assessment of the uncertainty attached to the analysis. Indeed, it is difficult to cite any major macroeconomic relationship about which there would be widespread professional consensus as to the appropriate specification. To be sure, specification tests are available that with sufficient data should enable us to sort through

alternative specifications, or to optimally combine forecasts from alternative models. And, the research program of the Board staff involves a considerable amount of this type of work (Oliner, Rudebusch, and Sichel, 1995, 1996; Ando and Brayton, 198x; Stockton and Glassman, 1987; Stockton and Struckmeyer, 1989; Porter and Feinman, 1992; Edison, 1991; Edison and Pauls, 1993; Meese and Rogoff, 1983.)

But the uncertainties that exist—and probably will continue in perpetuity—suggest a need to remain alert to the implications of alternative specifications. The use of a single model can inadvertently straightjacket thinking and miss important phenomena that are not incorporated in the model's specification. Some of these differences can have significant effects on the outlook. For example, whether one's model included an effect of cash flow on investment, an influence of stock market wealth on consumption, or a direct channel from money to price inflation would, at times in the recent past, have had significant consequences for the macroeconomic outlook. Ultimately, the staff must take a stand on these issues for purposes of presenting analysis to the policymakers. But, in our view, the emphasis on alternative specifications that characterizes the staff's judgmental approach to forecasting allows a fuller articulation of the risks facing policymakers than might a more narrowly focused model-based forecast. (Our colleague, Peter Tinsley has proposed the development of a facility in FRB/US that would allow the flexibility to "plug in" alternative specifications of equations or perhaps blocks of equations. This would allow a more thorough analysis of specification uncertainty within the context of the FRB/US model.)

4.15 Incorporation of Extramodel Information

Finally, a judgmental approach makes it easier to incorporate "extra-model" information and anecdotal evidence. Strikes, natural disasters, and other idiosyncratic shocks to the economy can have important timing effects on real output and inflation, even if they rarely have persistent effects. A purely model-based approach might misinterpret a strike-induced decline in production likely to have averaged persistence, when as a judgmental analyst would be able to recognize the shock as shorter lived

Anecdotal evidence, which plays no role in a pure model forecast, also can be exploited by a judgmental forecaster. If we were entirely confident of the quality and timeliness of our official data, the role of anecdotal information likely would be negligible. But our data systems are flawed and often subject to substantial revision, and unfortunately, large-scale econometric models are captives of the available data. A vast amount of information is collected by the staff, much of it on a relatively systematic basis, but some of it not. For example, about three weeks before each meeting of the FOMC, the staff of the Reserve Banks conduct an extensive set of interviews with firms of all types in their districts, including retailers, bankers, manufacturers, service providers, and others. This information is issued as the so-called Beige Book. The Beige is thought to have been useful on occasions in the past in shedding light on trends in the economy—especially trends too recent to have shown up in formal statistics. Board staff routinely make contacts with businesses to gather information of the conditions of their firms and industries. The Board also has various advisory councils, which can provide assessments of economic developments. The ongoing nature of these sources of informal evidence allows the staff to develop at least an intuitive

sense of the reliability of the resulting information. Nevertheless, it must be admitted that the quality of much anecdotal information is poor, the motives of those supplying the anecdotes often are suspect, and there are strong temptations to hear only those anecdotes that confirm one's present views. Consequently, while anecdotal information cannot be neglected, its contribution to macroeconomic analysis obviously will be quite limited.

4.2 The weaknesses of the judgmental approach to policy analysis

Although the judgmental approach offers significant advantages over a purely model-based method, there are significant potential pitfalls inherent in this less formalized methodology. First, the behavioral relationships underlying the judgmental forecast are much less susceptible than those embedded in the purely model-based approach to statistical validation and diagnostic testing. As noted above, in principle, as data samples grow infinitely large, a careful researcher should be able to discriminate between any two competing statistical representations of a given behavioral relationship. However, conventional statistical methods seem to us to be of dubious applicability to the problem of validating a judgmental forecast, not least because the formal "structure" generating the staff forecast is continually evolving over time. Therefore, an assessment, for example, of how the staff forecast would change in response to an oil price shock might not be the same in 1996 as the reaction embodied in the forecast of 1986. Of course, we monitor the out-of-sample track record of the staff judgmental forecast and assess performance with a variety statistical forecast evaluation techniques. (See Romer and Romer (1996) for an example of such an effort by two authors outside the Federal Reserve Board.)

A second difficulty with the judgmental approach stems directly from the very flexibility that is seen as the principal advantage of this approach over the purely algorithmic approach. This flexibility can result in a loss of discipline and rigor in at least three related but distinct ways. First, a tendency could exist for judgmental forecasts to be too heavily influenced by the most recent data observations. For example, in early stages of business cycle recoveries, it is difficult to disentangle the cyclical rebound on labor productivity from

any change in trend that might be occurring. During these periods, economic observers frequently cite many examples of industries or firms that are accomplishing significant productivity improvements. Nevertheless, statistical evidence confirming a broad-based shift in trend productivity often is slim or nonexistent when viewed over a complete cycle. In a similar vein, Fischer (1996) has noted that economists often adjust their estimates of the natural rate of unemployment toward the actual unemployment rate to a greater extent than might be justified by straight reading of the statistical evidence. While a purely algorithmic computer reading of the data would have no difficulty assigning a small weight to the most recent readings, such detachment can be more difficult for judgmental forecasters.

Loss of discipline can also be manifested in inconsistency over time. For example, in a judgmental process, there is no guarantee that a given set of extra-model information will provoke exactly the same reaction on the part of the forecaster at two different points in time. In part, such inconsistency can reflect nothing more than the fact that is different people are engaged in the assembly of the forecast from one FOMC meeting to the next, and inevitably different individuals will evaluate the same packet of information differently.[20]

Operationally, a problem related to consistency is that application of judgment can obscure the relative roles of changes in conditioning assumptions, shifts in economic relationships, or changes in views about key behavioral relationships in influencing the forecast. (Only the latter is inherently "judgmental.") In practice, the staff attempts to deal with this problem by focusing heavily on being able to explain the revision in the forecast

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[20]The severity of these problems is minimized by the continuity of the judgmental forecasting staff and the consistency of econometric and statistical techniques used in assembling the judgmental forecast.

from the previous round (or from some more distant date). This focus compels the staff always to attempt an explicit quantification of the role of judgmental factors in influencing the innovation in the forecast from the previous round.[21]

The hazards we describe here would doubtless be even greater were it not for the case that the staff develops, maintains, and consults macroeconometric models in the preparation of our forecasts and policy analysis. This attention to models makes us well aware of when we are deviating from established econometric relationships, and compels us to examine the strengths and weakness of the arguments for this divergence. Consequently, the problems that might be associated with an excess sensitivity to incoming data or a lack of consistency over time in reactions to recurring or idiosyncratic surprises can be minimized; the models provide an important reference point for ensuring consistency of reaction and analysis over time. We look forward to the time when a stable and reasonably complete "consensus" model of the economy exists that could eliminate our reliance on an ample dose of judgment. Until that time, we view our approach, which relies on large-scale macroeconometric models as inputs in our analysis but also considers alternative specifications and information from outside the model, as a necessary compromise.

5. Credit, balance sheets, and macroeconomic performance from 1989 to 1992

The cyclical episode running from 1989 to 1992 highlights both the difficulties and benefits associated with using a large-scale macroeconometric model for policy analysis. The

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[21]The difference between a judgmental and purely algorithmic forecast can be easily understood within this framework: A judgmental forecast allows the variance of the third term (pertaining to reassessment of behavioral relationships) to be non-zero, whereas a purely algorithmic approach sets that variance equal to zero.

recession of 1990-91 and the subsequent slow recovery was, at the time, attributed to a number of unusual influences including: the so-called "credit crunch" associated with changes in capital requirements and an increased reluctance to lend owing to deteriorating loan performance; and a deterioration in the balance sheets of business and households. (Collectively, these unusual influences were referred to by Chairman Greenspan as "financial headwinds.") The basic challenge that we confronted was that these explanations for the weak recovery suggested channels of influence that were not present in the MPS model. In this section, we shall review the basic macroeconomic setting and describe how we interpreted some of these events in light of the MPS model, accumulating research on the credit channel of monetary policy, and readings from other sources of information. Our emphasis here will be on how the MPS model was used in the analysis of these issues, rather than on resolving the questions surrounding the sources of the weak recovery from the last recession. Even now, we do not believe that there is a well understood or widely accepted answer as to why economic activity was as weak as it was during that period.

The recession, which began in the third quarter of 1990 and ended in the second quarter of 1991, was about of average depth and duration compared with other downturns in the postwar period. However, as seen in chart 1, the subsequent recovery, measured by either real GDP or industrial production, was much weaker than the norm. The upturn was especially delayed in labor markets, with nonfarm payrolls having failed to reach their previous peak by the end of 1992 and with the unemployment rate rising for nearly one and half years after the trough in activity. The contour of monetary policy, as indexed by movements in the federal funds rate, also was atypical both before and after the recession

(chart 2). The Federal Reserve began to lower the funds rate in the spring of 1989, five quarters prior to the business cycle peak. By contrast, for the average postwar experience, the federal funds rate continued to rise until the quarter preceding the peak. In large measure, this reflected the fact that, in the late 1980s, the Federal Reserve was not confronted with inflation pressures of the magnitude experienced in past episodes. However, a sharper difference in behavior occurred after the trough in activity. In the early 1990s, the funds rate declined for six quarters after the trough;for the average experience, the funds rate turned up shortly after the trough.

Among the explanations of the unusual weakness in this recovery was the contraction occurring in the depository sector. Growth of depository credit was exceptionally slow during this period, even by standards of past recessions, and, for a time, credit actually contracted (chart 3). During this period, the share of securities holdings in bank portfolios rose to a high level. There were also abundant anecdotal stories of businesses having difficulties acquiring credit—in some cases, from banks with which they had long-standing relationships. These stories received some support from the Senior Loan Officer Survey of 50 to 60 large banks conducted by the Federal Reserve Board. As seen in chart 4, from early 1990 until mid-1992, banks included in this survey reported tightening credit standards for loans to firms of all sizes, and growth in aggregate business loans from banks (chart 5) decelerated sharply. Survey readings from the National Federation of Independent Businesses (NFIB) also strongly suggested that small- and medium-sized businesses were having difficulty obtaining credit.

Meanwhile, a growing body of research—with substantial contributions from Federal Reserve economists—suggested that banks play a special role in the monetary policy

transmission process (see Kashyap and Stein (1993) for a review of this literature). This work stresses the function that banks serve in the presence of asymmetric information and emphasizes the transmission of monetary policy shocks through the asset side of the bank balance sheet to borrowers who rely heavily on bank lending—particularly small businesses and households. Empirical tests find support for this hypothesis using firm-level data, which showed that small firms' investment is more sensitive to changes in cash flow than that of larger firms (Gertler and Gilchrist (199x)).

The supply of credit was not the only unusual financial feature of this period. The balance sheets of both businesses and households were suffering from the decline in real estate values and rising debt burdens. In the corporate sector, gross interest payments absorbed about 40 percent of cash flow (chart 6), and in the household sector, the debt service burdens associated with mortgage and consumer credit outstanding were estimated to have risen above 18 percent of disposable income—both highs for the postwar period. Some observers expressed concern that cash flow and income were being diverted from spending and toward repair of balance sheets, thus implying that there was more restraint on spending for any given real interest rate than might normally be the case.

Both of these arguments—credit constriction and balance sheet pressures—certainly had some degree of plausibility. But neither of these factors played a direct role in the MPS model, where the principal transmission mechanisms were interest rates, exchange rates, and asset prices. (This remains the case in FRB/US.) Moreover, there were other explanations of the weakness that operated through the conventional channels of influence that were incorporated in the model: fiscal restraint associated with the downsizing of defense spending,

the collapse of the commercial construction, and the sharp slowing in activity abroad.

The MPS model served as a useful point of departure for assessing the relative merits of these arguments. To this end, the structural errors of the model equations were used to provide an accounting of model surprises, which could then be examined for their congruence with these alternative explanations of the restraint on activity (Stockton, 1993). The contribution of the series of structural errors from each sector was assessed by simulating the full model with the structural errors for that particular sector (or collection of errors, for sectors characterized by more than one equation) set equal to zero. Thus, the contribution of errors to aggregate output was taken to include both the direct effects of those errors on spending and the indirect multiplier-accelerator effects. The results of this exercise are displayed in table 1 for four major spending categories of domestic spending and for the set of equations determining productivity. On the spending side, the structural errors in the consumption equations accounted for the largest negative shock to output, taking an average of 0.5 percentage point per year off of real GDP growth over this period. The errors in the inventory investment block of equations accounted for an another 0.1 percentage point average reduction in real GDP growth over the period. On the supply side, the productivity equations also accounted for an important share of the effect of the structural errors on real GDP growth—amounting to a 0.3 percentage point per year restraint on the growth of activity; the immediate effect of a negative productivity surprise on the MPS model is to raise demand as income shifts in favor of labor income, out of which there is a larger propensity to consume. However, over time, the effects of lower productivity on profitability, equity values, and household net worth act to depress real activity.

This pattern of errors did not immediately point to credit constriction or balance sheet stress as an obvious alternative explanation of the slow growth in activity during this period. The fact that the equipment spending equations were tracking well during this period suggested that unmodeled credit constraints and balance sheet problems probably were not exerting an important depressing influence on outlays for capital equipment. By contrast, the consumption equation errors were consistent with the hypothesis that credit availability might have been a problem. But most of the shortfall in spending was for nondurables and services, rather than durable spending, where credit constraints might have been expected to exert greater restraint on spending. Moreover, the results of our Senior Loan Officer Survey never detected any reduced willingness to lend to consumers in this period (chart 4). And, when the errors from the consumption equations were regressed on measures of debt-service burdens no clear correlation emerged (table 2). The errors in the inventory investment equations also provided some evidence in favor of a credit supply channel on spending. This view received further support from research by Kashyap, Stein, and Wilcox (199x), which.... On balance, the pattern of errors from the model provided a hint that spending may have been affected by the unusually sharp contraction in bank lending, but the results were far from conclusive.

The errors in consumption equations were also noted by other researchers during this period (Hall (1993); Blanchard (1993)), who argued that there had been an exogenous shift in consumption spending relationships. It was observed that consumer sentiment was much weaker than could be explained by its usual correlates, including income growth, the unemployment rate, and inflation. Indeed, inclusion of the Michigan survey measure of

consumer sentiment in the consumption equations of the MPS model virtually eliminated the error in the equation for nondurables and services. Thus, the unusual weakness in consumer spending could have resulted more from heightened insecurity about job and income prospects than from the supply or demand for credit (Carroll, 1992). As a data footnote to this exercise, we should note that flow of funds estimates of household net worth were subsequently revised down by a substantial amount—largely on the basis of data showing much weaker real estate wealth than indicated by the preliminary figures—further erasing the consumption puzzle of this period. At the time, we recognized that this was a possibility (Stockton, 1993), but the magnitude of the revision was, nonetheless, surprising.

Despite the lack of a smoking gun from the examination of the performance of the MPS model during this period, the staff gave weight to the possibility that credit constraints and balance sheet problems were holding back aggregate demand. The micro-level research on the role of bank credit, the anecdotal reports of credit availability difficulties, and survey evidence gathered from the banks themselves suggested that these influences could not be dismissed. Certainly, judging from public pronouncements, many Fed policymakers also were of the view that these influences were exerting a significant drag on activity. And, beyond public statements, the actions of the FOMC also suggest that there was a view that unusual forces were weighing on the economy; the federal funds rate was well below the level consistent with a mechanical reading of the Taylor rule, which has been suggested by some to describe fairly well the behavior of the FOMC since 1987.

This description of the events and analyses of the 1989 to 1992 period is intended to highlight some of the difficulties that are encountered in the "real time" use of a large

macroeconometric model. We doubt that any model can avoid encountering periods when events, theory, or data raise questions about key elements of specification. However, having a well developed macroeconometric model is essential at least for framing questions about current economic developments and for testing that model against alternative explanations of events. But, we must recognize that the current state of our knowledge about empirical macroeconomics suggests that no one model is likely to provide a fully adequate description of the many complex phenomena that will confront policymakers. For this reason, we believe the eclectic approach chosen by the staff for developing macroeconomic analysis, at present, has no superior alternative.

6. Conclusion

Econometric models play an important role in at the Federal Reserve Board. The staff has long devoted considerable effort to the design, estimation, and implementation of large-scale macroeconometric models. These models are important inputs into the forecast process and into much of the staff's macroeconomic and monetary policy analysis. That said, the economic environment is a forbidding one for models: Appropriate specification and identification of models is elusive; data are faulty and subject to revision; the economy is in a constant state of flux; and events not contemplated at the time of model design frequently buffet the economy. Given the current state of econometric knowledge, these considerations imply that judgment will continue to be a necessary ingredient in the policy process for the foreseeable future.

Table 1
Effects of Structural Errors on Real GDP

	Simulated effect on the level of real GDP				Average annual effect on Q4/Q4 real GDP growth, 1980–1992
	1989	1990	1991	1992	
Consumption	–1.2	–2.7	–2.8	–2.1	–0.5
Equipment inventment	–.5	–.1	–.1	.2	0.0
Housing	.4	.2	–.2	–.1	0.0
Inventory investiment	–.2	–1.1	.2	–.3	–0.1
Productivity	.3	–.7	–1.5	–1.6	–0.3

Table 2
Consumption and Debt–Service Burdens

	Coefficients on:		
Consumption category	Total	Mortgage	Installment
Nondurables and services	.005 (.83)	.052 (.33)	.066 (.86)
Motor vehicles	–.012 (.38)	–.004 (.11)	–.034 (.93)
Other durables	.015 (1.70)	–.004 (.20)	.023 (2.39)

NOTES:

1. Each consumption equation was re–estimated with a debt–service measure. T–statistics are indicated in parentheses. Sample periods end in 1989:Q4

2. For nondurables and services, the estimated coefficients indicate the effect on the marginal propensity to consume out of disposable income of a one percentage point change in debt burden ratio. Coefficients in the two durables equations are semi–elasticities, measuring the short–run percentage change in spending that results from a one percentage point change or one index point change in the regressor.

Chart 1

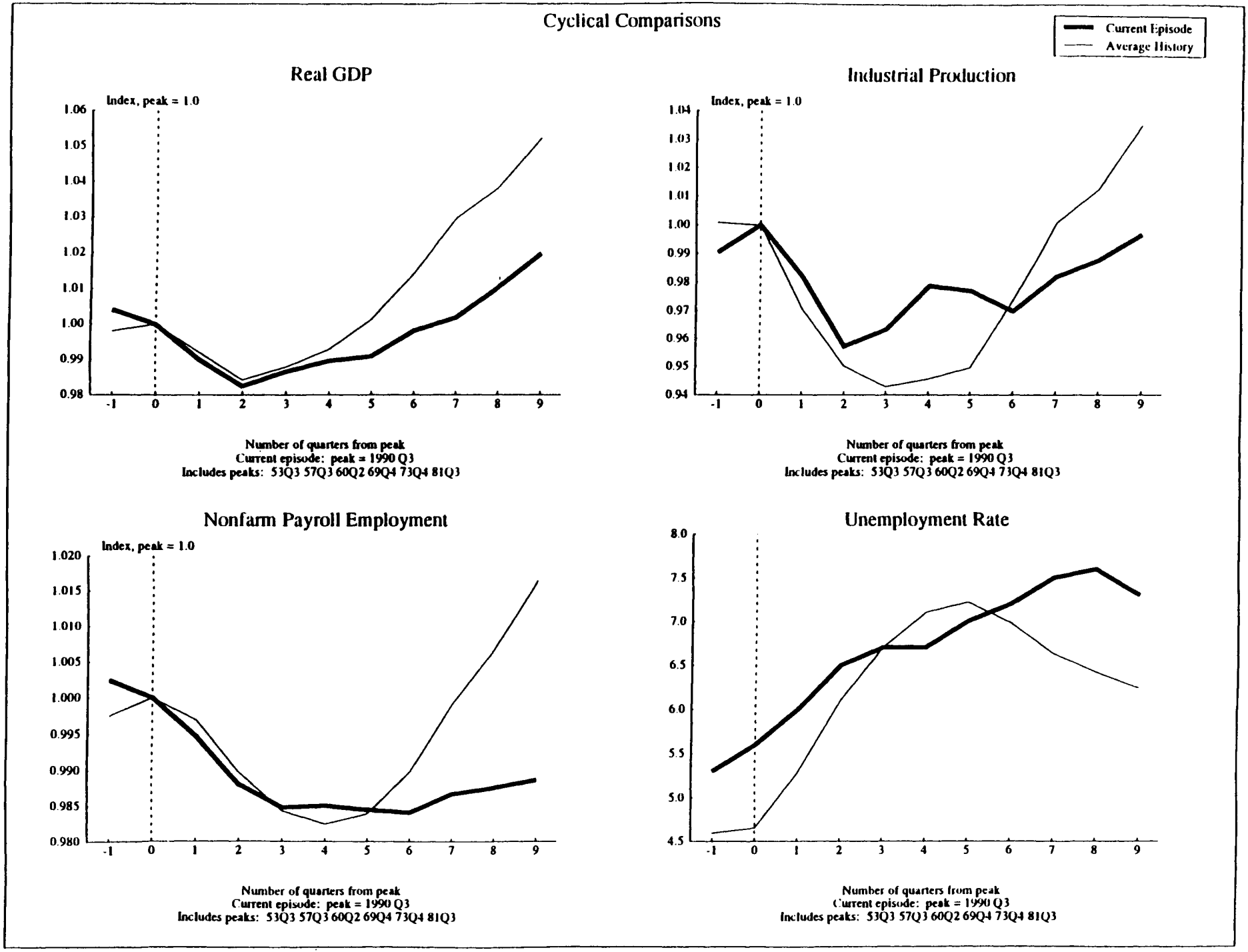
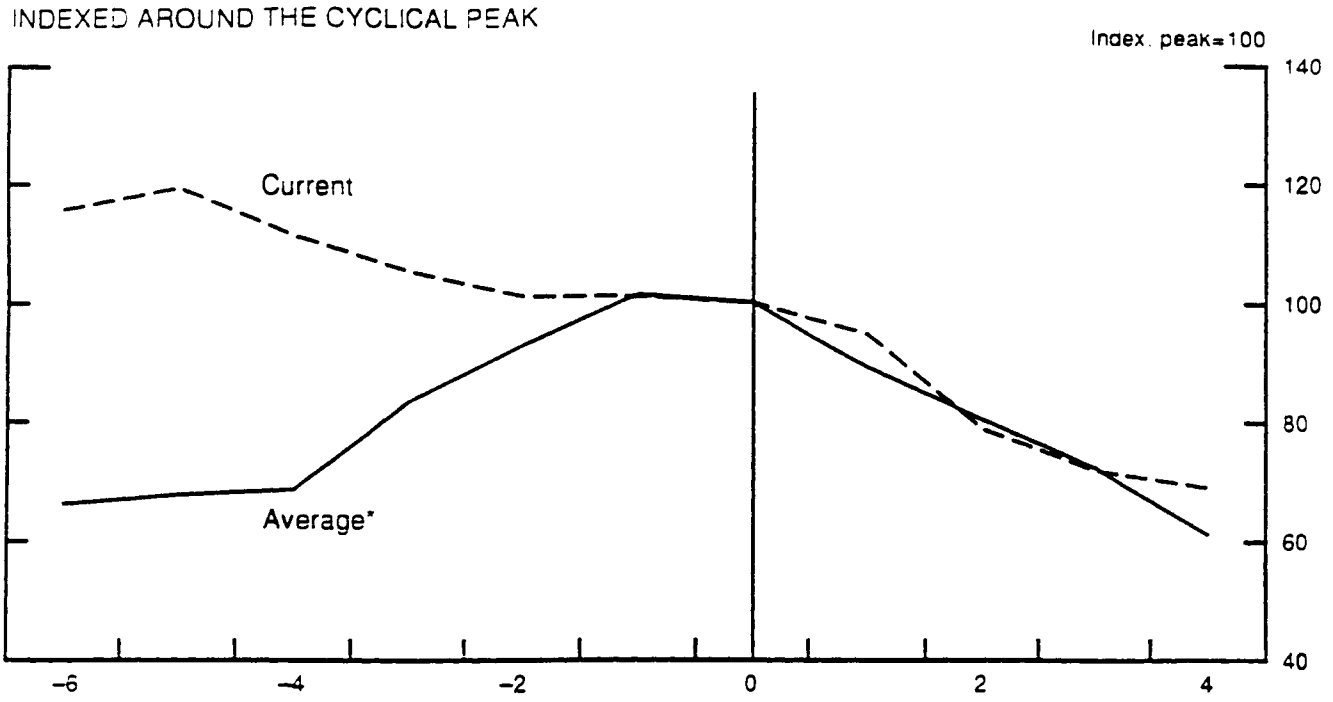
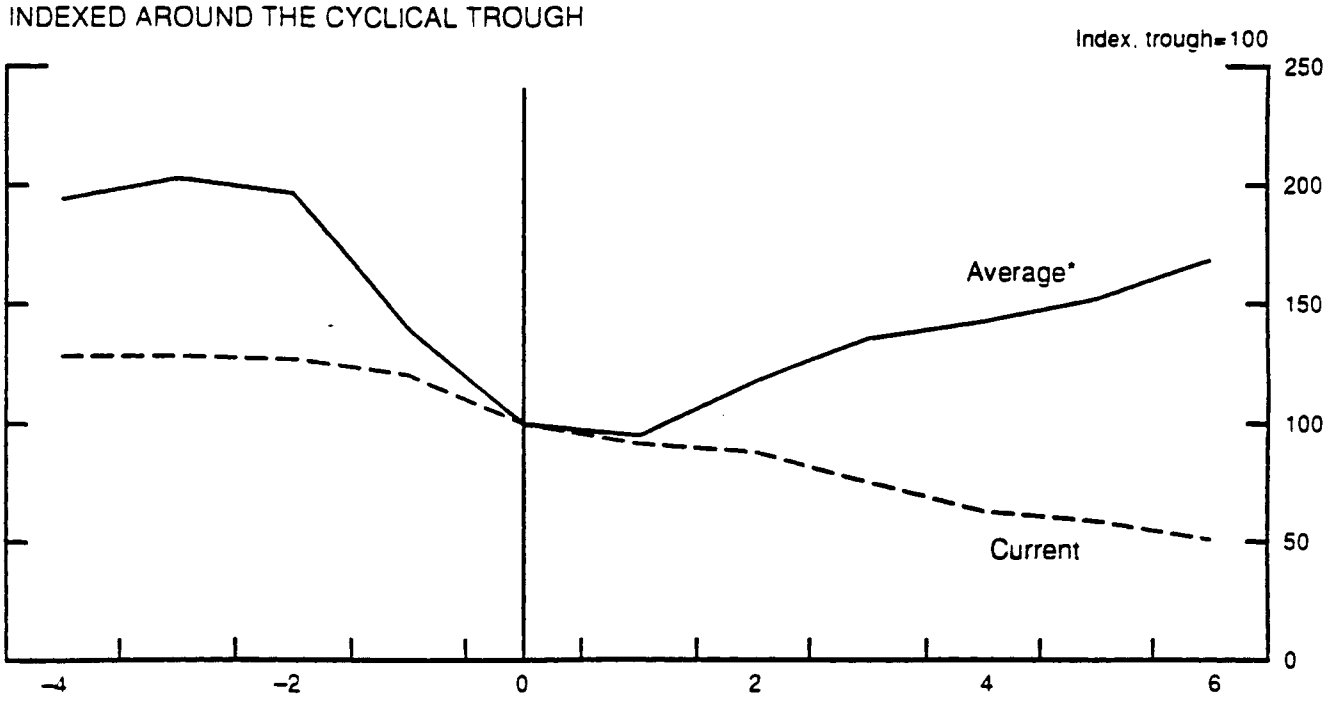


Chart 2

The Federal Funds Rate





*Average is the average index of the '57, '60, '69, '73, and '81 cycles.

Debt Growth

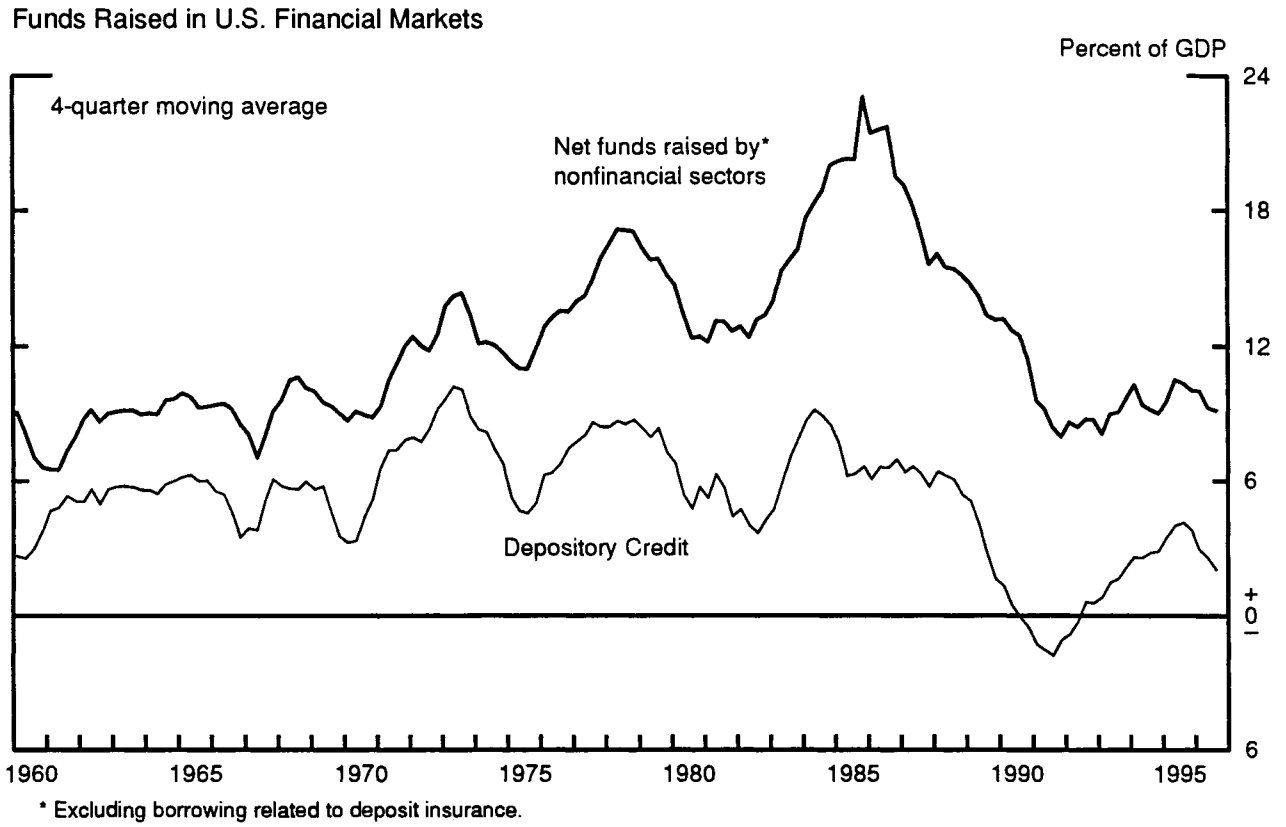
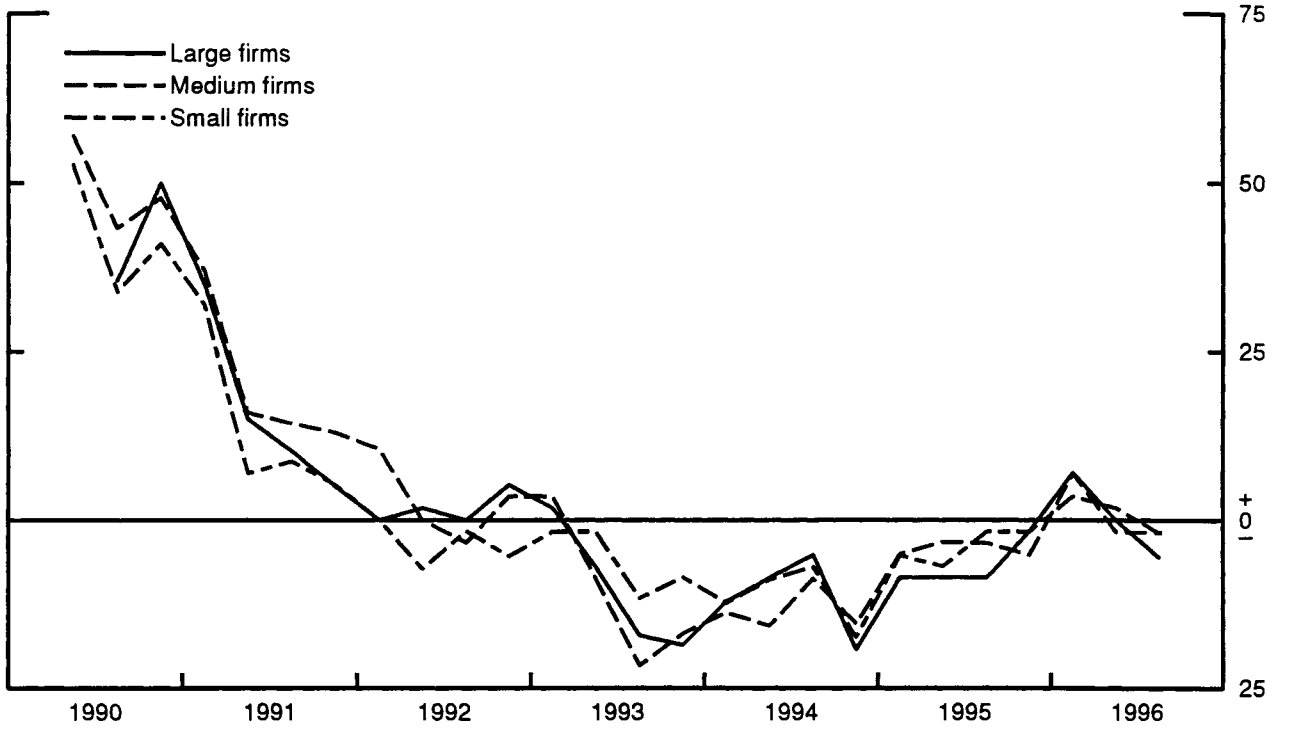
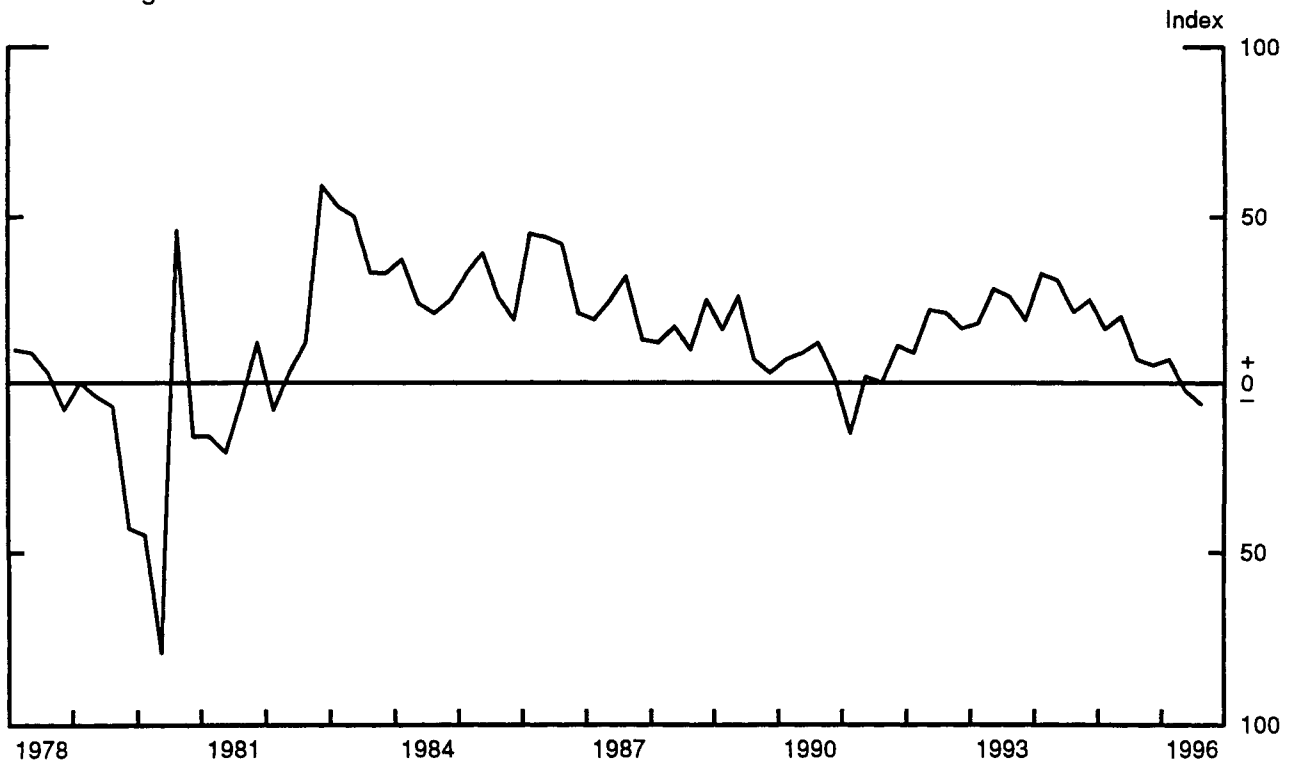


Chart 4

Net Percentage of Banks Tightening Credit Standards

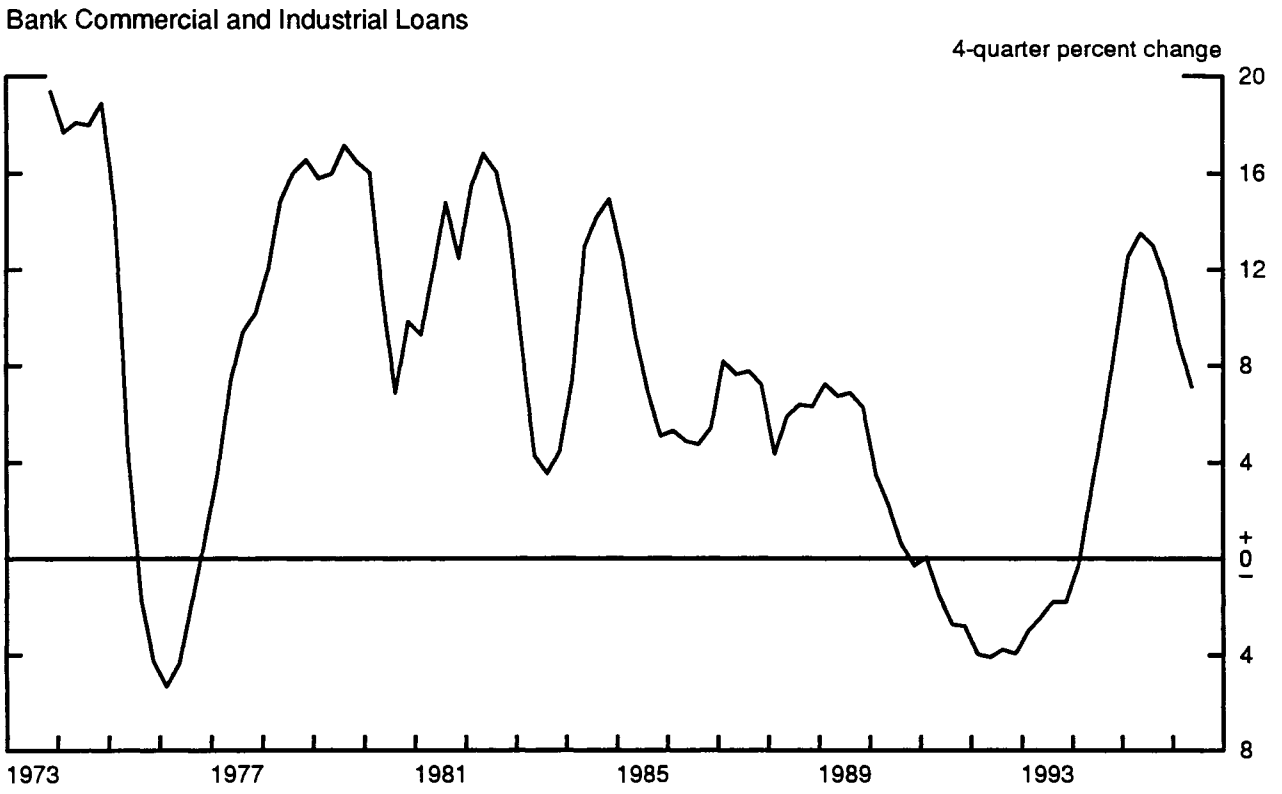


Bank Willingness to Lend to Consumers*



* Weighted response of banks more willing minus banks less willing to lend.

Bank Loans and Securities



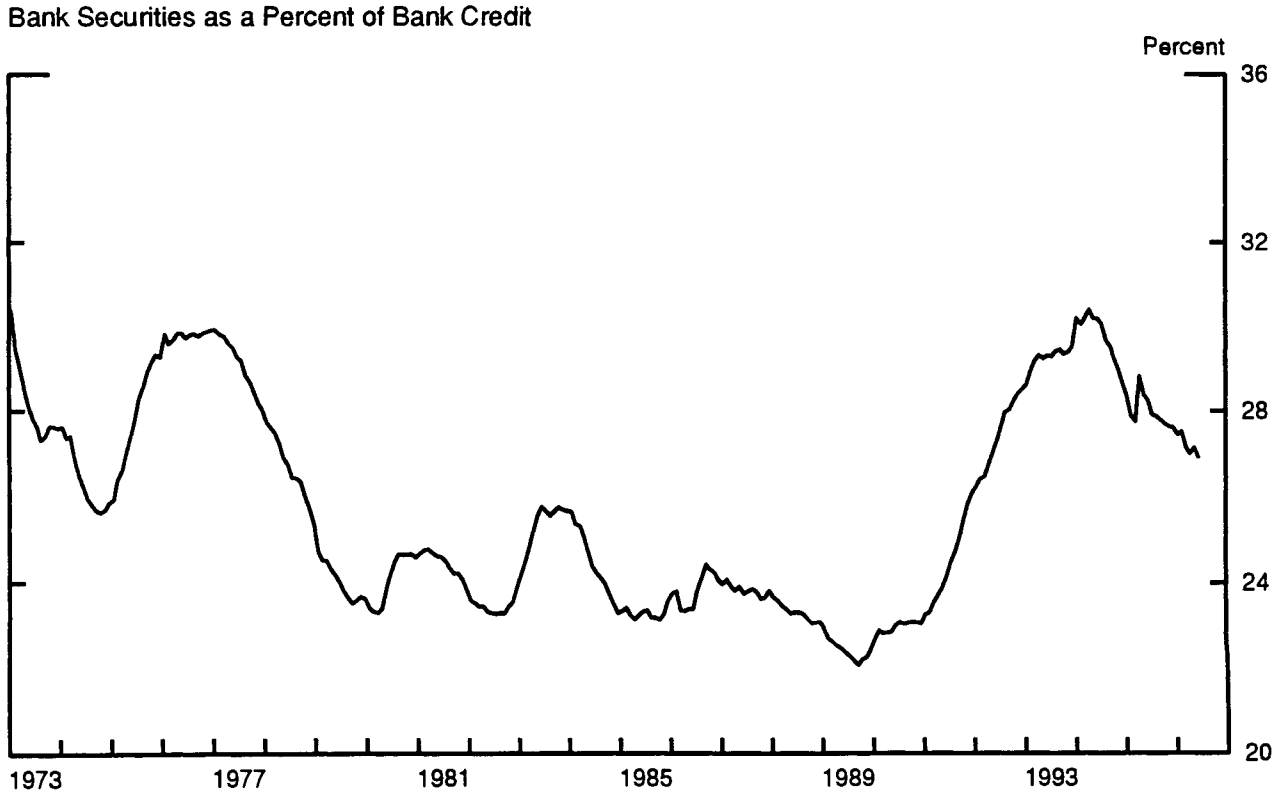
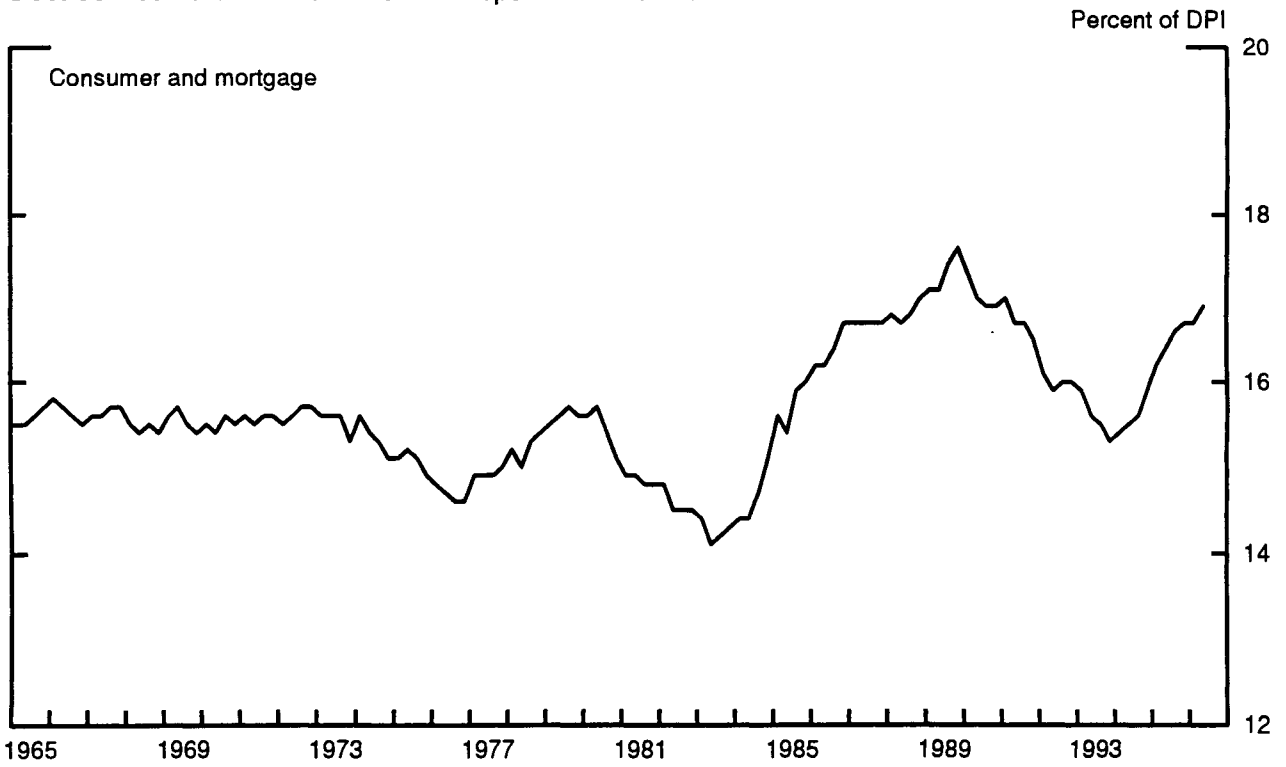


Chart 6

Nonfinanciai Corporations

Gross Interest Payments

Debt Service Burden as a Percent of Disposable Personal Income



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