Greenspan and The Greenbook

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ABSTRACT

A vast literature has emerged using Taylor rules to analyze monetary policy. Although very attractive both theoretically and empirically, such rules imply a mechanical response by the policy variable to fundamental ones.

This study looks for empirical evidence of a more sophisticated monetary policy, one which takes into account expected future developments. An important piece of information I use is the Greenbook forecast series, which are calculated by the Federal Reserve Board's Research Department prior to the Board meetings.

Using Greenbook forecasts allows calculation of future inflation shocks as expected by the Fed. These shocks are significant in the estimated Taylor rule, confirming that policymaking is forward-looking.

In addition, using Greenbook forecasts allows one to obtain better real time estimates of the potential output, and thus to obtain a more precise characterization of monetary policy.

Keywords: Monetary policy, Taylor rule, real time data.

JEL classification: E52, E58.

1 Introduction

It seems intuitively clear that policy making should be preemptive and should anticipate future developments. There has been much theoretical discussion recently in the economic literature describing monetary policy as being forward looking. At the same time not much empirical evidence of forward-looking policy has been provided.

Most studies assume that monetary policy rules respond to developments that have already taken place, since they use lagged fundamentals. This is based on the idea that a very high degree of inertia in variables such as inflation and output makes lags powerful predictors of leads. Such policy is however, overly "mechanical"; to paraphrase Vladimir Lenin (1917), it gives the impression that even "a cook can run the Federal Reserve".

In this paper I argue that policy making is indeed forward-looking. Such a statement however, leaves room for various interpretations.

Most of the research in this direction assumes that monetary policy is forward-looking in the sense that it aims at the public's expectations, which in turn, affect contemporaneous fundamentals. Yet such a policy may still be mechanical. Lansing and Trehan (2001), for instance, develop a model where fundamentals are driven both by inertia and expectations, but where the optimal rule is nevertheless lag based, thus assuming a mechanical backward response.

Monetary policy can also be considered forward-looking in the sense that it responds to shocks, of which policy makers have some information. These shocks can be of various natures. They may reflect unusually bad or good harvests, changes in the world price of oil or gold, etc. Finally they may reflect public expectations, even if these expectations are not driven by fundamentals.

Thus, these two types of forward-looking models are not inherently different, but they are not necessarily the same either. In an environment with rational expectations and without private information, these two approaches would depict the same picture. However, if policy makers have access to information which is not readily available to the general public, then responding to public expectations may not prove to be efficient. Romer and Romer (2000) provide an evidence of such asymmetry in information available to public and the Fed.

In this study, I am providing statistical evidence of a policy, which is forward-looking in the sense that it responds to shocks, whether they are expected by the public or not. These shocks are calculated based on the Greenbook forecasts of inflation and output, and thus represent the Fed's expectations. They are significant statistically present in the policy rule, confirming that policy makers take into account future developments, and that policy is more preemptive than a simple response to "inertial" components would suggest.

The gain of using the Greenbook forecasts is twofold. First, it allows testing for the rule's "direction". Second, the use of forecasts allows one to calculate more precisely the real-time estimates of lagged potential output which policy makers had at hand.

Most authors use ex post estimates of output gap, obtained by detrending the revised data for output. Tchaidze (2001) uses a more realistic specification of output gap, which is based on preliminary estimates of actual output and using only its lagged observations for estimating the economy's potential level. This paper constitutes one more step toward an even more realistic analysis by including the Greenbook forecasts into information set based on which output gap estimates are calculated.

The paper contains 4 sections. Section 2 estimates backward-looking rules using different estimates of the lagged output gap, starting with a commonly used specification, which is based on both lags and leads of output, and proceeding to more realistic ones, which are based first on lags only and then on lags and forecasts that reflect additional information policy makers have. Section 3 uses a simple model to derive a forward-looking rule, one which responds to inertial components of inflation and output gap as well as to expected shocks, and then discusses empirical results. Among other results, it argues that the inflation response coefficient is higher than the usually suggested values, and is about 2.5. Section 4 provides some historical evidence justifying the behavior of the Fed in a way suggested by the model. Section 5 concludes.

2 Re-estimating Lag Based Rules

In this section I estimate a backward-looking Taylor rule which responds only to movements in lagged fundamentals. The backward-looking specification of a Taylor rule looks as follows:

$$i_t = C + C_1\pi_{t-1} + C_2 y_{t-1}$$

where i is an overnight interest rate set by the Fed (also known as the Federal Funds Rate), π is inflation, measured as an annual growth of the GNP/GDP deflator[1], and y is the output

[1]Until 1993, GNP rather than GDP was used as a main indicator of national output. This switch is not expected to have any major impact on the results.

gap, measured as a difference between log-output and its trend. The rule is based on lagged fundamentals, as contemporaneous ones have not yet been realized and lagged observations are the most up-to-date pieces of information available to policy makers. All the data are quarterly. The sample[2] runs from 1987:3 to 1994:4.

In sub-section 2.1 I compare different estimates of the output gap trying to achieve the most realistic picture of an environment in which policy makers take decisions, while in sub-section 2.2 I estimate the rule.

2.1 3 Sets of Output Gap Estimates

I use three different sets of estimates of fundamentals. The first may be considered as ex post, the two others as real-time. The main difference between them is the way output gap estimates are constructed.

The very first specification of the rule uses 1999 vintage data for inflation and output levels. Most of these data (particularly its earlier components) have been substantially revised since their initial releases. For this particular specification I use estimates of output gap, which I call "Lags and Leads". I detrend the whole path for log-output (1947:1 – 1999:2) using a Hodrick-Prescott filter.

It is well known that for most of the univariate detrending techniques (linear, quadratic, HP) as well as for multivariate ones, calculating a trend at any point in time t very much depends not only on lagged observations, but also on lead ones. Had the economy evolved

[2] I start my sample in 1987:3 as it is the first quarter of Greenspan's chairmanship. I end my sample in 1994 because Greenbook forecasts for later observations were not available to me (see further).

differently after t, trend estimates would have been different.

Imagine that after a long period of growth, output declines over one or two consecutive periods. At this point, one cannot make a straightforward conclusion – whether a decline is a temporary correction, which will be followed by a further growth, or is the signal of a business cycle's turning point. Only after observing output over several more periods can one tell exactly what is happening, as this then allows for a more precise estimate of the trend at a point of interest t. Orphanides and Van Norden (1999) cite lack of information about an economy's future developments as a main cause of errors in real-time estimates of the gap.

Thus, the second specification of output gap is "Lags Only". For every point in time t, I detrend lagged observations of the output levels, from 1947:1 till $t-1$. Thus, the estimates are obtained using one-sided Hodrick-Prescott filter. Also, the inflation and output data that I use are unrevised, as reported in the Philadelphia Fed's real-time web dataset (for details see Croushore and Stark, 1999). The exclusion of leads of the data and ignoring revisions have a drastic effect on output gap estimates. An error term (defined as the difference between ex post – "Lags and Leads" and real-time – "Lags Only" estimates of output gap) ranges from -1.54 to 3.33, with a mean of 0.53, and a standard deviation of 1.45 (see table 1). Tchaidze (2001) argues that most of these errors should be attributed to the exclusion of leads rather than to revisions.

Although the data released in various statistical bulletins do not suggest much about further developments in the economy, policy makers undoubtedly know more. Even though

	Lags and Leads – Lags Only	**Lags and Leads – Lags and Forecasts**
Mean	0.53	0.24
St.Deviation	1.45	0.87
Max	3.33	2.09
Min	-1.54	-0.97

Table 1: Errors in Real-Time Estimates of Output Gap

they do not observe the leads of output and cannot make correct estimations of the trend based on observed values, they may be observing other signals which indicate approximate values of the trend and the direction which it is going to follow. Although over longer horizons these estimates become less and less precise, policy makers gain additional leverage, as they can influence future developments through the setting of policy variables.

To account for these factors, I construct the third set of estimates called "Lags and Forecasts". At every point in time t, I detrend time series which consists of observed lagged values (from 1947:1 till $t-1$) and the forecasts for the contemporaneous as well as the four following quarters (from t till $t+4$). Detrending such series allows me to construct estimates which are closer to the ones that policy makers used.

To construct forecasts of output, I use forecasts of output growth as reported in the "Current Economic and Financial Conditions" issues, also known as "the Greenbook". The Greenbook is a collection of various data that are prepared by the economists at the Federal Reserve Board, and are presented to the Board of the Governors before their regular meetings (the Board usually meets eight times a year).

For security reasons, the Greenbook data become publicly available with a five-year lag. Note that data are not really forecasts in the sense that they do not reflect the policy that is being implemented but rather assumptions of the economists about future policy and shocks. Obviously, had a different set of assumptions been made, the forecasts would have been different. However, since at the very short horizons, policy has a very small effect if any at all, I can assume that only the forecasts for $t+3$ and $t+4$ are not invariant with respect to the assumptions about the future policy.

As table 1 indicates, the inclusion of forecasts significantly improves real-time gap estimates. Both mean and standard deviation of the error term are about half of what they were before. Maximum and minimum values are much smaller in absolute terms as well. Figure 1 also shows that most of the time the "Lags and Forecasts" estimates lie between the "Lags and Leads" and the "Lags Only" estimates, indicating an obvious improvement in estimation results.

2.2 Estimating the Rule

Since the "Lags and Forecasts" output gap estimates are much closer to the ex post "Lags and Leads" estimates than the estimates which are based on lags only, it should not be surprising that the difference between ex post and real-time estimates of Taylor rule diminishes as well once the "Lags and Forecasts" gap estimates are used rather than the ones based on "Lags Only" (see table 2). Not only is the difference between the values of response coefficient estimates smaller, the difference in fit practically disappears[3].

The results still suggest a very strong inflation response of 2.33, which is higher than the

[3]The differences between estimates are also caused by the revisions. As mentioned earlier, the "Lags and Leads" specification uses revised data, while the other two use unrevised data. Tchaidze (2001) shows that accounting for revisions for this particular sub-sample is an important factor.

	LINFL	LGAP	CNST	$\bar{R}^2$	SSR
Lags and Leads	1.58	1.25	0.32	0.87	19.88
	(0.31)	(0.13)	(1.05)		
Lags and Forecasts	2.33	1.02	-1.39	0.84	24.58
	(0.23)	(0.14)	(0.94)		
Lags Only	2.90	0.83	-2.97	0.75	38.01
	(0.27)	(0.17)	(1.11)		

Table 2: Rules with Various Output Gap Specifications.

values usually suggested (1.4 – 2.0, see Rudebusch, 2000) and a strong output gap response of 1.02 leaning to the right end of the usually suggested range (0.5 – 1.0, see Rudebusch, 2000)

It is important to note that even though fits for the "Lags and Leads" and "Lags and Forecasts" regressions are almost identical, there is a difference in the values of the estimated coefficients. The values for the "Lags and Leads" specification are very similar to the suggested ones[4] of -1.5, 1 and 1. The values for the "Lags and Forecasts" specifications are different.

Testing whether coefficients in the "Lags and Forecasts" specification are equal to the ones suggested by the "Lags and Leads" specification provides the following results: one cannot reject a hypothesis that an output gap coefficient for the "Lags and Forecasts" specification is equal to 1.25, the value suggested by the "Lags and Leads" specification, but one rejects the hypothesis $C_\pi = 1.58$ at a 0.05 level of significance. Likewise one rejects a hypothesis $C = 0.32$, $C_\pi = 1.58$ and $C_y = 1.25$ at 0.05 significance level as well.

[4]The rule suggested by Taylor (1993) originally had an inflation coefficient of 1.5, output gap coefficient of 0.5 and a constant term of 1. Several studies have suggested however a stronger response to output gap (Ball 1999, Williams, 1999).

Thus, even though for all of the parameters confidence intervals[5] in the "Lags and Leads" and "Lags and Forecasts" regressions have a non-empty intersection, the tests indicate that there is a substantial difference between the two, and in particular, that the inflation coefficient is much higher than 1.5.

3 Forward-looking Rules

This section estimates a forward-looking specification of the rule, one which responds to movements in expected rather than lagged variables. Sub-section 3.1 uses a simple model of a closed economy to provide a theoretical basis for such a rule, while sub-section 3.2 discusses results of estimation.

3.1 Theoretical Model

To describe the economy, I use a model which has become a somewhat standard tool for such purposes (see Romer, 2001). The annual model was proposed by Ball (1999) and Svensson (1997). Orphanides (1998b) develops a similar semi-annual model, while Rudebusch and Svensson (1999) derive an analogous model formulated in quarterly terms.

The model consists of the two following equations:

$$\left(\pi_{t+1} - \pi^*\right) = \left(\pi_t - \pi^*\right) + \alpha y_t + \varepsilon_{t+1} \tag{1}$$

$$y_{t+1} = \lambda y_t - \beta \left(r_t - r^*\right) + \eta_{t+1} \tag{2}$$

[5] All the estimations in this paper are being done with an OLS/Newey-West procedure, thus accounting standard errors for possible heteroscedasticity and autocorrelation.

where a period is one year, r_t is a real interest rate set by policy makers, π_t and y_t refer to the newest information available to them before making a decision, and π^* and r^* refer to the respective long-run levels of inflation and real interest rate.

Equation (1) is an accelerationist Phillip's curve. Equation (2) is an IS curve, assuming an inertial output gap, which is affected by a real interest rate r_t. Finally, ε_{t+1} and η_{t+1} are zero mean, normally distributed random variables, reflecting supply and demand shocks.

Note that the model is completely backward-looking, and thus, implicitly assumes adaptive expectations. It is a common observation that alternative frameworks, assuming rational expectations, do not fit observed data as well unless there are some agents that are backward-looking to some degree (e.g. Ball 2000, Fuhrer 1997, Roberts, 1997 and 1998).

The model assumes that policy makers can affect inflation only within two periods, as monetary policy has an effect on output gap with a one period lag, and output gap affects inflation with a one period lag as well. This means that when policy makers are designing monetary policy by setting an instrument variable r_t, they treat expected inflation $E_t\pi_{t+1}$ as given. Furthermore, as equation (2) shows, setting interest rate is tantamount to setting expected output gap – for any given E_ty_{t+1} one can find r_t such that expected output gap next period will be equal to E_ty_{t+1}.

I assume that policy makers are minimizing a weighted sum of inflation and output gap variances. As Romer (2001) shows, such an objective implies a linear response function of the following form

$$E_ty_{t+1} = -qE_t\left(\pi_{t+1} - \pi^*\right) \tag{3}$$

where q is a parameter, determined by the weights that policy makers assign to inflation and output gap variances. Higher q is associated with a higher weight being placed on inflation variance, while lower q is associated with a higher weight being put on output gap variance.

Equation (3) shows that whenever policy makers expect inflation to be above its long-run level, they contract the economy in order to prevent it from overheating. At the same time, whenever inflation is expected to be below its long-run level, they loosen up and push the output above its potential level.

While the previous authors assumed that shocks ε and η are completely unforecastable, I assume that policy makers do have some information about them. In particular, although unconditional expectations $E\varepsilon_{t+1}$ and $E\eta_{t+1}$ are zero, policy makers' expectations $E_t\varepsilon_{t+1}$ and $E_t\eta_{t+1}$ as of time t are not necessarily so.

Substituting equations (1) and (2) into (3), I can solve for the interest rate in terms of lagged output gap and inflation, as well as expected output gap and inflation shocks:

$$\begin{aligned}
\lambda y_t + E_t\eta_{t+1} - \beta\left(r_t - r^*\right) &= -q\left(\pi_t - \pi^* + \alpha y_t + E_t\varepsilon_{t+1}\right) \\
\beta\left(r_t - r^*\right) &= \lambda y_t + E_t\eta_{t+1} + q\left(\pi_t - \pi^*\right) + q\alpha y_t + qE_t\varepsilon_{t+1} \\
r_t &= r^* + C_\pi\left(\pi_t - \pi^*\right) + C_y y_t + C_\pi E_t\varepsilon_{t+1} + \beta^{-1}E_t\eta_{t+1}
\end{aligned}$$

where $C_\pi = q/\beta$ and $C_y = \left(\lambda + q\alpha\right)/\beta$. This formulation suggests that the more anti-inflationary the preferences of policy makers, the more aggressive is the corresponding policy in response to deviations in *both* inflation and output gap lags.

Reformulating the rule in terms of a nominal rather than a real interest rate, results in:

$$i_t = \left(r^* - C_\pi\pi^*\right) + \left(1 + C_\pi\right)\pi_t + C_y y_t + C_\pi E_t\varepsilon_{t+1} + \beta^{-1}E_t\eta_{t+1} \tag{4}$$

Note that the policy makers respond to "inertial" variables – π_t and y_t as well as expected shocks $E_t\varepsilon_{t+1}$ and $E_t\eta_{t+1}$.

Unfortunately, not all of these variables are readily available when it comes to empirical estimations, in particular, ones reflecting expectations. The Greenbook does provide data on output growth and inflation forecasts, and at first glance, these might seem sufficient to solve the problem. However, the issue is more delicate.

Since inflation is predetermined for one period ahead and does not depend on the interest rate, I can use equation (1) by substituting the Greenbook forecasts in place of expected inflation $E_t\pi_{+1}$ and treat residuals as the expected inflation shock $E_t\varepsilon_{+1}$:

$$E_t\pi_{t+1} = \pi_t + \alpha y_t + E_t\varepsilon_{t+1}$$

At the same time, as equation (2) demonstrates, expected output shock $E_t\eta_{+1}$ cannot be recovered, as it depends on the assumed values of the interest rate which are not observed.

As already mentioned, the Greenbook forecasts are calculated *before* the Board makes a decision, and thus are not based on the true value of the policy instrument. They do not reflect implemented policy in the same manner as forecasts produced by the Bank of England or the Bank of Canada do.

The path for the interest rate assumed in these forecasts is suggested by the director of the Research Department (Michael Prell for the period covered). Very often, alternative forecasts are produced as well, and these are sometimes (though not always) included in the Greenbook. Over the course of a forecast exercise, the suggested path may well be revised if the staff (or their models) suggest that the path is unlikely to actually be realized in the economy.

Finally, apart from models, economists also use their own judgement when calculating forecasts, suggesting that these forecasts are highly subjective and do not necessarily reflect the Board's opinions.

As mentioned earlier, the main question of interest in this study is whether the rule is forward-looking – i.e. takes into account expected shocks – or purely mechanical – i.e. simply uses lags of the fundamentals. If these shocks are not directly included among the regressors, such a rule can be mistaken for a mechanical backward-looking one. However, when estimated as such, one implication would be a lower fit and a bigger sum of squared residuals.

Thus, estimating a lag based rule, both with and without inclusion of expected inflation shock, and comparing sums of squared residuals should indeed demonstrate whether "a cook can run the Federal Reserve" or not.

In addition to that, the model implies that the coefficients for lagged inflation and expected inflation shock should satisfy a restriction imposed by equation (4) – the difference between them should be equal to 1. Testing this hypothesis would provide another way of testing whether policy making is forward looking or not.

3.2 Empirical Results

This sub-section presents empirical results. Since the data that I use is quarterly, the notations are slightly different from those in section 3.1. In particular, the newest pieces of information that are observed by policy makers are lagged quarterly inflation π^q_{t-1}, and lagged output gap y^q_{t-1}, measured as in section 2, on the basis of the "Lags and Forecasts" specification. The inflation forecast for one year ahead corresponds to the 3rd horizon forecast $E_t\pi^q_{t+3}$.

I start by calculating expected inflation shock variable $E_t\varepsilon^q_{t+3}$. I estimate the forecast Phillip's curve, analogous to equation (1), but using $E_t\pi^q_{t+3}$ as a dependent variable, and assume that a residual term reflects expectations of the shock, which are not related to developments in lagged fundamentals.

The estimated forecast Phillip's curve looks as follows:

$$E_t\pi^q_{t+3} = \underset{(0.04)}{1.04}\pi^q_{t-1} + \underset{(0.08)}{0.34}y^q_{t-1} \qquad R^2 = 0.72 \tag{5}$$

Note that the coefficient on lagged inflation is very close to 1, and that the coefficient on lagged output gap is 0.34, corresponding to a sacrifice ratio of 3 (output gap of -3 per cent, in absence of shocks, causes a 1 per cent decrease in inflation), which is close to the estimates reported by Mankiw (1997) and Sachs (1985), – 2.8 and 2.9 respectively.

Next, I define $E_t\varepsilon^q_{t+3}$ as the difference between actual forecasts and fitted values based on equation (5):

$$E_t\varepsilon^q_{t+3} = E_t\pi^q_{t+3} - 1.04\pi^q_{t-1} - 0.34y^q_{t-1}$$

Figure 2 demonstrates the magnitude of these shocks. Most of the time, they are small, with a standard deviation of 0.48. There are, however, several points where the expected shock reaches levels of 1 per cent and higher, particularly in the second half of 1987, in 1988.2, and in 1992.2. Those moments will be discussed later on, in section 4.

Estimating backward and forward-looking specifications of the rule produces the following results[6]:

$$i_t = \underset{(0.70)}{-2.03} + \underset{(0.32)}{2.52}\pi^q_{-1} + \underset{(0.28)}{1.04}y^q_{-1} + \underset{(0.29)}{1.25}E_t\varepsilon^q_{+3} \qquad \bar{R}^2 = 0.90; SSR = 14.94$$

$$i_t = \underset{(0.94)}{-1.39} + \underset{(0.23)}{2.33}\pi^q_{-1} + \underset{(0.14)}{1.02}y^q_{-1} \qquad \bar{R}^2 = 0.84; SSR = 24.58$$

Inclusion of the expected inflation shock does improve the results, increasing the fit and lowering the sum of squared residuals. The difference between the coefficients on lagged inflation and expected inflation shock is close to 1, as the model predicts.

The presence of the expected inflation shock in the estimated rule serves as evidence that the Fed's policy is forward-looking, a factor ignored by the traditional Taylor rule. It suggests that instead of responding to events only after they have occurred, the Fed does take into account expected developments – the respective monetary policy is, in fact, designed to preempt rather than just react.

Note that the inflation coefficient is still estimated to be higher than the usually suggested values. In fact, Orphanides (1998a) reports an almost identical coefficient of 2.51 when substituting third quarter horizon inflation and output gap forecasts into the rule.

Estimates of the response parameters can also be used to estimate implied values for the real interest rate and inflation targets. Tchaidze (2001) calculates those according to the following formulas:

$$\widehat{\pi^*} = \frac{r^* - \widehat{C}}{\widehat{C_\pi}} \qquad \widehat{r^*} = \widehat{C} + \widehat{C_\pi}\pi^*$$

[6]Standard errors in the forward-looking specification are calculated according to methodology described in Pagan (1984).

where $\widehat{C}$ and $\widehat{C_\pi}$ are estimates of the constant and the inflation response in correspondence with the Taylor rule.

An assumption about one of the targets allows to calculate the value for the other. Taylor (1993) suggests a 2 per cent target for both variables. Judd and Rudebusch (1998) argue that under certain circumstances, average values may signal policy makers' intentions.

Assuming r^* at a 2.00 level suggests π^* equal to 3.22, while assuming r^* equal to the sample's average[7] of 2.48 suggests π^* of 3.61.

Likewise, assuming π^* to be equal to 2.00 produces r^* of 0.47, which is unrealistically low. At the same time, assuming π^* to be equal to the sample's average of 3.48, results in r^* equal to 2.32.

These calculations suggest that, while assumption of a real interest rate target of $2.0 - 2.3$ per cent may seem sensible, an appropriate value for the inflation would be much higher, at around $3.2 - 3.5$ per cent. That transforms into a $5.2 - 5.8\%$ target for the nominal interest rate, while an average over the sample is 5.97%.

4 Historical Evidence

In this section I present some evidence from various historical records. These are consistent with my estimates of expected shocks and confirm the behavior of the Fed suggested by the results of the previous section.

[7] Average inflation and real interest rate are calculated using revised data.

4.1 Expected Inflation Shocks

Figure 3 shows the actual path for the Federal Funds Rate as well as the fitted values based on the regressions with and without inflation shock included among the regressors. Most of the time, the difference between the two fitted series is not large, although inclusion of the shock seems to bring the series suggested by the rule closer to the actual path.

There are, however, several points where there is a substantial difference (about 1 per cent and even more) between the backward-looking rule and the actual path of the interest rate, whereas the difference between the forward-looking rule and the actual path is much lower. These divergences are caused by the high values of expected inflation shock (see figure 2).

In particular, notice the difference between the two rules in 1987.3 and 1987.4, when the values suggested by the backward rule are 6.07% and 5.49% respectively, corresponding values for the forward-looking rule are 7.03% and 6.76%, and the actual values are 6.84% and 6.92%. Such a difference is caused by a sharp increase in inflationary expectations. The Economic Report of the President (1988 p. 28, 38-39) cites a "potential for greater inflation, associated in part with weakness of the dollar" and in part with the flaring up inflation expectations as the basis for such tightening. The ERP explicitly points out that such policy was desirable in order to avoid inevitable *inflationary expectations*: "With output growth apparently well-maintained and inflation expectations building at times, the Federal Reserve acted to forestall a resurgence of deep-rooted inflation and to retain hard-won gains towards price stability."

Less than a year later, in 1988.2 and 1988.3, there was another peak in expected inflation shock, which causes another divergence between the two rules. This peak reflects upward pressure created by the excessive liquidity pumped into the economy following the October 1987 stock market crash. Later on, the Fed had to reverse its policy and tighten as it became "evident that the stock market crash would not seriously affect spending growth" (ERP, 1989, p.280).

Finally, the last peak in inflation expectations of 1992.2 seems to reflect a producer price inflation rebounce, unusually low throughout 1991 as a result of declining oil prices from their peak during the Gulf conflict in 1990.3 (ERP, 1993 p.47).

4.2 Expected Output Gap Shocks. The Last Piece of a Puzzle?

As figure 3 shows, inclusion of the expected inflation shock does not explain all of the movements of the Federal Funds Rate. In particular, from 1988.3 through 1989.1, the actual monetary policy was much tighter than the rule suggests (the differences are 1.36%, 1.52% and 1.38%), while in 1989.2 and from 1993.2 through 1994.1, the rule prescribes an interest rate about 1% higher than the actual one.

As equation (4) suggests, the difference may be explained by expected output gap shocks. As discussed on page 12, these could not be retrieved from the Greenbook forecasts, and thus are omitted when doing empirical estimations. However, equation (4) suggests that residuals from estimation of the forward-looking specification of the rule (as in section 3), are proportional to the expected output gap shock, as they are given by $\beta^{-1}E_t\eta^q_{+3}$, where β

is a parameter of the IS curve (2) that reflects the sensitivity of output gap with respect to changes in real interest rate. Ball (1999) uses $\beta = 1$ in his calibrations.

I define

$$\beta^{-1} E_t \eta^q_{t+3} = i_t - \left(-2.03 + 2.52\pi^q_{t-1} + 1.04 y^q_{t-1} + 1.25 E_t \varepsilon^q_{t+3}\right)$$

and plot this variable on figure 4.

A much tighter policy than the one suggested by the rule from 1988.3 through 1989.1 is translated into an excess demand, something confirmed by the Economic Report of the President (1989, p.275), which cites unusually rapid growth in producers' investments in durable equipment, and in the dollar's real depreciation, which made US produced goods more competitive on the international markets.

Likewise, figure 4 suggests expected declines in output in 1989.2 and from 1993.2 through 1994.1, for which the rule prescribes an interest rate about 1% higher than the actual one. I could not find, however, explicit confirmations of such beliefs, which means that other factors (such as, for example, exogenous shifts in policy makers' preferences) may have been at play.

5 Conclusion

This study incorporates information contained in the Greenbook forecasts into evaluating the Greenspan era Taylor rule. This is done in two ways.

First, forecasts help to improve the estimates of policy makers' real-time beliefs about the state of the economy. Second, they allow the retrieval of the Fed's expectations concerning future inflationary developments.

These expectations are significantly present in the Taylor rule, which indicates that monetary policy making is not as myopic as might be inferred from a class of simple backward-looking policy rules. Apart from responding to inertial components of fundamentals, such as inflation and output gap, the Federal Reserve takes into account future inflation shocks in a way consistent with the optimal behavior suggested by a simple two-equation model.

Together, these three variables explain about 90 per cent of the movements in the Federal Funds Rate. The remaining 10 per cent may represent expected output gap shocks, which could not be recovered from the Greenbook forecasts.

Finally, this paper confirms the hawkishness of Greenspan's Fed. This is reflected in the inflation response coefficient of 2.52, which is much higher than the usually suggested values.

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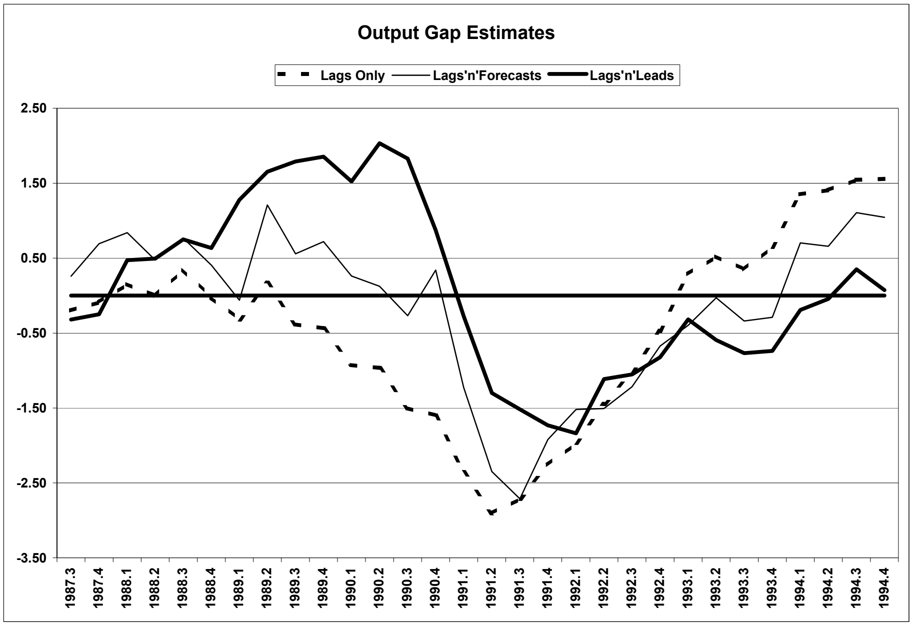

Figure 1: Output Gap Estimates

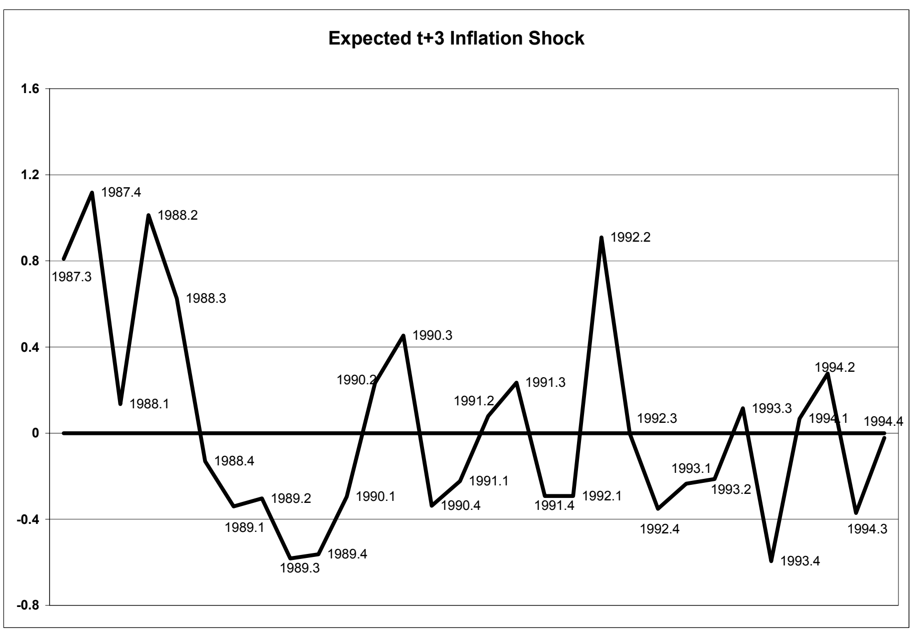

Figure 2: Expected $t + 3$ Inflation Shock as of t

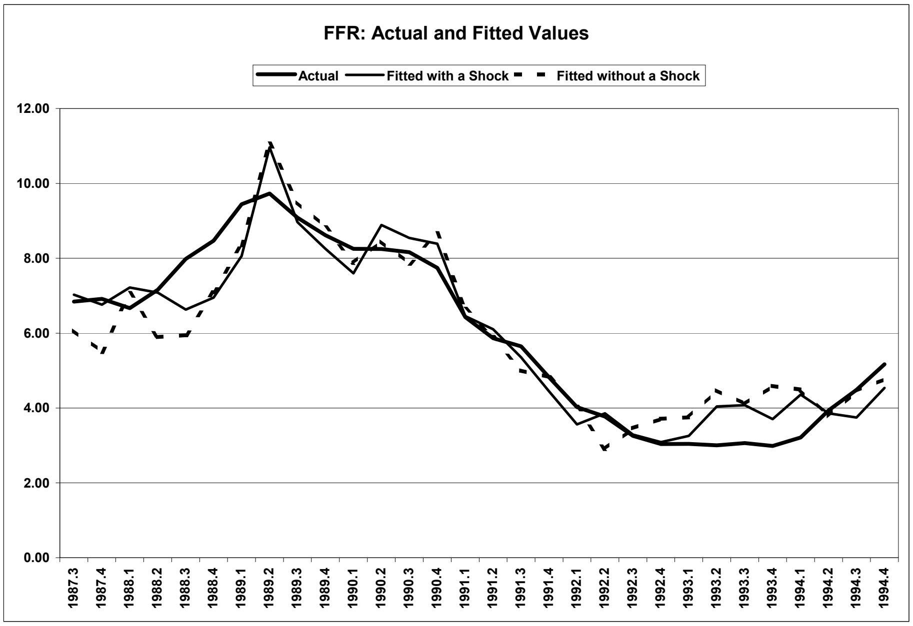

Figure 3: FFR: Actual and Fitted Values

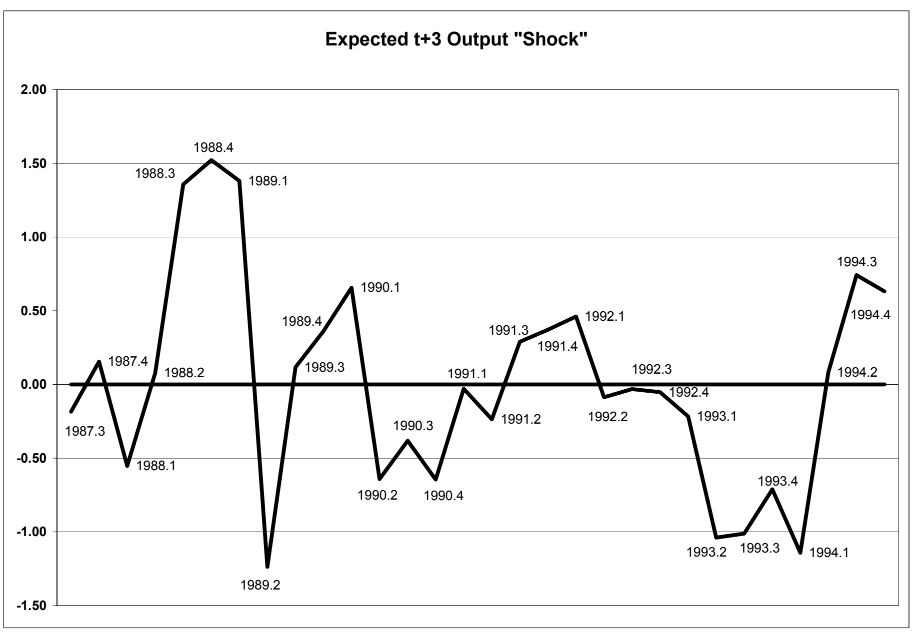

Figure 4: Expected $t + 3$ Output Gap "Shock" as of t