Nominal GDP versus Price Level Targeting: An Empirical Evaluation

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Abstract

In response to the ongoing discussion in the literature of the appropriate framework for monetary policy, we compare two of the most frequently discussed alternatives to inflation targeting—targeting either the level of nominal GDP or the price level—within the context of a simple vector autoregressive (VAR) model. Our approach can be considered a constrained-discretion approach. The model is estimated using quarterly data over the period 1979:4-2003:4, a period in which the economy was buffeted by substantial supply and demand shocks. The paths of the federal funds rate, nominal GDP, real GDP, and the price level under nominal GDP and price level targeting are simulated over the 2004:1-2006:4 period. We evaluate nominal GDP and price level targeting by computing the values of simple loss functions. The loss function values indicate that nominal GDP targeting produces noticeably lower losses in the simulation period than either price level targeting or a continuation of the flexible inflation targeting monetary policy that characterized the estimation period.

I. Introduction

The Federal Reserve's monetary policy framework before and after the 2008 financial crisis, has often been characterized as flexible inflation targeting, a policy of constrained discretion that, before the crisis, contributed to a low, stable rate of inflation around the target rate of 2 percent and to only modest fluctuations of output around estimates of potential output. Unfortunately, this good macroeconomic performance was not sufficient to ensure financial stability. This fact, along with the slow recovery of the United States and other economies from the recession associated with the financial crisis, has led to suggestions that the Fed should replace flexible inflation targeting with targeting the path of the level of nominal GDP or with targeting the path of the price level, policy approaches that their advocates argue would have been promoted a faster post-crisis recovery.[1]

Our objective in this paper is to analyze and compare targeting the path of the level of nominal GDP with targeting the path of the price level for a recent historical period (2004:1 – 2006:4), with our simulations beginning with the federal funds rate at then-historical lows. Analysis using this recent period is appropriate since the current normalization started from a federal funds rate of about zero.

Most previous evaluations of nominal GDP targeting or price level targeting have utilized a DSGE model that embeds a nominal GDP or price level targeting policy rule, and we are unaware of any study that compares the two policies utilizing the same model. We conduct counterfactual experiments to assess the statistical merits of both policies in the context of a single econometric framework, a simple vector autoregression (VAR). Our approach to evaluating nominal GDP and price level targeting is based on the description of the policy planning process discussed by Blinder (1997) that is roughly consistent

[1] As discussed briefly in the literature review below, other proposals for changing the monetary policy framework include increasing the target rate of inflation or only temporarily targeting the price level (Bernanke (2017)). Other suggestions for policy modifications include further use of large-scale asset purchases, forward guidance, and commitment strategies. We do not pursue evaluations of these alternatives for two reasons. First, nominal GDP and price level targeting proposals are broadly consistent with the Fed's dual mandate. Second, while specifying possible targets for these variables seems relatively straightforward, a target for the size of the balance sheet or an appropriate strategy for forward guidance are not obvious. For example, the Fed's normalization of the balance sheet has begun a runoff of assets acquired during the financial crisis, but there is no indication on what size of the balance sheet is (at least approximately) optimal.

with the constrained-discretion nature of inflation targeting. Hence, the approach we employ can be considered a constrained-discretion approach to nominal GDP or price level targeting. Thus, rather than embedding arbitrary policy rules into a specific structural model, we utilize an atheoretical model and the shocks to its estimated equations to construct, quarter-by-quarter, the simulation path of monetary policy shocks that achieve the nominal GDP or price level target over a moving 12-quarter horizon. We then combine these policy shocks with representative shocks from the other equations of the model to generate the path that nominal GDP, real GDP, and the price level would have taken if policy had been implemented to achieve a nominal GDP or price level target. Given the importance of the monetary policy framework to economic performance and the ongoing development of a consensus policy model, it seems crucial to evaluate alternative approaches to policy within a variety of macroeconomic models. We see this paper as an initial effort to evaluate nominal GDP and price level targeting within a framework of constrained discretion using a simple atheoretical model.

Using three variants of an ad hoc (but common) loss function with different weights on the squared deviations of real GDP and the price level from their specified target paths, we find that the nominal GDP targeting regime is superior to a policy aimed solely at the price level and also to a continuation of the type of implicit flexible inflation targeting (FIT) policy that characterized the estimation period.[2] In all cases we consider, the FIT-consistent policy is a marginal improvement relative to price level targets. However, while the policy instrument for attaining our targets, the federal funds rate, fluctuates within historical norms, adjustments to the funds rate needed to attain either the nominal GDP or the price level objective are, at the outset of the simulation periods, larger than the usual 25 basis point adjustments typical of monetary policy. Thus, the cost of attaining the nominal GDP or price level objective may be variability in market rates of interest.

We proceed as follows. In section II, we review recent policy discussions on alternative monetary policies and summarize the available empirical evidence on alternative policy targets. In section III, we

[2] Detailed below, the weighting schemes are characterized as representing the dual mandate, New Keynesian preferences, and flexible inflation targeting.

present the VAR model to be estimated and display its impulse response functions. In section IV, we discuss the counterfactual methodology employed to assess the relative merits of nominal GDP versus price level targeting. Empirical results are included in section V, and section VI concludes.

II. Literature Review

Before discussing several recent policy proposals for nominal GDP levels or price level targets, we begin with a brief, generic discussion of the relative merits of these alternatives in the context of a simple comparative statics aggregate demand-aggregate supply model.

Suppose the economy is initially at full employment output with the desired price level. Negative (positive) demand shocks imply falling (rising) nominal GDP, with falling (rising) output and prices. Such negative (positive) demand shocks would produce expansionary (restrictive) policy responses, returning output and the price level to their desired values. The monetary policy needed to offset the initial aggregate demand shock to return real GDP and the price level to their initial values should be about the same under both a nominal GDP target and a price level target.[3] But, negative (positive) supply shocks pose problems for policies, such as monetary policy, implemented on the demand side of the economy. Such shocks lower (raise) output but raise (lower) the price level in a short-run equilibrium. Under a strict price level target, a negative supply shock would call for a contractionary monetary policy, moving output further from its full employment level. However, under a nominal GDP target, the rise in the price level would be at least partially offset by the fall in output. If nominal GDP falls, then an expansionary monetary policy would be undertaken, in contrast to the response to a price level target. If nominal GDP rises, a restrictive policy would be undertaken, though it should be a relatively muted response compared with a price level target. So, while a nominal GDP target would moderate the fall in

[3] Moving outside the textbook AD-AS model, in a dynamic setting in practice, there may be some differences for the policy path. For example, with a strict price level target, policy might aim for a constant growth rate path for prices back to the original price level. With a nominal GDP target, the policy settings may take into account fluctuations in real GDP offset by fluctuations in the price level. For the negative demand shock, we see no particular reason why this policy would necessarily be identical to the policy targeting the price level.

output compared with the price level target in the face of a negative supply shock, in either case, the economy might not fully recover until the source of the negative shock dissipates.

Given that contemporaneously-available estimates of potential GDP along with a price level objective inform the selection of the nominal GDP target, such a target is broadly consistent with the dual mandate in maintaining price stability and muting movements of real GDP away from full employment, at least with regard to demand shocks. In addition, by targeting nominal GDP, the central bank allows market participants to make the fundamental decisions on the real vs. price responses to economic disturbances. A price level target may also be broadly consistent with the dual mandate if such a target is implemented in a flexible manner that allows for transitory countercyclical responses of monetary policy to deviations of output from the natural level.

We next turn to recent proposals to (a) alter the numerical value of the inflation target, (b) implement a price level target, and (c) target nominal GDP. As available, we also discuss empirical evidence regarding such proposals.

Bernanke (2017) has recently summarized several prominent proposals for policies to confront the prospective low-interest-rate, low-inflation environment. His presentation falls into two main categories: raising the target inflation rate and replacing the current inflation target with a price level target. Each category has a number of notable variants as well.

Raising the inflation target has a number of shortcomings. First, the Fed's dual mandate includes price stability, and moving to a higher inflation objective might raise questions about the Fed's commitment to price stability and perhaps invite additional congressional oversight. Second, subsequent to the acceleration of inflation during the 1970s, the Fed spent well over a decade lowering inflation to the low single digits and has gained credibility by maintaining inflation at and below about two percent. Moving to a higher inflation target risks this credibility. Third, low and stable inflation has accompanied low and stable expectations of inflation. For years, the Federal Open Market Committee (FOMC) statements have noted that expectations appear to be "well-anchored," or words to that effect. Raising the inflation target would risk loosening the link between actual and expected inflation by creating uncertainty about whether the inflation target would be raised further in the future. Fourth, a permanent increase in the inflation target would raise the nominal interest rate but not the natural real interest rate, though if a higher inflation target is accompanied by higher inflation expectations setting the policy rate to zero would allow for a more negative real rate in financial markets in the short run. Fifth, a temporary increase could cause expectations to become unanchored, confuse the public, and threaten credibility. If the ending date of a temporary increase is not announced, the potential ramifications noted in the previous sentence may become more pronounced.[4]

Adopting a price level target, which may allow for gradually rising prices, is consistent with the Fed's mandate for price stability and unlike inflation targeting, it does not let bygones be bygones. Bernanke notes that potential issues with price level targeting include whether it can be easily communicated to the public and whether it is viable in the face of supply shocks. With regard to the communication problem, Bernanke suggests a temporary price level target that can be implemented in the context of the existing inflation targeting framework. In his proposal, at a time when the interest rate is above the zero lower bound (ZLB), the FOMC would announce that if, at some point in the future, lowering the funds rate to zero is needed, then a necessary condition for subsequent increases in the funds rate would be that average inflation be at least 2 percent beginning with the date the funds rate was first set to zero. This implies that the price level will approach the 2 percent trend line relative to the date at which the ZLB is broached. When the price level returns to this trend, the interest rate will be allowed to adjust so as to maintain the inflation rate at 2 percent. Bernanke argues that such a policy, if introduced and explained in advance of any subsequent encounter with the ZLB, can thus be incorporated into the basic inflation targeting framework.[5]

Recent academic discussions of nominal GDP targets include Hendrickson (2012), Garín, Lester, and Sims (2016), Beckworth and Hendrickson (2016), and Benchimol and Fourçans (2017). Hendrickson

[4] For additional discussion on a temporary rise in the inflation target, see Bernanke (2017) and Cúrdia (2016).

[5] In an earlier analysis, Svensson (1999) finds conditions under which price level targeting is superior to inflation targeting even if society's preferences are for targeting the inflation rate.

(2012) presents evidence supporting the hypothesis that Fed policy changed dramatically in the Volcker-Greenspan period from 1979:4–2003:4 compared to the pre-Volcker period 1966:1–1979:3, what Hendrickson referred to as “an overhaul of Federal Reserve doctrine.” Specifically, he argues that given unanchored inflation expectations during the late 1970s, the Volcker regime can be thought of as a policy to stabilize expected inflation, from which would follow full employment. Hendrickson argues that this stabilization was achieved by a commitment to low, stable rates of growth in nominal GDP. In such an environment, the increased transparency of price signals would move the economy toward a low-inflation, high-employment equilibrium. After empirical work showing that the Fed funds rate reaction to expected nominal GDP growth was substantially stronger following the Volcker policy shift, Hendrickson embeds into two alternative DSGE models an interest rate rule in which the current value of the federal funds rate is a function of its lagged value and the rate of change in nominal GDP. He finds that the volatility of both inflation and real GDP decline the stronger the response of the Fed funds rate to nominal income.

Beckworth and Hendrickson (2016) find that, taking into account Hayek’s (1945) knowledge problem, nominal GDP targeting is superior to use of the Taylor rule in real time. Drawing upon Orphanidies (2002a, 2002b), they argue that the primary problem is that estimates of potential output depend on trending data in which the endpoints evolve through time. Thus, the measure of the output gap used in the Taylor rule depends on an imperfectly measured output gap that introduces a source of monetary policy errors in addition to issues related to periodic revisions to real GDP. Focusing on a nominal GDP target, in their view, allows the Federal Reserve to sidestep the knowledge problem associated with the output gap. Finally, their simulations with a New Keynesian DSGE model reveal that nominal GDP targeting would lower both inflation and output gap volatility compared with a Taylor rule implemented under realistic conditions.

Garín, Lester, and Sims (2016) investigate the welfare implications of targeting rules for nominal GDP, inflation, and the output gap that are special cases of a standard Taylor rule. The targeting rules are compared with those for a standard Taylor rule within calibrated versions of a textbook New Keynesian model and a medium-scale New Keynesian model. The textbook model allows for varying degrees of wage and price stickiness and two shocks—productivity and preference shocks. The medium-scale model allows for wage and price stickiness and introduces capital accumulation and variable capital utilization as well as habit formation in consumption; several stochastic shocks are considered. In virtually all cases for both models, output gap targeting does best, although nominal GDP targeting is a close second in most cases. The Taylor rule usually finishes third followed by inflation targeting. Garín, Lester, and Sims argue that successfully implementing an output gap rule is likely not feasible because of difficulties in accurately measuring the output gap in real time and difficulties in communicating the rule to the public. They also note that the output gap rule may generate equilibrium indeterminacy. Consequently, in a practical sense, their results suggest that nominal GDP targeting is a preferred alternative to inflation targeting or a standard Taylor rule.

Benchimol and Fourçans (2017) evaluate a DSGE model using a variety of policy rules including Taylor rule variants, nominal GDP growth rate targets, and level nominal GDP targets. Among their model simulations is the time period 1985 to 2007, which is quite similar to the period we analyze below. Their evaluation is in the form of a variety of loss functions for the central bank and household welfare measures. They find that when using the central bank loss function, which is the weighted sum of the variances of inflation, the output gap, interest rate changes, and wage growth as the criterion, level nominal GDP targets generally perform best, though household welfare measures tend to do better with Taylor-type rules.

Finally, a call for an evaluation of both nominal GDP and price level targeting is also included in U.S. House of Representatives (2017), with the Financial CHOICE Act (passed in the U.S. House of Representatives) including a proposed Centennial Monetary Commission to study how the Fed could conduct these policies, among others.

We note that the analyses just summarized tend to suggest that at least a preliminary case can be made for nominal GDP targeting. However, we are unaware of any direct comparisons of nominal GDP targets with price level targets. We now turn to such a comparison in the context of a single empirical model, with simulations that are initiated in an empirical setting with an interest rate near the zero lower bound.

III. The Empirical Model

We estimate a six-variable vector autoregression (VAR) that includes typical macro activity variables, monetary policy variables, and a measure of bond financing costs for nonfinancial firms. Specifically, the data series used in the analysis are the log level of the Commodity Research Bureau spot market price index for all commodities, the log level of the GDP deflator, the log level of real GDP, the effective federal funds rate, a measure of the money stock represented by the log level of MZM, which comprises the components of money with zero maturity,[6] and the Gilchrist-Zakrajšek (2012) excess bond premium, a credit spread that in other work has been deemed important in explaining economic activity.

Commodity prices are included to help mitigate the well-known "price puzzle" often found in VAR models. In the spirit of the monetary economics of Friedman and Brunner and Meltzer, Nelson (2003, p. 1029) argues for the inclusion of money in macro models as a "proxy for the various substitution effects of monetary policy that exist when many asset prices matter for aggregate demand." The money supply measure thus potentially captures information about monetary conditions not fully reflected in the federal funds rate. Favara et al. (2016) note that the excess bond premium, which removes the default risk of individual firms from the Gilchrist-Zakrajšek corporate bond market credit spread, captures credit market sentiment toward the general level of corporate credit risk. The excess bond premium is a forward-looking variable that reflects investors' expectations about future corporate defaults, which in turn depend on expectations about future corporate profits, employment, investment, and aggregate economic activity. Favara et al. (2016) summarize evidence that indicates an important effect of this variable in explaining economic activity.[7]

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[6] M2 less small time deposits plus institutional money market mutual fund deposits.

[7] Favara et al. (2016) find that the excess bond premium does indeed help predict future economic activity and serves as a leading indicator for recessions. They find that the predictive content of the Gilchrist-Zakrajšek corporate credit spread for economic activity stems solely from the excess bond premium; the default risk of individual firms

Since our focal point is targeting nominal GDP or the price level, it is natural to use real GDP and the GDP deflator in our basic model. As noted, other than the federal funds rate and the excess bond premium that are included in levels, we estimate the model in log levels. We will either target the sum of the logs of real GDP and the GDP deflator or, alternatively, just the log of the deflator.[8] We recognize that recent policy has aimed more at the personal consumption expenditures index, but use of the deflator is appropriate for an initial investigation given its formal role in defining nominal GDP. In addition, in the original proposal of the Taylor rule (Taylor 1993), the focus for the inflation variable was the deflator rather than narrower, consumer-focused indexes.

The model was estimated using quarterly data for the time period 1979:4–2003:4. The starting point corresponds to the period initiated by the special Saturday night FOMC meeting at which then-Federal Reserve chair Paul Volcker refocused monetary policy on reducing the inflation rate. Our ending date for estimation allows us to investigate counterfactual policies that begin in a low interest rate environment, the federal funds rate target having been 1 percent between mid-2003 and mid-2004, much as current policy normalization began with short-term interest rates just above zero. Among other things, this setting also allows us to see if the zero bound on the nominal rate is encountered in our counterfactual experiments. Ending the estimation in 2003:4 also allows us three years for out-of-sample simulations with which to form initial impressions of the relative advantages of nominal GDP and price level targeting before early signs of the financial crisis began to appear in 2007. Four lags of all variables were employed and were sufficient to whiten the residuals of the equations of the VAR.

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has no explanatory content. Based on these results, we used the excess bond market premium rather than the Gilchrist- Zakrajšek corporate credit spread.

[8] Since an integral part of our exercise includes the dynamic forecast of the VAR, we estimate in log levels, noting the recommendation of Lin and Tsay (1996). They argue that while the best forecasts are those that include the correct unit roots and cointegrating relationships, "when applied to real data, the results change. . . . Because the available cointegration tests have low power in rejecting the unit root hypothesis when the time series has characteristic roots close to 1, the danger of mis-imposing unit root constraints is real" (p. 537). More recently, Gospodinov, Herrera, and Pesavento (2013) argue that "the unrestricted VAR in levels appears to be the most robust specification when there is uncertainty about the magnitude of the largest roots and the co-movement between the variables."

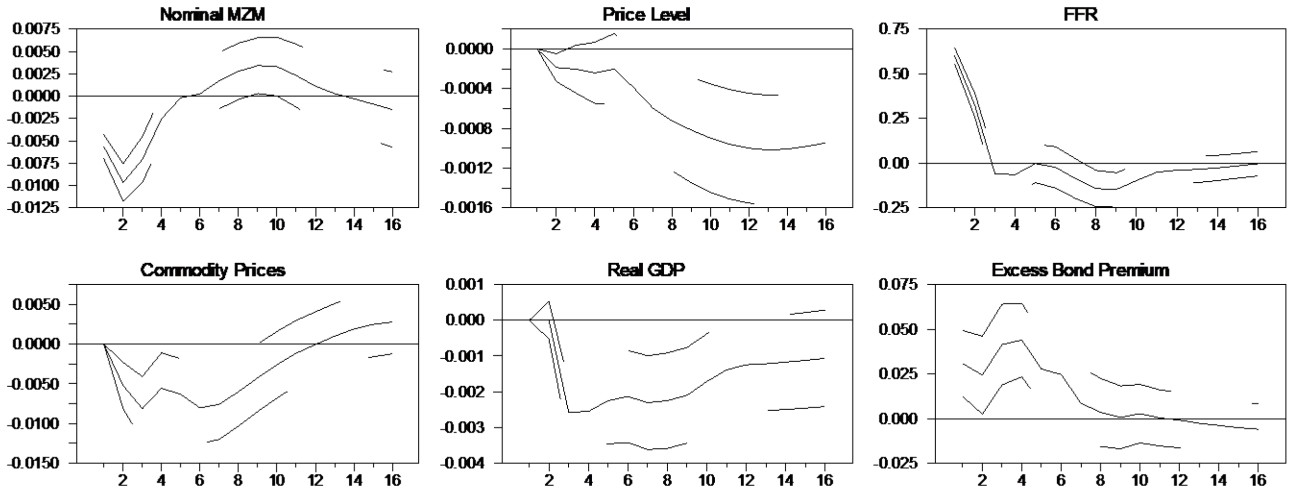
Monetary policy shocks are identified as innovations to the federal funds rate using a Choleski decomposition with the ordering listed earlier. In the identification scheme, a contemporaneous response by the Fed to movements in the macro variables (commodity prices, the inflation rate, and output) is allowed, but the Fed is assumed to respond only with a lag to movements in the monetary aggregate and the excess bond premium. The Fed is thus assumed to respond contemporaneously to the variables directly related to its dual mandate, but only with a lag to variables it doesn't directly target.

The sensitivity of the results to the Choleski method of identifying monetary policy shocks was checked by imposing structural constraints similar to those imposed by Leeper and Roush (2003). Three different structural identification schemes were examined, and each differed from the Choleski method only for the MZM and federal funds rate (ffr) equations. In the first scheme, the MZM equation was interpreted as a real money demand function by imposing the following constraints: no contemporaneous effect of the commodity price shock or the excess bond premium shock on real money demand, a contemporaneous coefficient of –1.0 on the log GDP deflator shock (which converts the log nominal MZM shock to a real money demand shock), and nonzero coefficients on the real GDP shock and the ffr shock. Thus, real money demand is specified to be a function of real GDP and ffr. In addition, in this first scheme, all model variables except the excess bond premium shock were allowed to affect the ffr shock contemporaneously. This configuration of the ffr equation thus allows MZM to affect ffr contemporaneously. Maximum likelihood estimation of this first structural model found a positive effect of real GDP and a negative effect of ffr on real money demand. Positive contemporaneous effects of commodity prices, the GDP deflator, and real GDP on ffr were found, and the effect of MZM on ffr was negative.

The second structural identification scheme imposed the same constraints as the first scheme for the MZM equation, and, in the ffr equation, eliminated the contemporaneous effect of MZM on ffr. The third structural identification scheme differed from the second by imposing a Taylor-rule-like structure on the ffr equation: the effects of commodity prices, MZM, and the excess bond premium on ffr were set to zero and the only nonzero effects allowed were for the GDP deflator and real GDP. For both the second and third identification schemes, the signs of the effects of real GDP and ffr on real money demand were the same as in the first, and the effects of the included variables in the ffr equation were all positive. Shocks to the ffr equation were interpreted as monetary policy shocks in all three structural alternatives, and impulse response functions (IRFs) for all three were essentially the same as those reported in the next paragraph for the Choleski decomposition which, for simplicity, is used hereafter. The methodology described in Section IV below can be adapted in a straightforward way for shocks from structural identification schemes.

The IRFs for a one standard deviation (SD) positive shock to the federal funds rate based on the Choleski decomposition are presented in Figure 1. In each panel, the solid line is the point estimate and the dotted lines are one SD confidence intervals computed using Monte Carlo simulations employing 10,000 draws. The pattern of results is as expected. A contractionary monetary policy shock, a rise in the funds rate, persists for several quarters but weakens and dies out as expected if the Fed responds to the negative output and price level effects of the initial contractionary shock. MZM falls at first and then returns to its initial level, as do commodity prices. The contractionary monetary policy shock has a negative and long-lived, but ultimately transitory, impact on real GDP and a delayed and then persistent negative impact on the GDP deflator. As expected, contractionary monetary policy, which pushes the economy into a transitory but long-lived recession, leads to a deterioration in the credit market's assessment of general corporate credit risk and hence to a transitory increase in the excess bond premium.

Figure 1: Impulse Responses to a Positive Shock to the Federal Funds Rate



IV. Methodology

We determine the path for the nominal interest rate over a planning horizon that maintains nominal GDP (the price level) within a desired range, a tolerance band around a target path specified by the policy maker. A byproduct of the policy path is that we also produce counterfactual paths for all system variables associated with the nominal GDP or price level targets.

In our application, as noted above, we use a Choleski decomposition as our structure, though our technique can be applied to a generic structural model of the form:

$$Y_t = A_0Y_t + A_1Y_{t-1} + \ldots A_pY_{t-p} + u_t$$

where Y_t is an nx1 vector of variables, the A_i are conformable nxn matrices with A_0 including the contemporaneous structural components of the model, and u_t is the corresponding vector of structural shocks.

The reduced form of the system is:

$$Y_t = \Pi_1Y_{t-1} + \Pi_2Y_{t-2} + \ldots + \Pi_pY_{t-p} + e_t$$

where $\Pi_i = (I - A_0)^{-1}A_i$ and $e_t = (I - A_0)^{-1}u_t$.

Using the lag operator, L, the system can be written as:

$$(I - \Pi_1 L + \Pi_2 L^2 + \ldots \Pi_p L^p)Y_t = e_t$$

and then solved for the moving average representation (MAR):

$$Y_t = (I - \Pi_1 L + \Pi_2 L^2 + \ldots \Pi_p L^p)^{-1} e_t$$

$$\equiv C(L)e_t$$

where C(0) = I. Finally, we can rewrite the MAR in terms of the structural shocks as:

$$Y_t = C(L)(I-A_0)^{-1}(I-A_0)e_t = D(L)u_t$$

where $D(L) = C(L)(I-A_0)^{-1}$ with $D(0) = (I - A_0)^{-1}$ and with the structural shocks $u_t = (I-A_0)e_t$.

Fundamental to our analysis is the historical decomposition, which in its basic form is found by advancing the prior equation by m periods and then decomposing the resulting expression into two terms:

(1) $$Y_{t+m} = \sum_{s=0}^{m-1} D_s u_{t+m-s} + \sum_{s=m}^{\infty} D_s u_{t+m-s}$$

The second term on the right side of equation (1) is the dynamic forecast or base projection (BP) of Y_{t+m} conditional on information at time t. The first term on the right side of equation (1) shows the influence on Y_{t+m} of the shocks to the variables in the system between periods t+1and t+m, which we refer to as the planning horizon. Even though the expected values of these shocks are zero, policy makers know that the realizations of these shocks are likely to be nonzero. Consequently, we proxy for the underlying shocks during the planning horizon by taking random draws from the estimated structural shocks from the VAR model.[9]

Equation (1) illustrates the intuition behind our approach; specific details are included in the appendix for the particular analysis provided below. Using time t as the estimation date, with the coefficients in the D matrices available from the estimation, and with the estimates of the structural shocks, the base projection is computed. A path for the system then depends on the values of the

[9] Two obvious alternatives to random draws from the estimated residuals deserve mention. One option is to set them to their expected values of zero. Of course, this option is not interesting if the policy maker would like to know about the inherent variability of the alternative policy path. A second option is to assume a particular probability distribution for the shocks to each variable and take random draws from these distributions. This option requires a possibly arbitrary choice of a probability distribution from which to draw. The option used here employing values drawn randomly from the estimated residuals (transformed to their structural values), being linear transformations of the reduced-form OLS residuals, are zero mean. They also have the advantage of reflecting the statistical characteristics of the data, avoiding misspecification that would likely occur with the selection of a probability distribution that may not reflect the data.

structural shocks over the planning horizon for the estimated equations. In our approach, we take a random draw relevant for the planning horizon from the estimated residuals and compute the path for the system implied by this draw. Using the drawn residuals for period t + 1, we compute the value of the target variable (say, nominal GDP). If this value is inside the target range, we retain the drawn policy shock. If the value lies outside the specified range, we compute the value for the period t + 1 policy shock (the shock to the fed funds equation, in our case) needed to return the variable to the specified range. This computed policy shock is then used in place of the drawn residual. We continue this process for the entire planning period, next computing whether the variable is within the target range for the next m period horizon beginning at t + 2, retaining the value for the period t + 1 policy shock. The final step is to compute the policy shock for period t + 12 for the final 12-period horizon, conditional on the prior shocks in the previous periods.

The process described above specifies 'an entire hypothetical path' of the policy tool in the 'first step' of the policy planning process (12 quarters in our application) described by Blinder (1997):

> First, you must plan an entire hypothetical path for your policy instrument from now until the end of the planning horizon, even though you know you will activate only the first step of the plan. It is simply illogical to make your current decision in splendid isolation from what you expect to do in subsequent periods. Second, when next period actually comes, you must appraise the new information that has arrived and make an entirely new multiperiod plan. If the surprises were trivial, that is, if the stochastic errors were approximately zero, step one of your new plan will mimic the hypothetical step two of your old plan. But if significant new information has arrived, the new plan will differ notably from the old one.

We expect this 'first step' to be especially interesting when considering adoption of a new policy approach, such as moving from an inflation target to a nominal GDP or price level target. Prior to such an adoption, the policy maker would like to know whether the proposed policy is acceptable when considering the implied paths and volatility of system variables, especially the variables included in the central bank objective function such as the Fed's dual mandate. In addition, the policy maker would like to know whether there would be instrument instability in the policy tool as well as whether adoption of the alternative approach would encounter Lucas critique issues, which if present may render existing data uninformative in the evaluation process.[10]

Two other points should be noted about the methodology used in this paper. First, it is unrealistic to attempt policy that exactly attains the policy goals each and every period. Accordingly, our policy innovations are computed in each period of the 12-quarter horizon to attain average nominal GDP over the subsequent 12-quarter horizon; the policy maker is viewed as having a medium term objective to be achieved on average rather than precisely each quarter. Thus, in a given trial, nominal GDP need not remain within the specified boundaries quarter-by-quarter as long as any excess or shortfall is offset in other periods within the horizon; occasional movements outside the tolerance band likely would be acceptable in practice as long as policy objectives are expected to be achieved over the medium to long-term. Second, for our experiments, we monitor the simulations for violations of the zero lower bound.[11] Specifically, in our experiments the policy evaluations begin in a period with a 1 percent fed funds rate and we investigate the frequency of violations of the zero lower bound. Our hope is to provide initial information about whether price level, nominal GDP targets, or both are feasible without violating a lower bound, given a funds rate target between zero and 25 basis points prior to the normalization initiated in December 2015.

A potential shortcoming of our approach arises when we replace policy shocks drawn from the estimated residuals with computed shocks needed to attain the policy objective. If the computed policy innovations are implicitly from some other probability distribution, they may lead agents to infer a change in the policy regime, an issue raised by the Lucas critique. If so, our estimated model might not be

[10] Blinder's "second step," which occurs after the passage of a time period, is more likely informative within a policy regime rather than when considering adopting a new regime.

[11] Until the financial crisis, many viewed zero as the lower bound (the ZLB) for the policy interest rate. Of course, during the crisis, some central banks found that the policy rate could be set somewhat below zero—the effective lower bound (ELB). In the U.S., the policy rate never fell below zero. Using simulations of two Fed models employing alternative interest rate rules (an estimated rule and the Taylor rule) and assuming a policy setting with low nominal and real interest rates along with low inflation, Kiley-Roberts (2017) find nontrivial probabilities (at most 20 percent) of hitting the ELB. Lubik, Matthes, and Price (2018) use simulations of a time-varying parameter VAR to estimate the probability of hitting the ZLB over a 40-quarter forecast horizon that begins in the third quarter of 2018. They find a 15 percent chance of the economy being at the ZLB in the long-run, and about a 25 percent chance that all forecasted paths of the funds rate hit the ZLB at least once over their forecast horizon.

relevant for the simulation period. To test for this possibility, we compute and report the "modesty statistic" introduced by Leeper and Zha (2003) to evaluate whether our policy interventions would have likely been viewed by agents as "modest" and hence unlikely to have led to an inference of a change in the policy regime. Technical details are in the appendix.

V. Results

V.1 Overview of the Experiments

We conducted several different experiments each for nominal GDP targets and price level targets. These experiments reflect combinations of target rates and widths of the tolerance band for each targeted variable. We begin with a description of the targets and the tolerance band selections and then provide additional details on the metric used for evaluation and on monitoring for violations of the zero lower bound. We also roughly mimic the policy makers' use of the Tealbook by evaluating a key comparison: rather than adopting either a nominal GDP or a price level target, what are the effects of a "FIT-consistent policy," defined to be the case where the tolerance bands are set arbitrarily wide so that the drawn policy shocks are never overridden by the computations suggested in the methodology discussion? Without interventions, then, this policy is a continuation of existing policy conditional on the representative shocks to the policy equation.

The selected targets for nominal GDP and the price level all show rising values over time. For a nominal GDP target, rising nominal GDP objectives reflect the desires for both rising real GDP and modest increases in the price level. A policy maker selecting a realistic nominal GDP target would do so against the backdrop of estimates of the path of potential GDP, reflecting a wide variety of factors such as projected productivity growth, demographic changes, and commitments on fiscal spending. In addition, the nominal GDP objective must at least implicitly incorporate an objective for increases in the price level. For a price level target, we expect that the rate of increase will be consistent with the recent inflation target, with the additional commitment to offset inflation "misses" by returning the price level to the desired path rather than letting bygones be bygones.

For nominal GDP, we target a growth rate of 4.5 percent per year, consistent with slowing productivity growth and an aging population. Following Hatzius and Stehn (2011), this 4.5 percent rate of growth is based on an assumed potential real GDP growth rate of 2.5 percent and a 2.0 percent inflation target. Furthermore, given current policy discussions about transitioning to a nominal GDP or price level target starting from a policy rate near zero, a relatively modest objective for the transition period seems reasonable. We have investigated rates of nominal GDP growth of 5.0 percent and 5.5 percent as well, continuing to assume a 2.0 percent inflation objective but real growth of 3.0 percent or 3.5 percent, respectively. Setting tolerance bands around these target rates is more problematic. The standard deviation for growth rates of nominal potential GDP reported by the Congressional Budget Office was 0.4 for the decade prior to the simulations, 0.8 for the 15-year period prior, and 2.2 for the estimation period. For this initial assessment, around each target path for nominal GDP, we use tolerance bands of ±1 percent or ±2 percent. All bands aim at using policy to maintain nominal GDP growth above zero.

For the price level target, we note that 2.0 percent has been a common target across the advanced economies, including the United States, and we use this value as our base case. However, targeting prices to grow at 2.0 percent usually corresponds to a measure of consumer prices. Here, consistent with nominal GDP targets, the GDP deflator is a natural alternative. The GDP deflator over the estimation period rose at a rate of about 3.3 percent. In the decade and a half prior to our simulation, it rose at a rate of 2.3 percent, and in the decade prior it rose at a rate of about 1.8 percent. Our base case result is thus not only consistent with publicly stated objectives for consumer prices, it is also within the range of the period leading to the simulation dates. We specify bands around these projections of ±1.0 and ±2.0 percent, avoiding an absolute decline in the price level.

To construct the target values of nominal GDP and the price level, we use the 2003:4 value of the relevant variable and then assume the target grows according to the growth rates discussed above. We then measure for each trial the root mean squared deviation (RMSD) around this trend. We compare and contrast nominal GDP targets versus price level targets in detail, first by comparing the RMSDs of the trials across the various target paths and tolerance bands. Since weighted averages of mean squared deviations (MSDs) of output and the price level around their specified growth paths are broadly consistent with loss functions employed in standard dynamic optimization problems, we also compute three alternative values for such loss functions. We compute one with equal weights on the MSDs of real GDP and the price level (the "dual mandate weights"), one with weights of 0.75 on real GDP and 0.25 on prices (the "Keynesian weights"), and one with weights of 0.25 on real GDP and 0.75 on prices ("flexible price level targeting weights").[12] We similarly compute MSDs for the FIT-consistent policy and the associated loss functions, where for purposes of comparison, the MSDs of this given policy are computed relative to the trend values used for the various nominal GDP and price level targets. Finally, although negative policy rates became commonplace in some countries during and subsequent to the financial crisis, negative rates were not employed in the United States. To see whether our simulations evolving from a federal funds rate of 1 percent entailed negative rates, for each experiment we report the number of periods in which the interest rate must be set below zero to attain the objective for that experiment and, when this occurs, the minimum value for the target rate.

For each experiment, we conducted 1,000 simulations, evaluating both the average policy paths and the response of the economy to nominal GDP targets or price level targets. We seek answers to the following questions. For each experiment: (1) Is the behavior of real GDP and the price level consistent with the Fed's policy goals? (2) How do the simulation results compare with the FIT-consistent results of the economy over the simulation period? (3) Is the policy path needed to target nominal GDP "reasonable" or is the degree of interest rate variability implausible? In the extreme, is there instrument instability? (4) Are agents alerted by the policy shocks to a change in regime? (5) Is either type of policy, a nominal GDP target or a price level target, obviously preferred to the other? Is either preferred to the FIT-consistent policy?

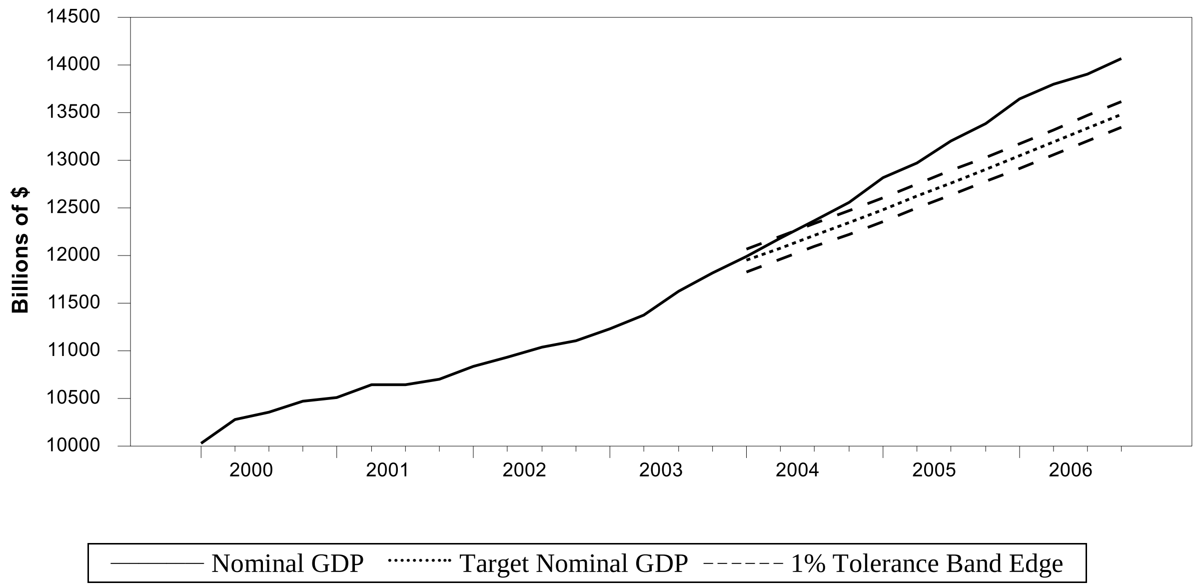
[12] Svensson (1999) suggests the loss function we use here, with squared deviations of the price level around the target path and squared deviations of the output gap. Although Svensson's loss functions are the present value of the discounted squared deviations, we compute the undiscounted values. Our purpose is to compare nominal GDP targeting with price level targeting over the same forecast horizon, and since the discount rate applied to the squared deviations would be the same in both cases, we can obtain the correct relative ranking using only the undiscounted sum of squared deviations.

V.2 Targeting Nominal GDP

Our first experiment is an investigation of a nominal GDP target. We specify a target path for nominal GDP growth along with a tolerance band and examine the implications for real GDP and the price level of using monetary policy to attain the nominal GDP objective. In addition, we analyze the interest rate path needed to attain the nominal GDP path. The analysis is based on 1,000 trials, which allow us to compute the variabilities of nominal GDP, real GDP, the price level, and the interest rate. In addition, we ask whether the policy as implemented would have violated the Lucas critique.

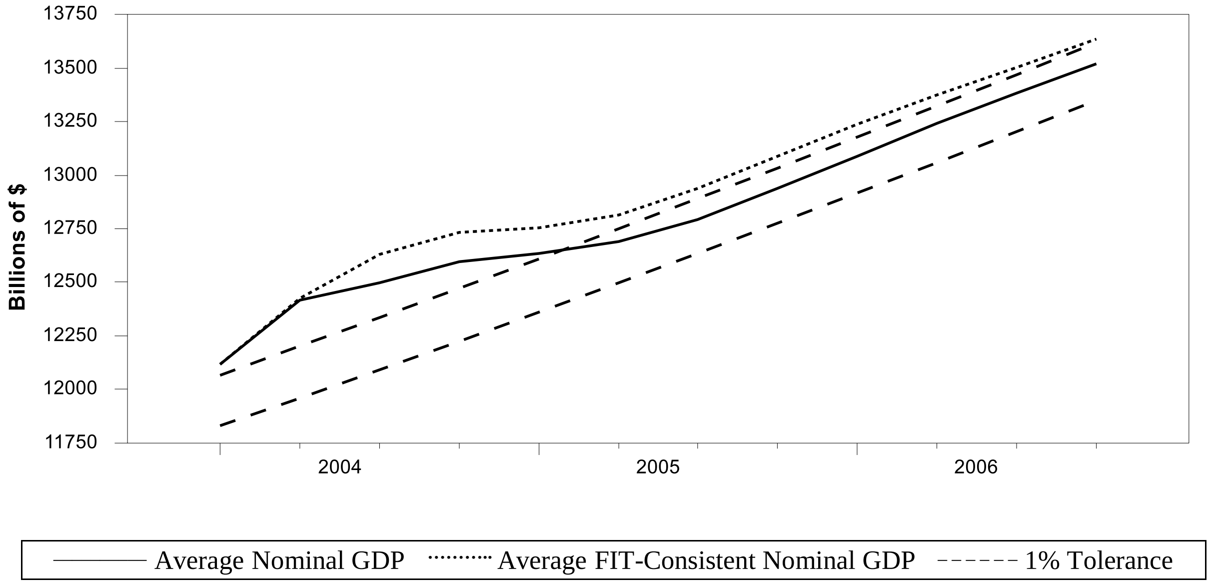
Having estimated our model through 2003:4, for our base case we target average nominal GDP growth of 4.5 percent at an annual rate for 2004:1 through 2006:4. In the context of recent history, Figure 2 shows this target path along with tolerance bands that are 1 percent above and below target. This target path is approximately in line with nominal GDP movements prior to our simulation period. However, while unknown to a policy planner at the end of 2003, in retrospect, this target path would have been somewhat restraining over the simulation period. What could have been computed, however, is the simulated path for the FIT-consistent policy, which will be included in the figures below, consistent with policy-making as an evaluation of alternatives.

Figure 2: Nominal GDP Targeting
Nominal GDP, Target Nominal GDP, and ±1% Tolerance Band



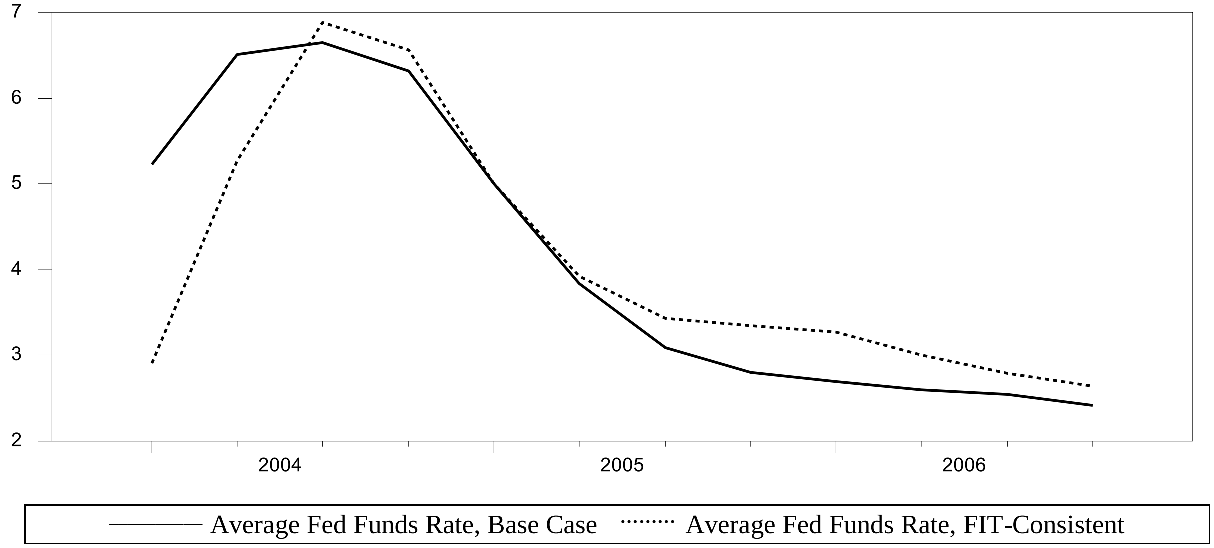
The solid line in Figure 3 shows the basic results for average quarter-by-quarter nominal GDP of 1,000 simulations in which policy is conducted to maintain average 12-quarter nominal GDP inside the prespecified bands; the dotted line shows the nominal GDP path for the FIT-consistent policy, which is above the upper tolerance band in every quarter in the simulation period. Thus, the FIT-consistent policy path suggests that, on average, the policy pursued over the model estimation period would not have kept nominal GDP within 1.0 percent of the 4.5 percent nominal GDP target path. Since our methodology selects a path for the policy shocks that attains this objective, once we have computed the path for the policy shocks that satisfies the policy objective, the policy innovations are included in the MAR along with the other shocks from the trial draw so that we can trace the paths of all system variables. As indicated in the description of the methodology, the computed policy shocks may allow individual quarterly values of the targeted variables to move outside the specified band (the dashed lines in Figure 3), as is evident in the first four quarters of the simulation. After the first year of the simulation, on average nominal GDP lies within the tolerance bands.

Figure 3: Nominal GDP Target
Average Nominal GDP, Average FIT-Consistent GDP, and ±1% Tolerance Band



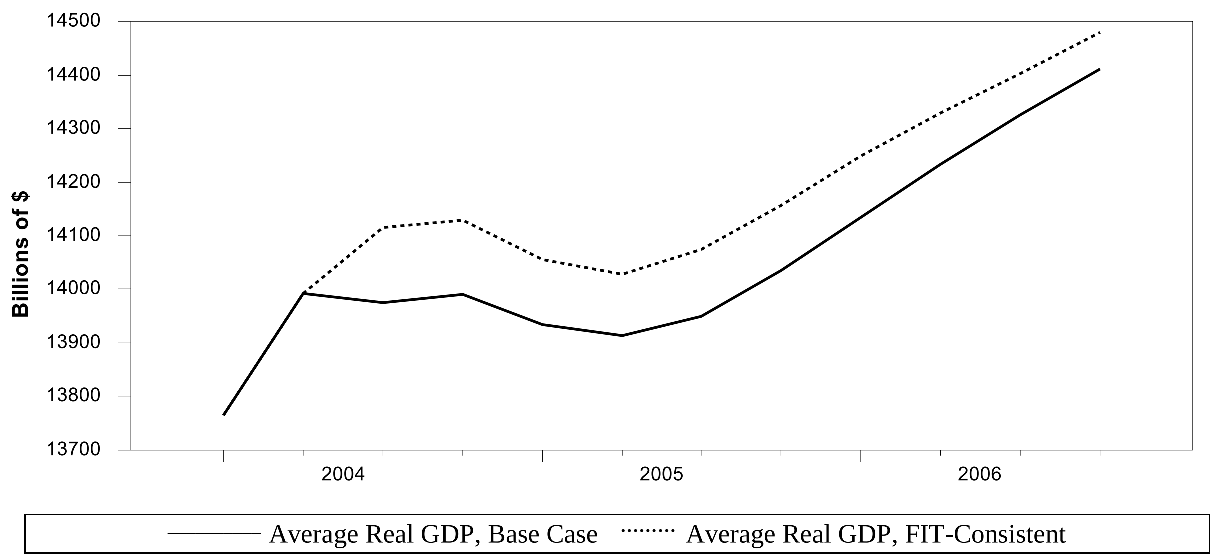
The solid line in Figure 4 shows the average path for the federal funds rate associated with the policy objective and the dotted line shows the average path for the FIT-consistent policy. Figures 5 and 6 show the real and price components of the nominal GDP path. As is evident from Figure 4, attaining the specified nominal GDP target requires an immediate and relatively large increase in the federal funds rate. In the average simulation, the funds rate rises to over 6.5 percent during the first year and then gradually declines. In contrast, this was a period in which the Fed was raising the funds rate target “at a measured pace” from the prior floor of 1.0 percent. Of course, in the simulations summarized here, there is no pretense of interest rate targeting; rather, policy settings are determined according to the desired path of nominal GDP. Furthermore, the rise in the average policy rate (though not its magnitude) is in the direction suggested by critics, often appealing to the Taylor rule, who argued at the time that rates were too low for too long during the 2003–2004 period. We also note that the range of the simulated fed funds rate is reasonably close to what transpired in actuality, though the pattern is quite different.

Figure 4: Nominal GDP Targeting
Average Federal Funds Rate for Base Case and for FIT-Consistent Policy



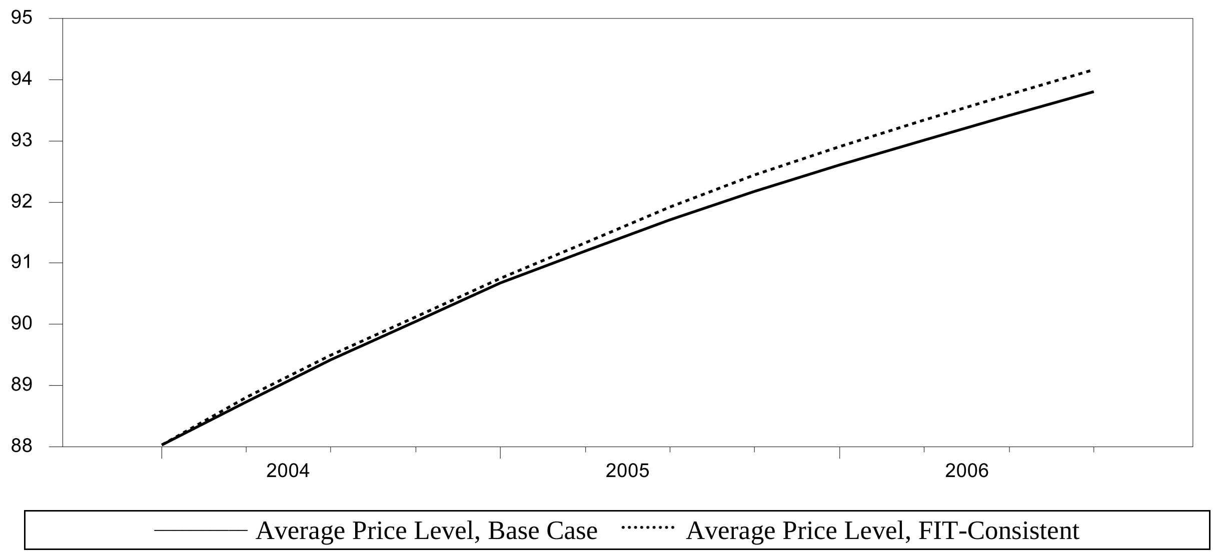
The solid line in Figure 5 shows average real GDP given the policy shocks needed to attain the nominal GDP target and the dotted line shows the average real GDP for the FIT-consistent policy. The restraint needed to maintain nominal growth inside the tolerance range induces a shallow recession, with output falling between the fourth quarter of 2004 and the second quarter of 2005 at an annual rate of about 1.1 percent, and then exceeding the previous peak by the fourth quarter of 2005. From the trough in 2005:2 until the end of the simulation, annualized output growth is 2.4 percent.

Figure 5: Nominal GDP Targeting
Average Real GDP for Base Case and for FIT-Consistent Policy



In Figure 6, the solid line shows the path for the GDP deflator implied by the policy shocks needed for the nominal GDP target and the dotted line shows the average path for the FIT-consistent policy. Annualized inflation implied by the path of the price level is 2.3 percent over the simulation period.

Figure 6: Nominal GDP Targeting
Average Price Level for Base Case and for FIT-Consistent Policy



As noted earlier, the dotted line Figure 3 shows the FIT-consistent path of nominal GDP. The targeted policy discussed above clearly restrains nominal GDP relative to the FIT-consistent path.[13] Consistent with the FIT-consistent path for nominal GDP being higher than the path with the explicit target value, the FIT-consistent path of the fed funds rate is substantially less contractionary over the initial two quarters than with nominal GDP targeting and then follows approximately the same path over the remainder of the horizon. Real GDP and the price level are persistently higher than with the nominal GDP target, as would be expected in light of the different initial paths of the federal funds rate. For the FIT-consistent case, real GDP falls at an annual rate of 1.4 percent between 2004:4 and 2005:2, with annualized growth until 2006:4 from the trough of 2.1 percent. The price level rises over the period at an

[13] The alternative paths are identical over the first quarter due to the nature of our Choleski decomposition, which places the policy variable lower in the ordering than the target variables.

annual rate of 2.5 percent. So, while the FIT-consistent case has a higher level of nominal GDP, it has a modestly deeper recession, grows less rapidly subsequently, and has moderately higher inflation.

Table 1 contains additional information about the base case nominal GDP and the FIT-consistent (and other) policy experiments. Several characteristics of these experiments warrant comment. First, there is no apparent "instrument instability" in the funds rate. Specifically, for a nominal GDP growth target of 4.5 percent and the ± 1 percent tolerance band, the average standard deviation of the policy rate across the trials is just marginally higher (1.80) than the actual standard deviation (1.61) over the period. Nonetheless, among the 12,000 quarters across the 1,000 trials, the maximum and minimum values ranged from -0.10 percent to 8.57 percent. In contrast, the corresponding range for the FIT-consistent policy was 0.06 percent to 8.62 percent (and the actual range was 1.0 percent to 5.25 percent). Second, there is only one instance in these 12,000 quarters in which the funds rate was set below zero, just marginally with a value of -0.10 percent. Despite the actual funds rate being 1.0 percent at the outset of our simulations, these results appear to allow a transition to the nominal GDP targeting regime without worry of sustained instances of negative policy rates. Third, panel A of Table 1 reports the absolute values of the maximum computed Leeper-Zha modesty statistics.[14] For our base case nominal GDP analysis, there does not appear to be concern regarding the Lucas critique. Our intuition is that while the range of interest rates in our experiments is wider than actually experienced, with the standard deviation of our experiment being roughly the same magnitude as actually occurred, those outside the actual range were sufficiently rare that the Lucas concerns were not of importance. Fourth, to reiterate a point made earlier, the average paths for the federal funds rate for both the FIT-consistent policy and the nominal GDP target are noteworthy for their large upward movements, inconsistent with the appearance of interest rate smoothing in the data. Whether policy makers would be willing to raise rates as aggressively as indicated in our experiments is an open question.

[14] We make one adjustment to their computation. Specifically, we use the randomly drawn disturbances to the other equations, with our policy interventions conditional on these disturbances, rather than assuming that the shocks to the nonpolicy equations are all zero (though our estimation, equivalent to OLS equation by equation, implies expected values of zero for these shocks). We do so since our computed policy interventions are conditioned on the drawn residuals in each trial.

As noted earlier, we have also considered higher targeted growth paths for nominal GDP of 5.0 percent and 5.5 percent based on alternative assumptions about the growth rate of real potential GDP. The results for these higher nominal GDP growth paths are summarized in Tables 1, 2, and 3. From Table 1, we note that the average standard deviations of the funds rate for these alternatives are greater than that 4.5 percent growth, although the increases appear to be negligible. The range of interest rate values rises somewhat with an increase in the target growth rate, as does the number of quarters with a negative interest rate. The Leeper-Zha statistics for the higher growth rates remain less than 2.0 in absolute value, so again there do not seem to be substantial Lucas critique concerns for the interest rate changes associated with the higher growth rates. However, we see from Table 2 that the average RMSDs for both real GDP and the price level for target nominal GDP growth of 5.0 percent and 5.5 percent are greater than for 4.5 percent growth, and from Table 3, we see that the loss function values are substantially different. For 5.0 percent growth, across the different weight schemes, the loss function values are 36.0 percent to 38.0 percent higher than for 4.5 percent growth and are 42.0 percent to 57.0 percent higher for 5.5 percent growth than for 4.5 percent growth.

We also considered a wider tolerance band of 2 percent. In Table 1, we see that the average standard deviations of the funds rate are lower for the wider 2 percent band than the 1 percent band, and the range of interest rate values is often smaller than for the 1 percent band since there are fewer policy interventions under the wider band. As would be expected for the wider band, there are fewer quarters with a negative interest rate; for 4.5 percent and 5.0 percent growth in nominal GDP, there are no quarters with a negative interest rate. The results presented in Table 2 reveal that the average RMSDs for real GDP and the price level for the different target growth rates of nominal GDP for the 2% tolerance band are sometimes higher and sometimes lower than for the 1% tolerance bands. However, the loss function values presented in Table 3 are always higher for the 2 percent tolerance band than for the 1 percent tolerance band across all weight schemes and nominal GDP growth rates. For 4.5 percent growth, the loss function values are 6.0 percent to 25.0 percent higher across the weight schemes for the 2 percent tolerance band than for the 1 percent band; for 5.0 percent growth, the range is 7.0 percent to 11.0 percent higher, and for 5.5 percent growth, the range is 9.0 percent to 51.0 percent higher.

The loss function values in Table 3 provide the most comprehensive evaluation of the nominal GDP targeting results and suggest that, for our estimation period, simulation period, and model, a 4.5 percent nominal GDP target growth rate with a 1 percent tolerance band around the target level of nominal GDP delivers better results than nominal GDP targets of 5.0 percent or 5.5 percent or a tolerance band of 2 percent and better results than a continuation over the simulation period of the type of policy that characterized the estimation period.

Table 1: Select Interest Rate Statistics, 1,000 Trials

A. Average Standard Deviation*†

Target Variable	% Rate of Change	Tolerance Band Width		Leeper-Zha Statistic
		± 1%	± 2%	± 1% / ± 2%
1. Price Level	2.0	2.23	1.57	1.59 / 1.48
2. Level NGDP	4.5	1.80	1.58	1.65 / 1.54
3. Level NGDP	5.0	1.83	1.64	1.58 / 1.52
4. Level NGDP	5.5	1.92	1.64	1.97 / 1.91

* **Actual:** 1.61
† **FIT-Consistent Policy:** 1.58

B. Minimum / Maximum Values*†

Target Variable	% Rate of Change	Tolerance Band Width	
		± 1%	± 2%
1. Price Level	2.0	-0.06 / 9.57	0.22 / 8.42
2. Level NGDP	4.5	-0.10 / 8.57	0.06 / 8.62
3. Level NGDP	5.0	-0.29 / 8.62	0.06 / 8.62
4. Level NGDP	5.5	-0.62 / 8.47	-0.67 / 8.62

* **Actual:** 1.0 / 5.25
† **FIT-Consistent Policy:** 0.06 / 8.62

C. Number of Quarters with Negative Rate*†

Target Variable	% Rate of Change	Tolerance Band Width	
		± 1%	± 2%
1. Price Level	2.0	3	0
2. Level NGDP	4.5	1	0
3. Level NGDP	5.0	3	0
4. Level NGDP	5.5	13	9

* **Actual: 0**
† **FIT-Consistent Policy: 0**

Table 2: Average Root Mean Squared Deviations (RMSD), 1,000 Trials[*†]			
RMSDs for Nominal GDP and Price Level Targets	**±1% band**	**±2% band**	**FIT-Consistent Policy[‡]**
Price Level Target Growth: 2.0%			
RMSD: Real GDP	2.382	1.559	1.559
RMSD: Price Level	0.988	1.392	1.352
Nominal GDP Target Growth: 4.5%			
RMSD: Real GDP	1.232	1.212	1.257
RMSD: Price Level	1.175	1.369	1.396
Nominal GDP Target Growth: 5.0%			
RMSD: Real GDP	1.450	1.541	1.548
RMSD: Price Level	1.366	1.397	1.396
Nominal GDP Target Growth: 5.5%			
RMSD: Real GDP	1.431	1.882	2.198
RMSD: Price Level	1.511	1.435	1.396

[*] All values multiplied by e-02.

[†] RMSDs are computed around the following trends. Target price level growth is always 2%, based on the actual value in 2003:4. Also, starting from the actual 2003:4 value, real GDP growth trends are 2% for target nominal growth of 4.5%, 3% for target nominal growth of 5%, and 3.5% for target nominal growth of 5.5%.

[‡] RMSDs for the FIT-consistent experiment calculated around trends used for the growth targets in the corresponding row.

Table 3: Loss Functions				
Type Loss Function/ Policy Objective	**% Rate of Change[a]**	**Loss Function Value[*]**		
		Tolerance Band Width		**FIT-Consistent Policy**
		±1%	**±2%**	
A. Dual Mandate Weights[b]				
1. Price Level	2.0	3.32503	2.18407	2.12919
2. Level NGDP	4.5	1.44922	1.67155	1.76443
3. Level NGDP	5.0	1.98423	2.16315	2.17256
4. Level NGDP	5.5	2.16544	2.80057	3.39001
B. Keynesian Weights[c]				
1. Price Level	2.0	4.49948	2.30728	2.27984
2. Level NGDP	4.5	1.48352	1.57025	1.67224
3. Level NGDP	5.0	2.04336	2.26891	2.28443
4. Level NGDP	5.5	2.10660	3.17125	4.11061
C. Flexible Inflation Targeting Weights[d]				
1. Price Level	2.0	2.15059	2.06087	1.97855
2. Level NGDP	4.5	1.41492	1.77286	1.85662
3. Level NGDP	5.0	1.92509	2.05738	2.06069
4. Level NGDP	5.5	2.22428	2.42990	2.66941

[*] All values multiplied by e-04.

[a] The desired rate of change employed in computing the target path of the level of the variable over 2004:1–2006:4. The 2003:4 value is projected forward as the target value at the indicated rate of change.

[b] Dual Mandate Weights: .5 on the variance of both output and the price level from the target value.

[c] "Keynesian" Weights: .25 on the variance of the price level from target and .75 on the variance of the output from target.

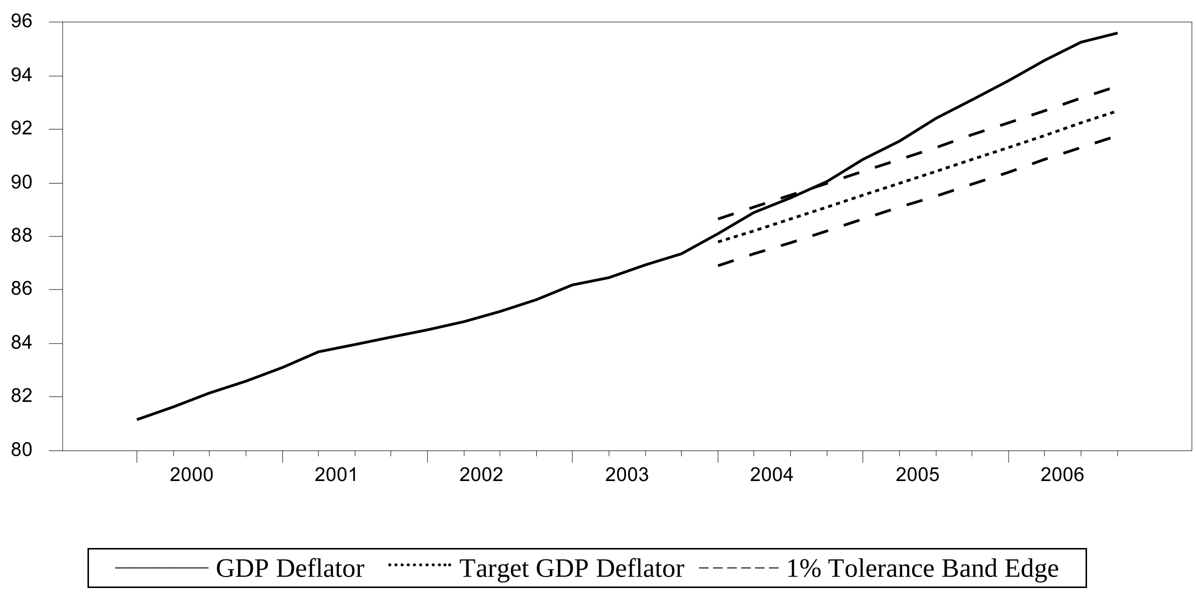
[d] Flexible Inflation Targeting Weights: .75 on the variance of the price level from target and .25 on the variance of the output from target.

V.3: Targeting the GDP Deflator

Our second experiment analyzes a target path for the price level. Similar to the analysis of the nominal GDP target, we specify a target path for the GDP deflator along with a tolerance band and examine the implications of using monetary policy to attain the targeted price level objective. Specifically, we analyze the interest rate path needed to attain the price level goals along with the implications of this path for real GDP. The analysis again is based on 1,000 trial simulations, which allows us to compare the variabilities of nominal GDP, real GDP, the price level, and the interest rate over our trials. As before, we ask whether the policy as implemented would have violated the Lucas critique.

Consistent with 2 percent inflation targets at major central banks around the world for much of the past several decades, and having estimated our model through 2003:4, we target price level growth of 2 percent with tolerance bands, alternatively, of ± 1 percent and ± 2 percent. While unknown to a policy planner at the end of 2003, this target path, specified to be about the same pace as then-recent historical values, would have been somewhat restraining over the simulation period; Figure 7 shows the target path with ± 1 percent tolerance bands.

Figure 7: Price Level Targeting
GDP Deflator, Target GDP Deflator, and ±1% Tolerance Band



Average results for the 1,000 trials are shown in Figures 8 – 10. We begin with Figure 8, which shows the quarter-by quarter average path for the price level under our base case price level target (solid line) and the quarter-by-quarter average path for the price level under FIT-consistent policy (dotted line). We note that with the FIT-consistent policy, after three quarters, the price level rises above the upper tolerance band and remains above the upper boundary for the rest of the simulation. Price level targeting gradually lowers the price level to a value within the tolerance band. As noted earlier, under price level targeting, the 12-quarter average price level meets the criterion set out in the methodology discussion, and this criterion does allow the quarter-by quarter price level to move modestly outside the tolerance band, although in each quarter it is below the price level implied by the FIT-consistent policy. We expect that policy makers would tolerate such temporary, modest deviations of the price level from the tolerance band. Inflation over the simulation period is 2.2 percent, close to the 2.0 percent rate that defined the target path for the price level.

Figure 8: Price Level Targeting:
Average GDP Deflator, Average FIT-Consistent GDP Deflator, and ±1% Tolerance Band

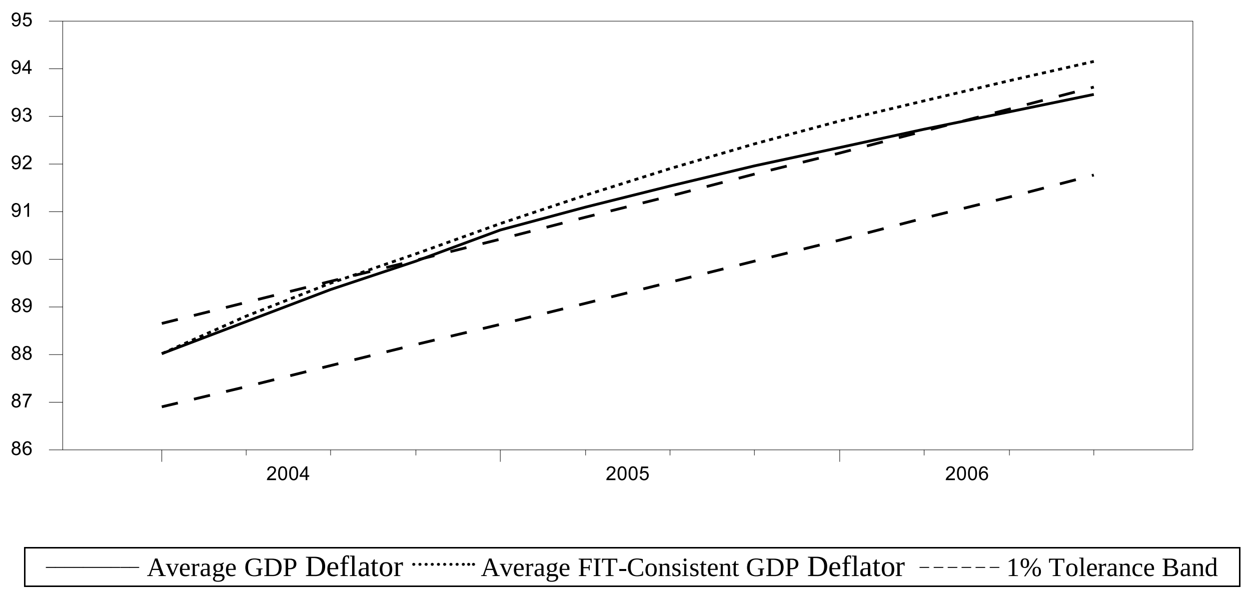
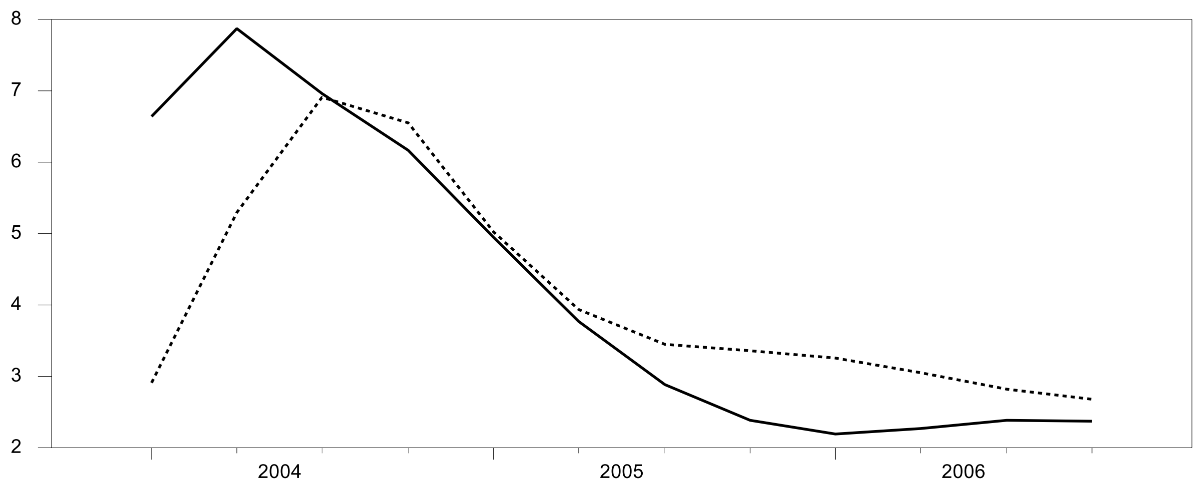
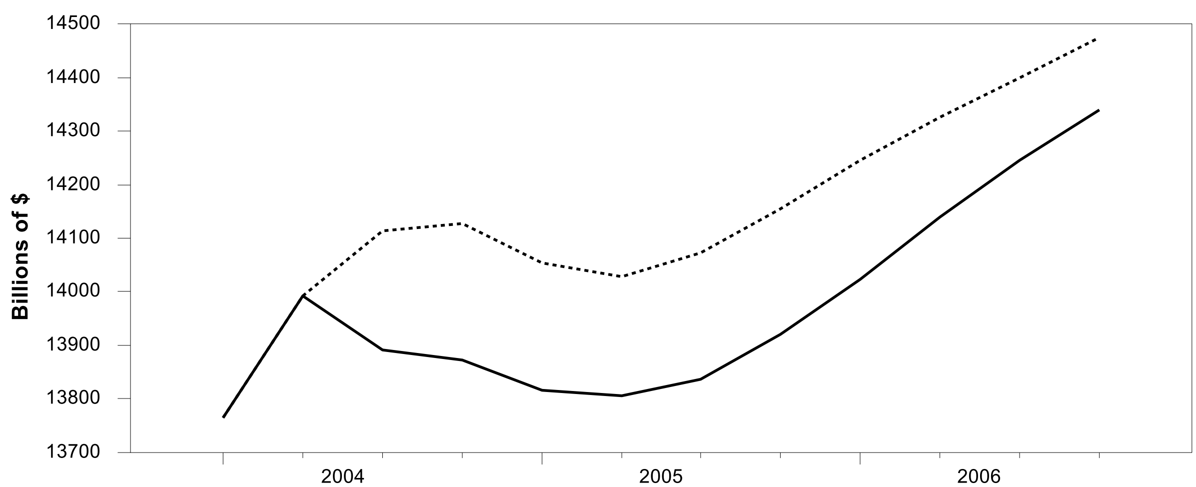


Figure 9: Price Level Targeting:
Average Federal Funds Rate for Base Case and for FIT-Consistent Policy



Average Fed Funds Rate, Base Case ········ Average Fed Funds Rate, FIT-Consistent

Figure 10: Price Level Targeting
Average Real GDP for Base Case and for FIT-Consistent Policy



Average Real GDP, Base Case ········ Average Real GDP, FIT-Consistent

Figure 9 shows that, as expected from the fact that price level targeting generates a price level path below that of the FIT-consistent policy, monetary policy is initially substantially tighter under price level targeting than with the FIT-consistent policy. In 2004:1, the value of FFR implied by price level targeting is approximately 6.5 percent compared to a value slightly below 3.0 percent for the FIT-consistent policy. In 2004:2, under price level targeting, ffr is raised to almost 8.0 percent, whereas it rises to slightly above 5 percent under the FIT-Consistent policy.

The tight policy under price level targeting reduces real GDP with a slight lag (Figure 10) and begins to restrain the rise in prices relative to the FIT-consistent policy (Figure 8). Under price level targeting, the average decline in real GDP is from $13.99 trillion in 2004:02 to $13.81 trillion in 2005:02, rebounding to $13.92 trillion two quarters later and then to $14.34 trillion by 2006:04. The initial decline is 1.3 percent, followed by growth in 2006 of 3.0 percent. The annualized rate of inflation for our price level target over the simulation period is 2.2 percent, somewhat below the 2.5 percent annualized inflation rate under the FIT-Consistent policy.

The decrease in real GDP is followed by cuts to ffr for both the targeting and the FIT-consistent approaches. Under price level targeting, after rising initially, ffr is cut in 2004:3 and the cuts continue until 2005:1, when ffr approximately levels out at a value slightly above 2 percent. With the FIT-consistent policy, ffr is increased to about 6.5 percent in 2004:3 (which is about the same value ffr is reduced to under price level targeting) and is cut in 2004:4 and thereafter. From about 2005:3 to the end of the simulation, ffr under price level targeting is actually below the values implied by the FIT-consistent policy. Although ffr is higher for a longer period of time under FIT-consistent policy than under price level targeting, for the FIT-consistent policy the peak in ffr is lower, the downturn in real GDP is smaller and less long-lived (two versus four quarters), and the recovery, which begins in 2005:2 for both policies, is weaker than for price level targeting.

Table 1 also contains information about this policy experiment. First, as before, there is no apparent “instrument instability” in the funds rate. Specifically, for the ± 1 percent tolerance band, the average standard deviation of policy across the trials is somewhat higher (2.23) than the actual standard deviation (1.61) over the period and the standard deviation for the FIT-consistent policy (1.58). Among the 12,000 quarters across the 1,000 trials, the highest interest rate needed was about 9.6 percent compared with an actual maximum of 5.25 percent. Second, there are only three instances in the 12,000 quarters in which the funds rate was set below zero, and just marginally (-0.06 percent). Despite the actual funds rate being 1 percent at the outset of our simulations, as with nominal GDP targets, these results appear to allow a transition to the price level targeting regime without worry of sustained instances of negative policy rates. Also consistent with the nominal GDP target, we note that the path of FFR differs substantially from the smooth rise in the actual value of FFR over the simulation period and again question whether policy makers would move from a policy of modest adjustments of 25 basis points in order to attain the price level target. The absolute values of the maximum computed Leeper-Zha modesty statistics in Table 1, panel A indicate that, as was the case for nominal GDP targeting, there does not appear to be concern regarding the Lucas critique.

As with nominal GDP targeting, we also considered a 2 percent tolerance band for price level targeting. For price level targeting, the average standard deviation of the funds rate (Table 1, panel A) falls sharply for a 2 percent tolerance band relative to the 1 percent band, and is essentially the same as for nominal GDP targeting of 4.5 percent, with a 2 percent tolerance band. The range of values of the funds rate for a 2 percent price level targeting tolerance band is now less than the range for nominal GDP targeting with a 2 percent tolerance band, and there are no periods in which a negative interest rate is required. With the price level objective, the average RMSD for real GDP falls when the tolerance band is widened from 1 percent to 2 percent (Table 2), but it rises for the price level. In Table 3, the loss function value for price level targeting for a 2 percent band is substantially lower than for a 1 percent band for the dual mandate and Keynesian weights but is only slightly less for flexible inflation targeting weights. However, for all threes weight schemes, the loss function values for price level targeting with a 2 percent band are greater than those for the nominal GDP targeting of 4.5 percent with a 2 percent band and higher than the best results for the same nominal GDP target but with the 1 percent band for all weighting schemes.

We have also experimented with higher targeted growth paths for the price level. Generally, since we are starting with a relatively low interest rate at the outset, these cases required a substantial number of negative interest rates to attain higher price level objectives. As an example, when the price level is targeted to grow at a 2.6 percent rate with a ± 1 percent tolerance band, 1,305 quarters of the 12,000 across the trials required a negative rate to attain the objective. With a target growth in the price level of 4 percent, 4,874 quarters required a negative rate.[15] In addition, these alternatives fare poorly in terms of the ability to implement them without raising substantial Lucas critique objections. Examples such as these raise the question, given the model specification, of whether policy can emerge from a low interest rate environment by raising the price level objective over time, as suggested by some in the current environment.

V.4: Should There Be a Preference?

As we saw in the previous section, qualitatively, the effects of nominal GDP and price level targeting are similar. There are, however, some quantitative differences for the simulated paths of the key variables, real GDP and the price level. Both policies generate a brief downturn in real GDP followed by a recovery, and both restrain the increase in the price level relative to the FIT-consistent policy. Under nominal GDP targeting, the downturn is only two periods in duration (2005:1-2005:2), and real GDP falls by $77.2 billion. Real GDP peaks in 2004:2 under price level targeting, and a trough is reached in 2005:2. Real GDP declines by $187.3 billion. Thus, under price level targeting, the recession is longer and deeper than with nominal GDP targeting. With the FIT-consistent policy, real GDP falls in 2005:1 and 2005:2 and the decrease in real GDP is $100.3 billion. Price level targeting generates a decrease in real GDP that is 2.4 times the decrease under nominal GDP targeting and 1.3 times the decrease with the FIT-Consistent policy. Although both targeting policies generate a price level below that of the FIT-Consistent policy, the price level at the end of the simulation period is somewhat lower for price level targeting than for nominal GDP targeting. However, the annualized rate of inflation over the simulation period is about the same for nominal GDP and price level targeting. Across trials, inflation averages 2.3 percent for nominal GDP targeting and 2.2 percent for price level targeting; the FIT-Consistent policy generates a moderately higher rate of inflation of 2.5 percent.

[15] While inflation averaged 3.3 percent over the estimation period, we evaluate a 4.0 percent price level growth objective in light of some proposals to at least temporarily raise the inflation target above 2.0 percent. Our guess is that 4.0 percent is the likely upper bound policy makers would tolerate given the potential loss of credibility for policy of rates higher than this and given the costs of returning inflation to the longer-run 2.0 percent objective.

Comparing Figures 4 and 9, we note that although the pattern of adjustment of the funds rate is similar under both types of targeting, policy is initially tighter under price level targeting than under nominal GDP targeting (a maximum funds rate of almost 8.00 percent in Figure 9 vs. about 6.75 percent in Figure 4) and that both types of targeting generate initially tighter policy than for the FIT-Consistent policy (a maximum funds rate of about 6.50 percent). We also note that the average standard deviation of FFR under price level targeting (2.23) is somewhat higher than under nominal GDP targeting (1.80), and both are moderately higher than for the FIT-Consistent policy (1.58) or for the actual standard deviation (1.61). Over the simulations, the spread between the maximum and minimum values of the funds rate is comparable, although the range is somewhat wider for price level targeting than for nominal GDP targeting. The number of quarters with a negative funds rate is negligible for both types of targeting using the base case parameters for the targeting experiments. The Leeper-Zha statistics suggest that the Lucas Critique is not an issue for the base cases.

Table 2 shows the RMSDs for the various experiments, computed around trend values as specified earlier. Table 2 indicates that for the price level objective for the ± 1 percent tolerance band, the RMSDs are notably different than for the base case for nominal GDP targeting. In particular, the RMSD for real GDP is nearly twice as large as for the nominal GDP target example, while the price level RMSD is about 20 percent lower. The tighter control of the price level is not surprising, given that the price level is the objective of this experiment. The constraint on prices may be what forces additional variation in output, though this would likely need a disaggregated analysis to provide additional insights.

Table 3 presents the values of the loss functions associated with the dual mandate, Keynesian, and flexible price level targeting policy preferences. In Table 3, a comparison of our two base cases—4.5 percent nominal GDP growth with ±1 percent tolerance bands and 2 percent price level growth also with ±1 percent bands—shows that the nominal GDP targeting approach produces notably lower loss values for each set of weights; for the dual mandate weights and Keynesian weights, the nominal GDP targeting loss function values are less than half of those for price level targeting, and are one-third lower for flexible price level targeting weights. The loss function values for nominal GDP targeting for the different sets of weights are also lower than the FIT-consistent policy values, although by smaller margins. We also note that although the loss function values for price level targeting vary substantially across different weighting schemes, the loss function values for nominal GDP targeting across the different weighting schemes are very similar in magnitude.

VI. Concluding Comments

In light of the ongoing discussion in the monetary literature of the appropriate framework for monetary policy, this paper compares two of the most frequently discussed alternatives to inflation targeting—targeting the level of nominal GDP and price level targeting—within the context of a small VAR model estimated over 1979:4–2003:4, a period in which the economy was buffeted by substantial supply and demand shocks. The paths of the federal funds rate, nominal GDP, real GDP, and the price level under nominal GDP and price level targeting and for a continuation of the flexible inflation rate targeting rate regime followed by the Fed over the estimation period are simulated out-of-sample over the 2004:1–2006:4 period. The federal funds rate at the end of the estimation period had been reduced to 1 percent, so we begin our evaluation of nominal GDP and price level targeting when these policies are implemented at a very low initial federal funds rate, roughly comparable to the level of the funds rate if these policies were implemented today.

In our simulations, there is no apparent instrument instability in the funds rate under either nominal GDP or price level targeting. Leeper-Zha statistics suggest no concerns regarding the Lucas Critique for either type of targeting, and violating the zero lower bound was not an issue in the simulations. In comparing nominal GDP targeting, price level targeting, and flexible inflation targeting, we evaluate three loss functions—a dual-mandate function, a "Keynesian" function, and a "flexible price targeting" function—for each policy. The loss function values indicate that nominal GDP targeting produces noticeably lower losses in the simulation period than either price level targeting or the flexible inflation targeting-consistent policy, and the flexible inflation targeting-consistent policy produces lower losses than price level targeting. Further, the loss function values for nominal GDP targeting are very similar in magnitude across dual mandate, Keynesian, and flexible price level targeting weights, whereas the loss function values for price level targeting vary substantially across the different weighting schemes. Thus, our evaluation of nominal GDP and price level targeting suggests better outcomes under nominal GDP targeting than under either price level targeting or a continuation of the monetary policy that characterized the estimation period for our model. We note that Garín, Lester, and Sims (2016), using a very different model, find that nominal GDP targeting outperforms inflation targeting and that Benchimol and Fourçans (2017), again using a very different model, find that policy rules targeting the level of nominal GDP generally outperform rules that target nominal GDP growth or policy implemented using variants of the Taylor Rule. Further, Beckworth and Hendrickson (2016), using a New Keynesian model, suggest that nominal GDP targeting is preferred to a Taylor Rule.

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Appendix: Technical Detail of the Methodology (Not for Publication)

Our simulations assume that each period a forward-looking policy maker has a twelve-quarter policy horizon, and Blinder's policy planning process at a given date requires 'an entire hypothetical path' for the policy instrument. To implement this 'first step' of the policy plan for the 'entire hypothetical path,' begin with a random draw of length 2m-1 from the estimated residuals for each equation; with m = 12, the length of the draw covers 23 periods. Assuming these are representative shocks for each equation, for this particular draw at period t and given the shocks to the nonpolicy equations, we need to compute a sequence of policy innovations $\{\hat{u}_{k,t+1}, \hat{u}_{k,t+2, \ldots,} \hat{u}_{k,t+12}\}$. Each policy innovation aims for the desired path for the subsequent 12 quarters, so the policy shock implemented in t+1, $\hat{u}_{k,t+1}$, aims for the path for the target variable for periods {t+1, t+2, …, t+12}. Similarly, the shock $\hat{u}_{k,t+2}$ is implemented with the objective of attaining the path for the target variable for periods {t+2, t+3, …, t+13}, and so on until we finally compute $\hat{u}_{k,t+12}$ with the goal of the target variable path over {t+12, t+13, … , t+23}.

As detailed below, to compute the innovation at period t+1 needed attain the objective over {t+1, t+2, … , t+12}, we take as given not only the shocks to the nonpolicy equations but also the remaining drawn shocks to the policy equation. We note that it is possible for the drawn policy shock for period t+1 to be consistent with the policy objective, in which case this value is retained; otherwise, it is discarded, and the shock needed for the objective is computed. In either case, given the policy innovation $\hat{u}_{k,t+1}$, we next need to select the innovation for period t+2, $\hat{u}_{k,t+2}$, which will attain the policy objective over {t+2, t+3, …, t+13}. Continuing through the process, the final computation at period t is to determine the innovation needed at t+12, given the prior policy innovations, $\{\hat{u}_{k,t+1}, \hat{u}_{k,t+2, \ldots,} \hat{u}_{k,t+11}\}$. This final innovation assures achievement of the objective over {t+12, t+13, …, t+23}. In this manner, for a given random draw from the estimated residuals, we have planned the 'entire hypothetical path' at time t and using this policy path in combination with representative shocks for the nonpolicy equations, we can then compute that trajectory for the system of equations from the MAR.

For a detailed exposition, for convenience we place the two variables whose sum we wish to target, say the logs of real GDP and a price index, as the first and second elements, y_1 and y_2 in the vector Y. The policy variable is thus in position k, $2 < k \leq n$, and the policy shock to this equation is denoted by shock, $u_{k,t+1}$. Using a Choleski decomposition, the policy shock in period t+1 cannot affect either y_1 or y_2 in period t+1. However, it will influence $y_{1,t+2}$, $y_{2,t+2}$, … $y_{1,t+12}$, $y_{2,t+12}$, both directly and indirectly through its impact on other system variables via the system dynamics. Taking as given the values of the system disturbances over the period {t+1, t+2, …, t+12} (holding in reserve the residuals drawn for periods t+13 through t+23), consider the role of $u_{k,t+1}$ on the path of log nominal GDP over periods t+1 through t+12:

$$(y_{1,t+1} + y_{2,t+1}) = (d_{0,11} + d_{0,21})u_{1,t+1} + d_{0,22}u_{2,t+1} + 0^*u_{k,t+1} + BP_{1,t+1} + BP_{2,t+1}$$

With a Choleski decomposition, the first term in the MAR, denoted by D(0) in the main text, is a lower triangular matrix. Thus, the coefficients on all the shocks for $u_{j,t+1}$, j>2, are all zero; here we only explicitly note the zero coefficient on the policy shock, $u_{k,t+1}$. Similarly, highlighting the role of $u_{k,t+1}$ for periods t+2 through t+12:

$$(y_{1,t+2} + y_{2,t+2}) = (d_{0,11} + d_{0,21})\, u_{1,t+2} + d_{0,22}\, u_{2,t+2} + \sum_{i\neq k}^{n}(d_{1,1i} + d_{1,2i})u_{i,t+1} + (d_{1,1k} + d_{1,2k})u_{k,t+1} + (BP_{1,t+2} + BP_{2,t+2})$$

$$(y_{1,t+3} + y_{2,t+3}) = (d_{0,11} + d_{0,21})\, u_{1,t+3} + d_{0,22}\, u_{2,t+3} + \sum_{i=1}^{n}(d_{1,1i} + d_{1,2i})u_{i,t+2} + \sum_{i\neq k}^{n}(d_{2,1i} + d_{2,2i})u_{i,t+1} + (d_{2,1k} + d_{2,2k})u_{k,t+1} + (BP_{1,t+3} + BP_{2,t+3})$$

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$$(y_{1,t+12} + y_{2,t+12}) = (d_{0,11} + d_{0,21})\, u_{1,t+12} + d_{0,22}\, u_{2,t+12} + \sum_{i=1}^{n}(d_{1,1i} + d_{1,2i})u_{i,t+11} + \sum_{i=1}^{n}(d_{2,1i} + d_{2,2i})u_{i,t+10} + \ldots + \sum_{i=1}^{n}(d_{10,1i} + d_{10,2i})u_{i,t+2} + \sum_{i\neq k}^{n}(d_{11,1i} + d_{11,2i})u_{i,t+1} + (d_{11,1k} + d_{11,2k})u_{k,t+1} + (BP_{1,t+12} + BP_{2,t+12})$$

In this particular random draw, the value of $u_{k,t+1}$ along with the other disturbances may or may not yield desired values for nominal GDP. The policy objective, of course, is to select a value for the policy shock $u_{k,t+1}$ to attain a desired path for nominal GDP, continuing to hold fixed the values for the other system disturbances. Denote the desired value for nominal GDP in a period t+j as $(y_{1,t+j} + y_{2,t+j})^*$, and substitute these into the above expressions in place of the actual values for j=1,2,..,12. Summing these expressions, on the left side we obtain $\sum_{j=1}^{12}(y_{1,t+j} + y_{2,t+j})^*$ and on the right side we collect terms in $u_{k,t+1}$ and the other shocks and base projections. Conditional on the values for the other shocks, we solve for $\hat{u}_{k,t+1}$ the policy setting needed to attain the target path.[1]

Having found the policy shock for period t+1, update the equations above for periods t+2 through t+13. Solve for the policy shock for period t+2, $\hat{u}_{k,t+2}$, that attains the desired values for nominal GDP conditional on the shock computed above for $\hat{u}_{k,t+1}$ and given the other disturbances for periods 3 through 13. Continue through the policy planning horizon, determining the policy shocks needed to attain the desired values, at each step retaining the previous policy innovations. For a twelve-period planning horizon, then, the last needed shock is for period t+12, computed for the system equations for periods t+12 through t+23. (While a shock for period t+12 has no impact on nominal GDP in t+12 in our setup, it does affect any variables that may be below it in the policy equation. In this case, a complete accounting of the entire system over the planning horizon requires the policy shock for this period.)

The analysis we actually implement modifies the approach above to account for an acceptable tolerance range for the policy process. Generally, if the desired value for nominal GDP in period t+j is $(y_{1,t+j} + y_{2,t+j})^*$, policy makers know it is unrealistic to attain that value exactly. Thus, attaining a value in the range of $(y_{1,t+j} + y_{2,t+j})^* \pm \tau$ is viewed as the actual policy objective. For our computations, if the random draw from the residuals implies that the policy objective is attained for a given period without a policy intervention, then computation of the above policy shock for that particular period is not needed; the drawn policy equation residual is just retained. If the drawn system shocks produce nominal GDP above $(y_{1,t+j} + y_{2,t+j})^*+\tau$, we compute the shock needed to return nominal GDP to this upper bound; similarly, if the drawn shocks produced nominal GDP below $(y_{1,t+j} + y_{2,t+j})^*- \tau$, we compute a policy

[1] Recall that, consistent with our discussion of Leeper and Zha (2003) above, this computed shock is treated as the policy decision variable, even as it is viewed as random by participants in the economy. Should the drawn shock to the policy innovation be consistent with the policy objective, we continue to view the implied value for the policy variable as a decision by the policy maker.

shock sufficient to return to this lower bound.[2] Accordingly, the vector of policy shocks over the planning horizon will be a mixture of residuals drawn from the estimation and shocks computed to return nominal GDP to the specified tolerance band if it happens to move outside that band.

Having passed through the data for the simulation period, we combine the policy shocks (some of which may simply be those in the random draw) along with the other shocks for the nonpolicy equations that particular draw and compute the implied paths of real GDP, the price level, and the other system variables. Finally, the process described above is repeated over 1,000 draws for each so that we can then compute the means and variances of the variables to summarize the statistical properties of the nominal GDP target.

The Leeper and Zha theoretical approach is a Markov-switching model, with each regime a linear model of the economy (a VAR in their case). The effect of a policy intervention is described by the first term on the right side of our equation (1), where our policy interventions are input as the residual of the federal funds rate equation, altering the path of the system variables relative to the base projection. Specifically, picking a policy sequence $\{u_{k,t+1}, u_{k,t+2}, \ldots, u_{k,t+m}\}$, computing the expression $\sum_{s=0}^{m-1} D_s u_{k,t+m-s}$ and then scaling by $\sqrt{\sum_{s=0}^{m-1} D_s^2}$ provides the "modesty statistic." We note that Leeper and Zha use the *u* shock to the policy equation as the policy innovation and assume as we do that

[2] We select policy to return to the edge of the band for several reasons. First, Brainard (1967) notes that if the policymaker is uncertain about the effect of policy on the economy (multiplicative uncertainty) and uncertain about the direct effect of other factors on the economy (additive uncertainty) and assuming no correlation between these types of uncertainty, the policy response should be in the same direction but less forceful than the indicated policy setting computed under certainty equivalence. While some nonzero values of the correlation between multiplicative and additive uncertainty may overturn this conclusion, Blinder (1997) notes that as a Federal Reserve governor, he nonetheless in practice viewed this "Brainard conservatism principle" as "extremely wise." Applying this principle to our framework suggests that it would be better for the policy authority to aim at the edge of the tolerance band than at the midpoint of the range. Furthermore, Barlevy (2009) finds that, in the same circumstances as those in Brainard, robust control techniques imply an even more conservative policy response. However, the analysis is more nuanced if there is correlation between multiplicative and additive uncertainty. Second, returning to the edge of the band requires a smaller policy innovation than returning to the midpoint; that is, we undertake the smallest policy action needed to attain the objective. The trade-off is that these smaller interventions may be more frequent than relatively aggressive actions aimed at returning to the midpoint of the band since the probability of a shock moving the economy outside the band is likely higher. Third, there may be a lack of consensus among policy makers on how quickly to approach the target.

“although the policy advisor chooses [the *u*-innovation], private agents treat it as random” (Leeper and Zha 2003, p. 1678).

Leeper and Zha (2003) argue that the “modesty statistic” has a standard normal distribution, so a computed statistic of less than two implies that the policy innovation embedded in the $\{\hat{u}_k\}$ sequence does not cause agents to alter their assessments about the policy regime in place.[3] We report information on the values of the modesty statistic along with our other results in the text of the paper.

[3] Of course, alternative policy regimes can be “close” to each other, so that distinguishing between these regimes may be difficult. Thus, a modesty statistic of less than 2 is necessary but not sufficient to claim that no important Lucas-critique effects are present.