MIND THE GAP OR FOCUS ON INFLATION:
A CASE FOR BOTH IN MONETARY POLICY

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Abstract

This study seeks to answer the question of to what degree monetary policy should respond to deviations in current output from its natural level, given that the real-time output gap is unobservable. I propose a proxy for the unobservable real-time output gap, which is the real-time Council of Economic Advisors (CEA) forecast of the output gap adjusted by an output-gap uncertainty (OGU) index. The OGU index is simply a linear transformation of the time-*t* standard deviation of the log of real GDP forecasts by professional economists. I find that this measure of output-gap uncertainty corresponds well to periods that were historically thought of as having a high degree of output-gap uncertainty. I then use this real-time uncertainty-adjusted output gap proxy in a monetary policy rule derived from a New Keynesian economic model. Using this rule and a model-independent method for deriving the optimal monetary policy rule, I compare the performance of various specifications of the rule over the period from 1968 to 1999. The monetary policy rule using the OGU-adjusted output gap proxy performs comparatively to the specification that ignores the output gap (inflation targeting), thus providing evidence that central banks might be worse off by not considering forecasts of the real-time output gap in formulating monetary policy.

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1. Introduction

The charter of the Federal Reserve of the United States explicitly states that the main duty of the monetary authority is to maintain stable prices.[2] This is also a consensus view in monetary theory as well as in practice at the Fed. However, the Federal Reserve Act also states the Fed is to maintain long run growth or full employment. Some take this to mean that the Fed has a mandate to respond to fluctuations in output around its natural level. But this point is not unanimously supported in monetary theory literature, nor is it the consensus view among monetary policy makers.

This paper seeks to answer the question of to what degree monetary policy should respond to deviations in output from its natural level (the output gap), given that the real-time output gap is unobservable. The question will be looked at through the framework of a monetary policy rule derived from a central bank optimizing in a simple New Keynesian economy. The idea of a central bank setting monetary policy by following a rule that weights deviations of output and inflation from their respective targets was made prevalent by Taylor (1993). Since that time, the validity of monetary policy rules or "Taylor rules" as a framework for evaluating monetary policy has been debated thoroughly.

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[2] The mandate of the Federal Reserve is found in the Federal Reserve Act of Congress, December 23, 1913, 12 USC 225a. As added by act of November 16, 1977 (91 Stat. 1387) and amended by acts of October 27, 1978 (92 Stat. 1897); Aug. 23, 1988 (102 Stat. 1375); and Dec. 27, 2000 (114 Stat. 3028).

One camp of monetary thought suggests that monetary policy should completely ignore output and should focus solely on deviations of inflation from an inflation target (inflation targeting). Prominent studies in this vein include McCallum (2001), Bernanke and Mishkin (1997), Svensson and Leiderman (1995), and Spencer (2004). Bernanke is probably the most notable of the group that favors inflation targeting as he served on the Federal Reserve Board of Governors from 2002 to 2005 and is widely thought of as a leading candidate to succeed Alan Greenspan as Chairman of the Federal Reserve.

The argument for monetary policy rules that target inflation and ignore the output gap is based on a lack of confidence in the quality of real-time data on the output gap. Real-time data on the output gap and on the inflation gap are both unobservable. But the real-time inflation gap is relatively easier to measure because the policy maker sets (and therefore knows) the inflation target. So the only thing that must be forecasted is the current or expected future level of inflation. Orphanides (2003b) shows that, on average, the differences between real-time and revised inflation deviations from target inflation are much less than the differences between real-time and revised output gap deviations. The output gap is, therefore, more difficult to forecast because of its added dimension of uncertainty—no one really knows what the natural level of output is (potential GDP) in real time. So not only is there uncertainty about the current level of output, but there is also uncertainty about the current level of potential GDP. Orphanides (2001), McCallum (2001), and Spencer (2004) document the substantial differences between real-time data and their revised data counterparts and their relationship to monetary policy rules, as well as the very different policies that each type of data implies.

The question of inflation targeting usually amounts to whether or not it is optimal to throw away real-time information about the current output gap due to its poorly measured nature. One problem with this approach is that macroeconomics is blessed with an abundance of competing models, each of which has different implications for monetary policy. Of the models of money that predict nominal money balances having a real effect on the economy, each of them is based on tenuous or *ad hoc* microfoundations. The same difficulty arises in trying to find models in which the existence of money is even supported. So a key problem in monetary theory is convincingly justifying any effects on the real economy or even existence of money.

This paper follows Clarida, et al (2000) in using a New Keynesian economy to derive a forward looking monetary policy rule. Even though the New Keynesian model has some notorious weaknesses, the analysis of this paper also has some strong empirical interpretations that are independent of the model. Orphanides (2003b) shows that a Taylor rule framework is a good approximation of how the Federal Reserve behaves in reality. This implies that estimation of a Taylor rule will give a good picture of how a central bank administration makes policy and reacts to deviations of inflation and output from their target and natural rate, respectively.

As a method of sidestepping the criticism of model dependence, I utilize a trick following Spencer (2004). I estimate an optimal monetary policy rule based on the strong assumption that the first eight years of the Fed Chairmanship of Alan Greenspan (1987:3 to 1995:3) was the period of the best monetary policy in U.S. history, which rule is based on revised data. Using this rule, I judge other "implementable" monetary policy rule specifications that use real-time data by how close they come to this "optimal" rule.

The result is that a policy rule that uses an uncertainty-adjusted proxy for the real-time output gap performs about as well as a pure inflation targeting rule that ignores the real-time output gap.

In Section 2 of this paper, I propose a proxy for the level of real-time output-gap uncertainty in the U.S. economy. I then derive a monetary policy rule from a New Keynesian macroeconomic model in Section 3. In Section 5, I use the rule from Section 3 to estimate a baseline (optimal) monetary policy rule based on the first eight years of Greenspan's tenure as Federal Reserve Chairman (1987:3 to 1995:3) and based on revised historical data. Then, using the estimated rule, I show what the corresponding "optimal" counterfactual fed funds rate would have looked like over the whole sample. This gives a method of assessing how well monetary policy was conducted in different periods of the Fed's history—particularly the 1970s and the mid-to-late 1990s.

I then compare the performance of alternate monetary policy rules that use various proxies for the real-time output gap—policy rules that could actually be used in making monetary policy. The idea is to see which implementable real-time monetary policy rule comes the closest to the optimal revised-data rule. The real-time output gap proxies examined are the steady-state level of the gap (zero; inflation targeting), the real-time forecast of the output gap as given in the estimates of the President's Council of Economic Advisors (CEA), and then an uncertainty-adjusted real-time output-gap forecast.

2. Output-Gap Uncertainty (OGU) Index $\sigma(s_t)$

I construct this proxy for output-gap uncertainty as an index with values between zero and one using quarterly data from the Philadelphia Federal Reserve's *Survey of Professional Forecasters*. Each quarter, the Philadelphia Federal Reserve surveys leading economic forecasters on their predictions for output and prices as well as other economic indicators.[3] Forecasts are given for horizons of one quarter ahead of the current period up to four quarters ahead.

The idea is that each forecaster implicitly has a belief about where the economy's steady-state or natural level of output is and where the economy currently is in relation to that steady state. The forecasters then predict how the economy will grow based on their beliefs. If all the forecasters have the same beliefs about the level of the steady state and the economy's current state, then their forecasts should be very close to each other resulting in low standard deviations and, thereby, low output-gap uncertainty. On the other hand, when the level of uncertainty is high about what the steady state output level is or where current output is, the standard deviation of GDP forecasts from the survey should be high.

Figure 1 shows the time path of the standard deviations for the log of each month's forecasts of real GDP for forecast horizons from one quarter ahead to four quarters ahead.[4] As can be seen, the character of the path of standard deviations doesn't change much across forecast horizons aside from standard deviations slightly increasing

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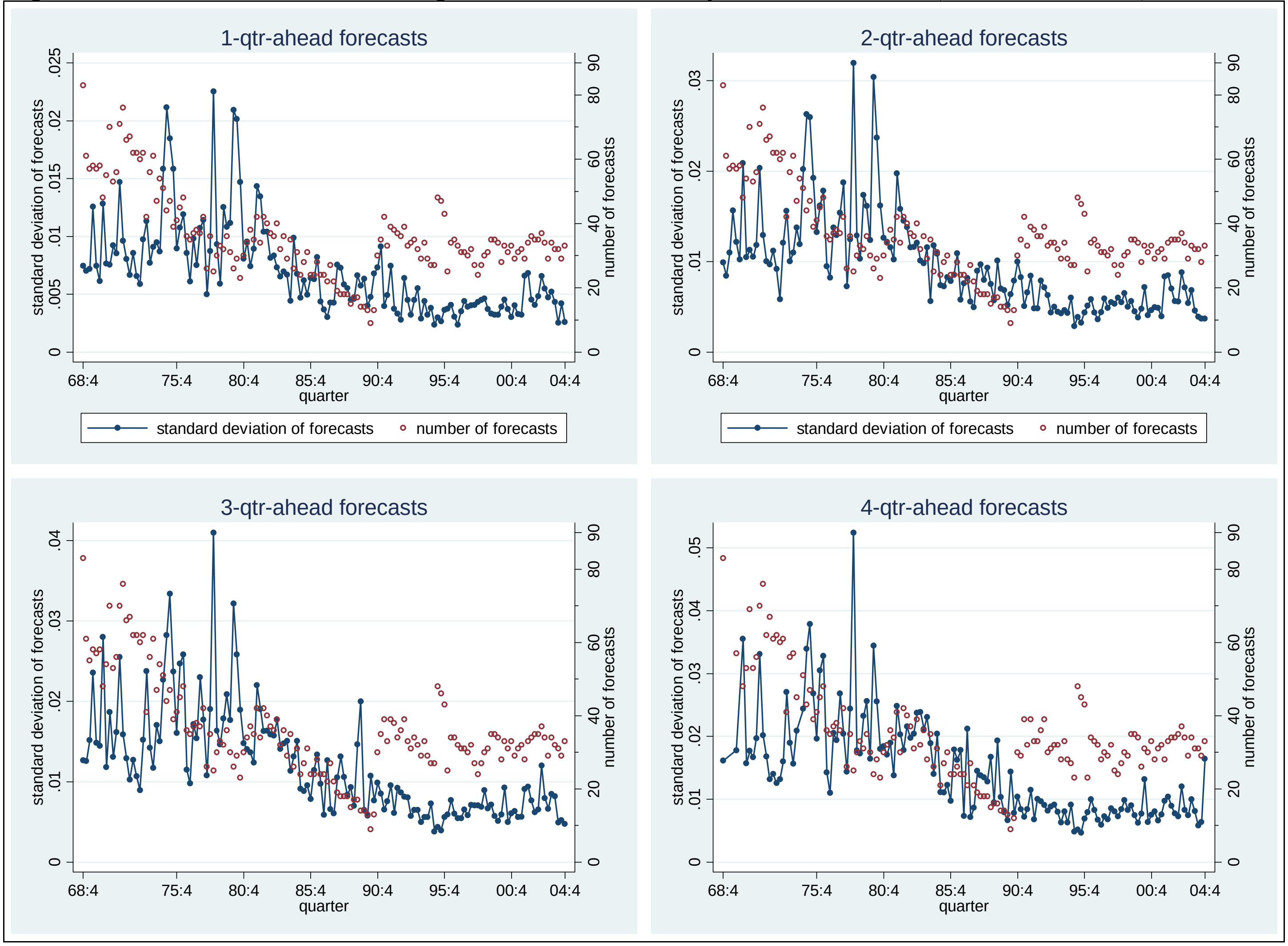
[3] Information about the Survey of Professional Forecasters can be found at http://www.phil.frb.org/econ/spf/index.html.

[4] This is actually a version of real GDP constructed from the survey's forecasts of nominal GDP adjusted by the corresponding forecasts of the GDP deflator. I chose this method because forecasts of real GDP were not collected until the third quarter of 1981. Because the period of the 1970s is crucial to this study and because the constructed real GDP values do not differ substantially from the direct real GDP values, I chose to use the constructed values.

Figure 1: Standard deviations of log real GDP forecasts by forecast horizon (1968:4 to 2004:4)



Source: Philadelphia Federal Reserve, *Survey of Professional Forecasters*.

as the forecast horizon increases. For the index proposed here, I will use the standard deviations of the one-quarter-ahead forecasts. These should be more robust to the relation of the timing of the survey to the position in the business cycle as well as to other sources of error. That is, a one-quarter-ahead forecast is more likely to be moving in the same direction in relation to the steady state as the current period's GDP.

Three facts stand out from Figure 1. First, the decade of the 1970s was a time in which the variance in real GDP forecasts was at its highest level. This corresponds to the findings of Orphanides (2002a, 2003a, 2003b, 2004) and Spencer (2004) that the 1970s was marked by a systematic misperception of the real-time output gap. The second insight from Figure 1 is that the early-to-mid 1990s has the lowest variance of the sample. This corresponds to the widely held belief that U.S. monetary policy in the early 1990s was as good as it has ever been; the first half of the 1990s is considered to be Greenspan's heyday. The tie-in with output-gap uncertainty is that monetary policy can be more accurately administered in periods of lower uncertainty.

The last fact to note from Figure 1 is that the variation in forecasts begins to increase after 1995, although only slightly. GDP growth in the mid-to-late 1990s achieved levels that hadn't been seen since the end of World War II. It was in 1996 when Greenspan made his famous comment about the "irrational exuberance" of the stock market, and talk of a stock market bubble became mainstream.[5] On the other hand, another camp of economists said that the accelerated U.S. GDP growth was being driven by large increases in productivity driven by the technology boom. The first camp was arguing for a large output gap, while the second camp was arguing for a smaller gap. I expected the uptick in the variance of forecasts after 1995 to be greater than what is shown in Figure 1, but at least it shows a small upward trend.

The index of output-gap uncertainty (OGU index) is calculated as a linear function of a given quarter's standard deviation of one-quarter-ahead forecasts s_t. Let $\sigma(s_t)$ be the value of the OGU index. Then the index is calculated by the following relation:

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[5] Greenspan first described the possible stock market bubble as "irrational exuberance" in a speech to the American Enterprise Institute in Washington, D.C., on December 5, 1996.

$$\sigma(s_t) = \min\left\{\frac{1}{\max\left\{s_i\right\}_{i=1}^{T}}\cdot s_t,\ 1\right\} = \min\left\{44.37 s_t,\ 1\right\} \tag{1}$$

Figure 2: OGU index (1968:4 to 2004:4)

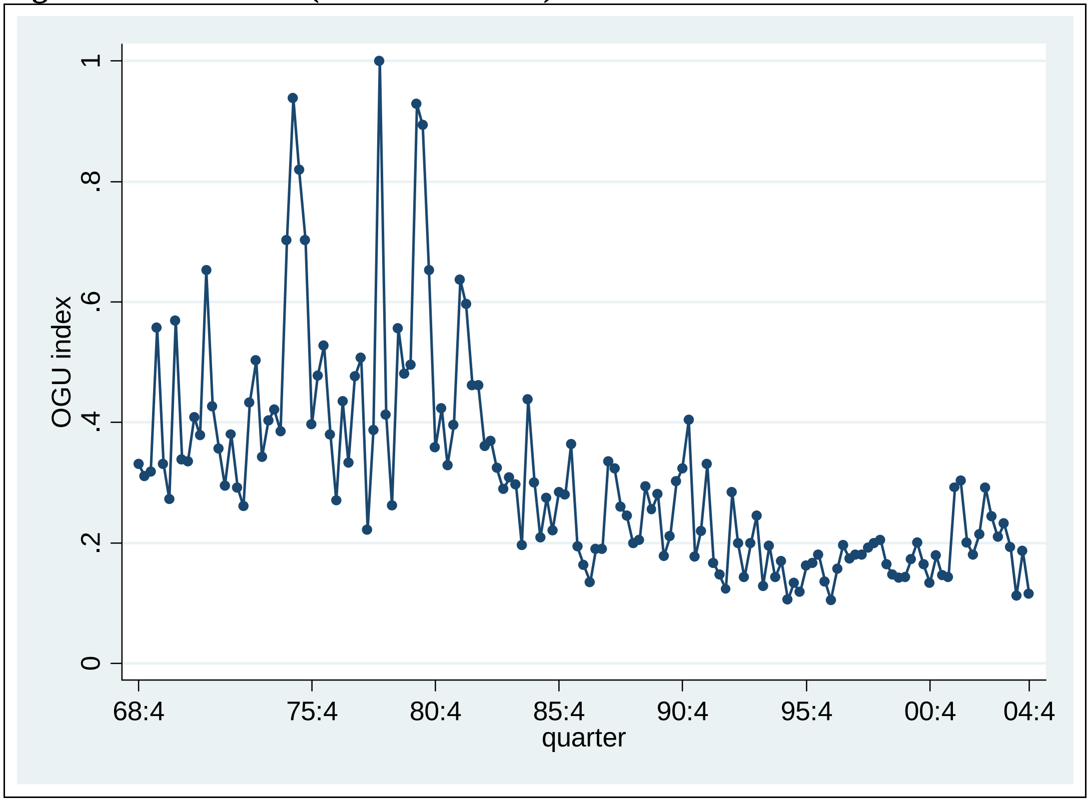

Table 1: Descriptive statistics and OGU index values for standard deviation series

Variable	obs.	mean	std. dev.	min	Max
OGU index $\sigma(s_t)$	145	0.313	0.177	0.105	1.000
Standard deviation s_t	145	0.0071	0.0040	0.0024	0.0225

Source: Philadelphia Federal Reserve, *Survey of Professional Forecasters* (1968:4 to 2004:4).

where s_t is the value of the standard deviation of the GDP forecasts in period *t* and $\max\{s_i\}_{i=1}^{T}$ is the maximum standard deviation over the sample. The minimum operator simply allows this calibration of the index to be used in future periods in which the maximum standard deviation over the sample may exceed this sample's maximum.

Figure 2 shows the time path of the OGU index over the period of 1968:4 to 2004:4. Because it is simply a linear transformation of the series of one-quarter-ahead forecast standard deviations, the OGU index series looks the same as the series in the upper-left corner of Figure 1. Table 1 gives the descriptive statistics for the OGU index as well as for the series of standard deviations from which it was derived.

Corresponding to the series of forecast standard deviations, the high values of the OGU index occur in the third quarter of 1978 (1.00), the first quarter of 1975 (0.94), and the first quarter of 1980 (0.93). After 1982, the index never rises above 0.50. The average value of the index during the decade of the 1970s is 0.45. By comparison, the average values of the OGU index during the 1980s and 1990s are 0.35 and 0.19, respectively. The minimum value of the index occurs in the first quarter of 1995 (0.11).

3. Model

Most of the parts of the model that this paper will use to derive its monetary policy rule are set out by Clarida, Galí and Gertler (1999, 2000). The framework is a dynamic general equilibrium model with money, monopolistic competition, and nominal price rigidities in which aggregate behavioral equations come from household and firm optimization.[6] Let y_t and z_t be the logarithm of the stochastic and natural levels of output, respectively. Then the output gap x_t is defined in terms of percent deviation from potential output as:

$$x_t \equiv y_t - z_t \tag{2}$$

Let the inflation rate π_t be the percent change in the price level from period t-1 to period t, and let i_t be the nominal interest rate. The general equilibrium model can be reduced to the following two equations, which represent an "IS" relation and a Phillips-curve relation, respectively.

$$x_t = -\varphi\left[i_t - E_t\pi_{t+1}\right] + E_t x_{t+1} + g_t \tag{3}$$

$$\pi_t = \lambda x_t + \beta E_t \pi_{t+1} + u_t \tag{4}$$

The error terms g_t and u_t are autoregressive and have the following form:

$$g_t = \mu g_{t-1} + \hat{g}_t \tag{5}$$

$$u_t = \rho u_{t-1} + \hat{u}_t \tag{6}$$

where $0 \leq \mu,\rho \leq 1$ and where both $\hat{g}_t$ and $\hat{u}_t$ are i.i.d. random variables with zero mean and variances σ_g^2 and σ_u^2, respectively.

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[6] For thorough derivations of the economic model, see Yun (1996), King and Wolman (1996), Woodford (1996), and Bernanke, Gertler, and Gilchrist (1999).

A central bank with a quadratic loss function in deviations of inflation and output from their respective targets and the economic model described above give rise to the following monetary policy rule:

$$r_t = (1 - \rho)\left[rr^* - (\beta - 1)\pi^* + \beta\pi_{t,k} + \gamma x_{t,q}\right] + \rho(L)r_{t-1} + \varepsilon_t \tag{7}$$

where r_t is the nominal federal funds rate, rr^* is the desired real federal funds rate when both gaps are zero, π^* is the target level of inflation, $\pi_{t,k}$ is the change in price level between periods t and $t + k$, $x_{t,q}$ is a measure of the average output gap between periods t and $t + q$, $\rho(L)r_{t\text{-}1}$ is a polynomial lag of the nominal federal funds rate where the value of the parameter ρ gives the degree to which the Federal Reserve smoothes interest rates, and an error term ε_t. This paper will assume that both k and q are zero; that is, the Fed responds to expected current-quarter gaps.

My contribution to one of the real-time specifications of the model will be to add a variable $\sigma_t \in [0,1]$ that represents uncertainty in the output gap, with $\sigma_t = 1$ being the most uncertainty and $\sigma_t = 0$ being the least uncertainty. This variable will fluctuate exogenously over time as the level of output gap uncertainty changes. The new monetary policy rule under this specification is:

$$r_t = (1 - \rho)\left[rr^* - (\beta - 1)\pi^* + \beta\pi_{t,k} + (1 - \sigma_t)\gamma x_{t,q}\right] + \rho(L)r_{t-1} + \varepsilon_t\,. \tag{8}$$

With this rule, the uncertainty-adjusted weighting of the output gap goes to zero as its uncertainty σ_t increases to its maximum value of 1. Under this specification, an inflation targeting policy rule arises from two possibilities. If $\gamma = 0$, then it is optimal for the central bank to always ignore deviations in output, regardless of the level of output gap uncertainty. In the case of $\gamma > 0$, if $\sigma_t = 0$, then the optimal policy in period t will also be to ignore the output gap. However, if the degree of output gap uncertainty decreases in a subsequent period and $\gamma > 0$, the central bank is no longer bound to ignore the output gap. Good information is not thrown away. Equation (8) allows the central bank to target inflation sometimes, but it also allows the central bank to have the flexibility to respond to deviations in output when the real-time estimates are more certain.

4. Data

The historical revised data on the federal funds rate, real GDP, GDP deflator, and other aggregate and financial series come from the FRED system (Federal Reserve Economic Data) of the Federal Reserve Bank of St. Louis.[7] The real-time series for nominal and real GDP and the GDP implicit price deflator come from the Federal Reserve Greenbook forecasts data compiled by the Federal Reserve Bank of Philadelphia.[8] As a proxy for the output-gap uncertainty variable σ_t from the model, I will use the OGU index described in Section 2.

The series for the output gap $x_{t,q}$ can be obtained in at least three ways. The Congressional Budget Office publishes a series based on their own formulation, Orphanides (2001, 2003a) uses his own formulation of the real-time output gap based on Council of Economic Advisors (CEA) data, one could simply treat an HP filter series of output over the sample period as potential GDP, or one could use a simpler linear time

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[7] This data is available online at http://research.stlouisfed.org/fred2/.

[8] This data is available online at http://www.phil.frb.org/econ/forecast/greenbookdatasets.html. They currently only go through 1999.

trend forecast.[9] I will use the CBO data for the revised historical output gap in the baseline model, and I will use Orphanides' (2001, 2003a) real-time CEA estimate for the real-time output gap.

5. Estimation and Counterfactuals

The policy rule in equation (7) provides a moment for estimating the parameters of interest by Generalized Method of Moments (GMM):

$$\varepsilon_t = r_t - (1-\rho)\left[rr^* - (\beta - 1)\pi^* + \beta\pi_{t,k} + \gamma x_{t,q}\right] - \rho(L)r_{t-1}, \tag{9}$$

where the error term ε_t is a function of the forecast errors in the two gaps, which are both assumed to be zero. This gives an expected value of zero to the error. Let Z_t be a vector of instruments. The moment condition then becomes:

$$E\left\{r_t - (1-\rho)\left[rr^* - (\beta - 1)\pi^* + \beta\pi_{t,k} + \gamma x_{t,q}\right] - \rho(L)r_{t-1} \middle| Z_t\right\} = 0. \tag{10}$$

GMM estimation of the parameters in (10) comes from minimization of the following criterion function:

$$\min_{\rho,\beta,\pi^*,\gamma} \varepsilon' Z\left(Z'\hat{\Omega}Z\right)^{-1} Z'\varepsilon \tag{11}$$

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[9] The linear time trend might be used instead of the HP filter because the original working paper by Hodrick and Prescott did not begin circulating until 1981. Their paper is now published [Hodrick and Prescott (1997)].

where $\hat{\Omega}$ is the heteroskedasticity and autocorrelation consistent matrix proposed by Newey and West (1987). It should also be noted that either rr^* or π^* is not identified in this estimation. The approach taken by Clarida, et al (2000) is to take the average real interest rate over the sample period as the proxy for rr^*. This then allows estimation of the inflation target π^*.

Clarida, et al (2000) use as instruments in Z_t, lags of federal funds rate, inflation, output gap, commodity price inflation, M2 growth, spread between long-term bond rate and 3-month T-bill.

The baseline (optimal) specification is to estimate Equation (7) by GMM as described above over the period from 1987:3 to 1995:3—the first eight years of Alan Greenspan's tenure as Fed Chairman—using historical revised data. These estimates correspond to Specification (A) in Table 2. The estimates for this optimal baseline rule look very similar to those of Clarida, et al (2000) who use the same methodology.

Table 2: Monetary Policy Rule Estimates (1987:3 to 1995:3)

	Specification			
Parameter	**Baseline (A)**	**OGU-adjusted output gap proxy (B)**	**Unadjusted output gap proxy (C)**	**Steady-state output gap proxy (D)**
β	1.726	1.439	1.467	1.259
	(0.118)	(0.057)	(0.066)	(0.077)
γ	0.516	0.455	0.509	
	(0.126)	(0.053)	(0.041)	
π^*	3.081	2.030	1.726	3.193
	(0.143)	(0.199)	(0.208)	(0.555)
ρ_1	1.042	0.312	0.756	1.166
	(0.121)	(0.114)	(0.041)	(0.088)
ρ_2	-0.533	0.108	-0.162	-0.625
	(0.104)	(0.083)	(0.036)	(0.063)
rr^*	3.046	2.784	2.784	2.784

Data type	revised/historical	real time	real time	real time
Sample size	33	33	33	33
J-statistic	8.113	8.190	7.615	6.980
degrees of freedom	20	20	20	17

Each of the operational rules that uses real-time data—Specifications (B), (C), and (D) in Table 2—will take the following form:

$$(12) \qquad r_t = (1-\rho)\left[rr^* - (\beta - 1)\pi^* + \beta\hat{\pi}_{t,k} + \gamma\hat{x}_{t,q}\right] + \rho(L)r_{t-1} + \varepsilon_t$$

where the only difference from Equation (7) is that $\hat{\pi}_{t,k}$ and $\hat{x}_{t,q}$ are real-time proxies for the inflation gap and output gap, respectively. In each case, the proxy for current inflation is the Fed's Greenbook forecasts published by the Federal Reserve Bank of Philadelphia. The differences among Specifications (B), (C), and (D) come from the proxy for the output gap that is used.

The first proxy for the real-time output gap is the uncertainty-adjusted real-time output gap.

$$(B) \qquad \hat{x}^B_{t,q} = (1-\sigma_t)\breve{x}_t$$

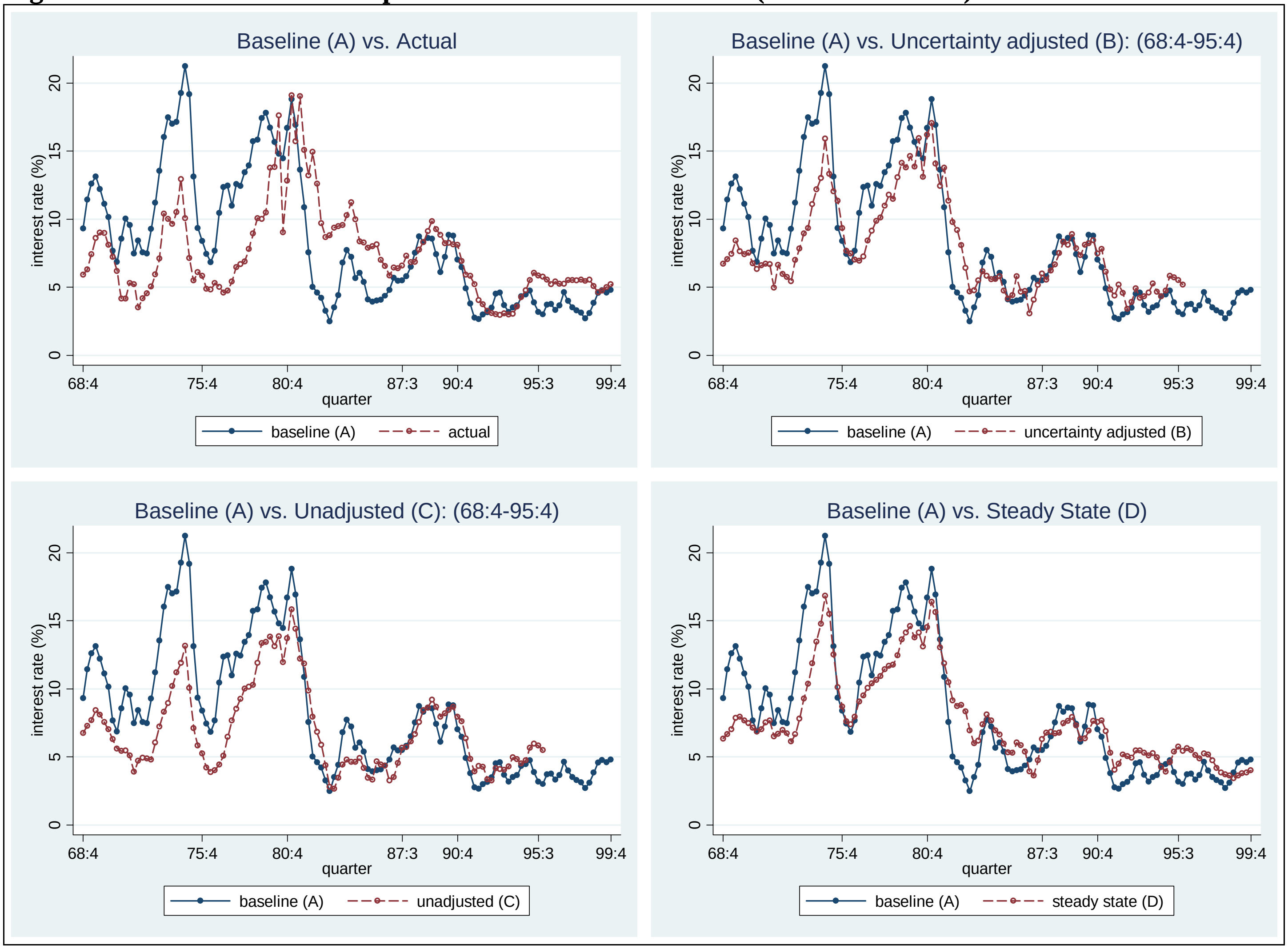
where the variable for the period-*t* output gap uncertainty σ_t is the OGU index described in Section 2, and $\breve{x}_t$ is the real-time CEA output gap as described in Section 4. These estimates are reported in Specification (B) in Table 2.

Specification (C) in Table 2 uses an unadjusted real-time output gap proxy. This equation simply proxies the output gap with the real-time CEA series $\breve{x}_t$ described above.

(C) $$\hat{x}^{C}_{t,q} = \breve{x}_t$$

Lastly, Specification (D) takes the steady state value of the output gap $\bar{x}_t$ as its proxy.

Figure 3: Counterfactual time paths of the federal funds rate (1968:4 to 1999:4)



(D) $$\hat{x}_{t,q}^{D} = \bar{x}_t = 0$$

This specification is equivalent to inflation targeting.

Each of the estimated rules from Table 2, (B) through (D), with its accompanying real-time data proxies, implies a different time path for interest rates. Assuming that the time path of rule (A) is the optimal path, I measure which implied real-time path is closest to (A). Figure 3 shows the actual time path of the federal funds rate along with the implied paths of Specifications (A), (B), (C), and (D). Following Spencer (2004), I use as a measure of proximity to specification (A) the root mean squared error (RMSE). The RMSE is calculated by the following expression:

(13) $$RMSE_{(S)} = \left[\frac{1}{T} \sum_{t=1}^{T} \left(r_t^{(S)} - r_t^{(A)} \right)^2 \right]^{\frac{1}{2}}$$

where specification $S = \{B, C, D, actual\}$ and T is the number of periods in the sample. Table 3, below, gives a comparison across the implied interest rate paths from specifications (B), (C), and (D) of the RMSE distance from the optimal baseline interest rate path from specification (A).

Table 3: RMSE distances from the optimal interest rate path of specification (A)

	Real-time output gap proxy			
	Uncertainty adjusted (B)	**Unadjusted (C)**	**Steady state (D)**	**Actual fed funds rate**
RMSE (1968:4 to 1999:4)	2.745*	3.341*	2.423	4.115

RMSE (1970:1 to 1979:4)	3.698	4.967	3.085	5.769
RMSE (1990:1 to 1999:4)	1.284*	1.227*	1.395	1.485

* This series only goes to 1995:4, which is the end date of the CEA real-time output gap proxy series that I have at this point. I need to extend this series through 1999:4.

6. Conclusion and Extensions

As can be seen from Table 3 and from Figure 3, I need to get the CEA real-time estimates of the output gap from 1996:1 to 1999:4. Once I extend this data, I will be able to completely compare apples to apples in Table 3. But even without the complete data on the real-time output gap, the results here provide some valuable insights.

Although the data are still incomplete, the evidence from Figure 3 and Table 3 suggest that the best monetary policy in the United States might ignore the output gap altogether and implement a policy of inflation targeting. However, it will be important to see what happens to the RMSEs when the OGU-adjusted output gap proxy is used for the last half of the 1990s—a period in which some increasing uncertainty was seen over the first half of the 1990s.

In addition to the estimated monetary policy rules, the OGU index proposed in Section 2 provides a valuable measure of the level of uncertainty in the economy at any given point in time with respect to the output gap. As is shown in Figure 1, it corresponds well to the consensus opinions about historical periods of either relative uncertainty or certainty. Although it is used in this paper as part of a real-time proxy for the output gap, it may have other applications in macroeconomics.

Also, even though Specifications (B) and (C) are still incomplete, the comparison of the interest rate path of optimal Specification (A) to the actual federal funds rate in panel 1 of Figure 3 provides some insight into what was wrong with monetary policy in the 1970s—it was too low. The results here correspond to Clarida, et al (2000) in that I find that the Fed in the 1970s did not respond sufficiently to inflation.

More interesting to me is how closely the interest rate path implied by inflation targeting, Specification (D), mirrors the optimal interest rate path from Specification (A) from 1985 on in panel 4 of Figure 3. The key to this paper will be to see if the uncertainty-adjusted Specification (B) can get closer to (A) than Specification (D). As can already be seen from Table 3, the unadjusted Specification (C) will not beat either of the other two real-time alternatives.

As an extension to this paper, I could check what kind of monetary policy rules are derived from macroeconomic models different from the simple New Keynesian model used here. Being careful about how the theoretical parameter for output-gap uncertainty σ_t fits into the model, I would like to see if there are any other macroeconomic models that I like better and how my results might change.

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