Monetary Policy Inertia: Fact or Fiction?*

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Many interpret estimated monetary policy rules as suggesting that central banks conduct very sluggish partial adjustment of short-term policy interest rates. In contrast, others argue that this appearance of policy inertia is an illusion and simply reflects the spurious omission of important persistent influences on the actual setting of policy. Similarly, the real-world implications of the theoretical arguments for policy inertia are open to debate. However, empirical evidence on policy gradualism obtained by examining expectations of future monetary policy embedded in the term structure of interest rates is definitive and indicates that the actual amount of policy inertia is quite low.

JEL Codes: E44, E52.

1. Introduction

In recent years, there has been a clear shift in the focus of monetary policy research. While a decade or so ago, monetary aggregates were often used to model monetary policy, now the most common representation uses a short-term interest rate as the monetary policy instrument. Indeed, the literature on how central banks manipulate policy interest rates has grown very rapidly.[1] Especially since the introduction of the now-ubiquitous Taylor (1993) rule, many

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[1]For some of the arguments underlying the shift away from monetary aggregates, see Rudebusch and Svensson (2002).

researchers have examined monetary policy rules or reaction functions that relate the policy interest rate to a small set of observables.[2] There has been voluminous research on the optimal design of such policy rules and on the empirical estimation of these rules using historical data. Many important normative and positive issues regarding the form of these rules have been considered—notably, the choice of the relevant argument variables in the rules and the nature of the dynamic adjustment embodied in the rules. This paper will examine the latter issue and broadly characterize the amount of monetary policy inertia or partial adjustment contained in optimal and empirical interest rate rules.

The dynamic adjustment process of monetary policy is a particularly interesting topic because of the lively debate about its nature. However, at the outset, it should be noted that this debate is largely limited to interest rate movements at a quarterly frequency, which is the relevant frequency for the empirical macroeconomic policy rules literature. In contrast, at a higher frequency—daily, weekly, or even monthly—the existence of a *short-run* smoothing of policy rates by central banks is widely acknowledged. Such short-term partial adjustment involves, for example, cutting the policy rate by two 25-basis-point moves in fairly quick succession, rather than reducing the rate just once by 50 basis points.[3] However, short-term partial adjustment *within a quarter* is essentially independent of whether there is monetary policy inertia *over the course of several quarters*, and this latter issue is the one that is relevant for estimated monetary policy rules and is discussed below.[4]

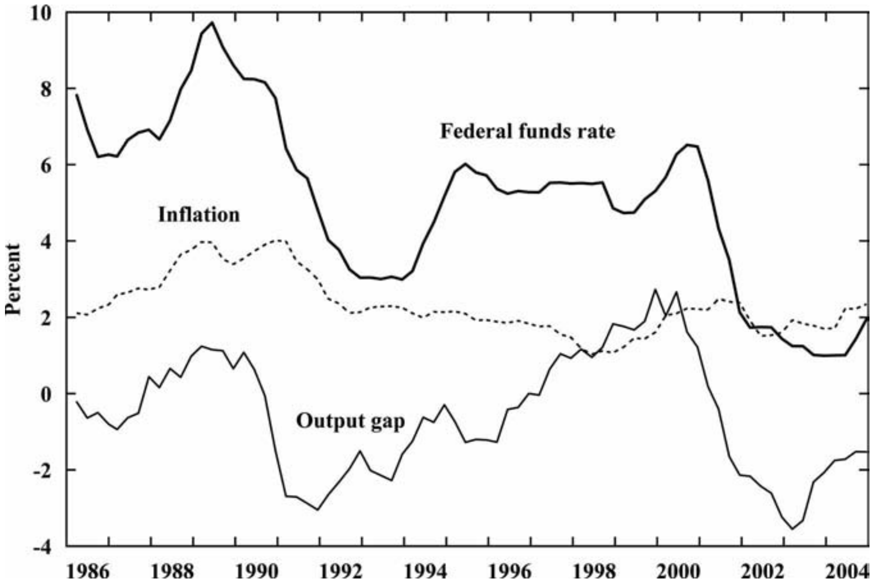
The debate about the dynamic adjustment of central bank policy rates focuses on the persistent quarterly cyclical fluctuations in

[2]See Svensson (2003) for a discussion of targeting rules as an alternative representation.

[3]For example, as described in Rudebusch (1995), central banks tend to adjust their policy interest rates in sequences of relatively small steps with only rare reversals of direction.

[4]Indeed, as described in Rudebusch (2002b), given their disparate time frames, a central bank could conduct short-run partial adjustment without quarterly inertia or vice versa. For example, a central bank could spread a desired change over several quarters but make only one rate adjustment per quarter. Alternatively, it could spread a desired change over a month or two but essentially hit its desired rate on a quarterly average basis. It is this latter scenario that is consistent with the evidence below.

Figure 1. U.S. Economic Data



central bank policy rates—as illustrated in figure 1 for the United States.[5] The dispute is not about whether such slow adjustment exists but about its source. One school of thought, the partial-adjustment view, asserts that the persistence of policy rates reflects an inertia that is *intrinsic* or *endogenous* to the central bank. Under this view, there is a long, intentionally drawn-out adjustment of the policy rate in response to economic news. Such partial adjustment implies that the central bank knowingly distributes desired changes in the policy interest rate over an extended period of time; therefore, the smooth persistent policy rates reflect deliberate "interest rate smoothing" or "partial adjustment" or "gradualism" or "inertia" on the part of the central bank. For example, given typical empirical estimates, if a central bank knew it wanted to increase the policy rate by a percentage point, it would only raise it by about 20 basis

[5]Figure 1 shows the quarterly average federal funds rate as the U.S. monetary policy instrument. Figure 1 also displays two important indicators for policy: the four-quarter percent change in the price index for personal consumption expenditures excluding food and energy, labeled "inflation," and the output gap as estimated by the Congressional Budget Office (CBO).

points in the first three months and by about 60 basis points after one year. That is, there is a very slow convergence of the policy rate to its desired level.

The opposing view to partial adjustment is that the persistence of the policy rate simply reflects the response of the central bank to the slow cyclical fluctuations in the key macroeconomic driving variables of monetary policy, such as inflation and output, which are also illustrated in figure 1 for the United States. In this case, the persistence of the policy rate reflects an inertia that is *extrinsic* or *exogenous* to the central bank. Therefore, from this second perspective, the slow adjustment of the policy rate simply reflects the slow accretion of information relevant to the setting of the policy interest rate by policymakers, who then completely adjust the policy rate fairly promptly—typically within a few months—when confronted with new information.[6]

This disagreement is not just an academic debate about macroeconomic behavior but is highly relevant to the practical conduct of monetary policy. For example, as then–Federal Reserve Governor Larry Meyer noted at the February 1999 Federal Open Market Committee meeting (according to the now-public transcript): "I pay a lot of attention to the policy prescriptions from the Taylor rule. Sometimes the different rules that are in the standard packet yield quite different implications for policy." Dynamic adjustment was a key feature that differentiated the various rules supplied to Larry Meyer and other Federal Reserve governors.[7] Some of the rules assumed significant policy partial adjustment while others did not, and this difference led to alternative policy prescriptions. In particular, the crucial difference between, say, Taylor rules with and without endogenous inertia is evident in the policymaker's reaction to news about inflation and output. For example, when faced with a surprising economic recession or a jump in inflation, the inertial policymaker slowly changes the policy rate, while the non-inertial

[6] This same debate also occurs for other macroeconomic time series. For example, as many have noted, the infrequent adjustment of prices could reflect the inertial nature of price determination—menu costs, etc.—or it could indicate the sluggish economic determinants of completely flexible prices.

[7] This is evident in the now-public "standard packet," namely, the "Financial Indicators" FOMC material dated January 29, 1999.

policymaker responds to the news with immediate and sizable interest rate adjustments. (See the discussion in section 4 below.)

Policymakers themselves appear unclear about the source of the slow adjustment of policy interest rates. For example, Ben Bernanke (2004) was a proponent of the intrinsic view in which the slow adjustment of the policy rate reflects "partial adjustment and monetary policy inertia." In contrast, William Poole (2003) argued that there was no partial adjustment: "In my view of the world, future policy actions are almost entirely contingent on the arrival of new information.... Given information at the time of a meeting, I believe that the standing assumption should be that the policy action at the meeting is expected to position the stance of policy appropriately." A closely related policy debate, described in Rudebusch and Williams (2006), centers on how much information central banks can and should reveal about their future intentions for policy rate changes. Of course, a central bank that follows a partial-adjustment procedure typically will be able to communicate insights about likely future changes in the policy rate—namely, insights about the remaining policy partial adjustment. However, many policymakers vehemently deny that they are in a position to provide guidance about the future path of policy interest rates. As the Governor of the Bank of England (King 2006) recently noted: "The [Bank of England's monetary policy committee] reaches a new judgment each month, made afresh in the light of all the new information about the prospects for inflation. We don't decide in advance. So trying to give direct hints on the path of interest rates over the next few months risks deceiving financial markets into believing there are definite plans for the next few months when no such plans exist."[8]

Still, to be clear, the absence of central bank partial adjustment does not mean that central banks are not trying to influence long-term interest rates. Again, both sides of this debate agree that a change in the central bank policy rate is likely to persist, and both sides agree that such a change in the policy rate is likely to affect expectations of future short-term rates and hence long-term rates

[8]Goodhart (2005), a former member of the Bank of England's monetary policy committee, also relates how a central bank with no intrinsic inertia can still display an ex post track record with long sequences of small interest rate adjustments in the same direction.

as well. In order to influence the long rate, a central bank only must present a path for the policy rate that can shape expected future short rates. The partial-adjustment rule provides one such path, but it is not the only one. As noted by Goodfriend (1991) and Rudebusch (1995), an ex ante constant path, which is what some non-inertial rules approximate, is another obvious choice.

In the next section, in light of the clear theoretical and practical importance of the topic, I review the basic evidence for and against monetary policy inertia. The inertial view appears widely supported by estimated monetary policy rules. When such rules are estimated without policy inertia, the residuals indicate significant, persistent deviations of the rule recommendation from the historical policy rate. With the addition of partial adjustment (in the form of a lagged dependent variable), these deviations are greatly reduced. The alternative view, as noted above, is that the deviations represent persistent influences on central bank behavior that are not captured in a simple Taylor-type rule. These persistent influences may include, for example, responses to financial crises, judgmental adjustments, or differences between real-time and final revised data. Unfortunately, as is well known in econometrics, at least since Griliches (1967), the two dynamic representations of partial adjustment and persistent omitted variables can be very hard to distinguish in simple single-equation regressions. Indeed, this appears to be the case for the monetary policy rule regressions, especially since there is so much uncertainty about the exact arguments of the policy rules.

Therefore, section 3 turns to theory and examines whether a central bank would want to engage in sluggish partial adjustment from the perspective of optimal monetary policy prescriptions. There are three key rationales for inertial behavior, namely, to reduce interest rate volatility, to exploit the expectational channel for monetary policy, and to respond optimally to data and model uncertainty. While there appears to be some validity to each of these rationales, they do not appear to be able to justify the extremely slow monetary policy inertia suggested by the estimated monetary policy rules.

In contrast to the weak and inconclusive single-equation evidence and theoretical rationales in sections 2 and 3, a very powerful set of evidence on monetary policy inertia is introduced in section 4. This evidence is contained in the term structure of interest rates, which can bring a vast amount of information to bear on the appropriate monetary policy rule. Assuming financial market participants understand the policy rule that links short-term interest rates to the realizations of macroeconomic variables, they then will also use that rule in pricing forward interest rates. Accordingly, any deviations between expected future short-term rates and expected rule recommendations based on future macroeconomic conditions will be arbitraged away. Therefore, at any point in time, multiperiod interest rates, which embody expectations of future short rates, will contain much information about the properties of the monetary policy reaction function. Section 4 presents three different ways to use such yield-curve information—predictability regressions, macro-finance system estimates, and event studies based on macroeconomic data surprises. These procedures differ in the amount of economic structure imposed and also operate at three different frequencies—quarterly, monthly, and intraday. The resulting consistent set of results from these diverse methodologies appears to provide decisive evidence against the presence of significant monetary policy inertia.

Finally, section 5 concludes with some suggestions for future research.

2. Gradualism and Inertia in Policy Rules

An inertial view of monetary policy dynamic adjustment implies that the short-term policy rate is changed at a very sluggish pace, so a monetary policy reaction to new economic data is distributed over many quarters. I first clarify policy inertia as a general proposition (or, depending on your perspective, highlight some of the ambiguity involved with any such definition) and then survey some of the relevant empirical work.

2.1 Defining Policy Gradualism and Inertia

It is perhaps useful to discuss in general terms what is meant by the "inertial" and "non-inertial" hypotheses regarding the conduct of policy. In the literature, "inertial" rules follow the standard partial-adjustment form: $i_t = (1-\rho)\hat{\imath}_t + \rho i_{t-1}$, where i_t is the level of the policy interest rate set in quarter t, which is a weighted average of the current desired level, $\hat{\imath}_t$, and last quarter's actual value, i_{t-1}.

Based on historical data, estimates of ρ are often in the range of 0.8, so these empirical rules appear to imply a very slow speed of adjustment—about 20 percent per quarter—of the policy rate to its fundamental determinants. The large coefficient on the lagged dependent variable is widely interpreted as evidence for a "monetary policy inertia" behavior by central banks.[9]

In fact, at a general level, it does not seem that any logical distinction can be drawn between inertial and non-inertial rules as descriptions of policy. For example, by defining an "underlying" desired interest rate level as $\tilde{i}_t = \rho\tilde{i}_{t-1} + (1-\rho)\hat{i}_t$, the above inertial interest rate rule can be rewritten in an ostensibly non-inertial form as $i_t = \tilde{i}_t$.[10] That is, an inertial versus non-inertial designation makes sense only in conjunction with specific assumptions about the arguments of the rule. Of course, there is a natural set of arguments to consider, namely, the standard major macroeconomic data series—especially inflation and output, which are the arguments of the popular Taylor rule. Indeed, the hypothesis examined in this paper is not partial adjustment in all its generality, but partial adjustment toward a target that depends in a straightforward way on inflation and output (as exemplified by the Taylor rule). As described below, this is the case of overwhelming interest in the literature.

Therefore, to make progress, I will limit consideration to rules in which the desired rate is a simple function of a set of standard macroeconomic variables, formally, $\hat{i}_t = \beta' X_t$, where X_t is a vector of the variables influencing policy. The *inertial* rule can then be written as

$$i_t = (1-\rho)\beta' X_t + \rho i_{t-1}. \tag{1}$$

The corresponding *non-inertial* rule is

$$i_t = \beta' X_t. \tag{2}$$

[9]For example, Clarida, Galí, and Gertler (2000, 157–58) describe their U.S. estimates of various partial-adjustment policy rules as follows: "... the estimate of the smoothing parameter ρ is high in all cases, suggesting considerable interest rate inertia: only between 10 and 30 percent of a change in the [desired interest rate] is reflected in the Funds rate within the quarter of the change."

[10]This is just the observational equivalence of the information-smoothing and partial-adjustment models noted by Waud (1968).

The common finding in the empirical literature discussed below is that the inertial rule fits the data better (say, in an R^2 sense) than the non-inertial rule. An alternative view, however, is that the non-inertial rule is not misspecified in terms of dynamics but in terms of arguments, so there is an alternative non-inertial rule that could be formalized as

$$i_t = \beta' X_t + \phi' Z_t, \tag{3}$$

where Z_t is a vector of persistent omitted factors that also influence policy. The rest of this paper discusses the evidence for these varying specifications.

2.2 Gradualism and Inertia in Estimated Policy Rules

The belief in sluggish policy adjustment in the real world is based on estimated policy rules. The most commonly estimated inertial policy rules have been dynamic forms of the Taylor rule. In such rules, the actual interest rate partially adjusts to a desired interest rate that depends on inflation and the output gap; specifically,

$$i_t = (1-\rho)\hat{\imath}_t + \rho i_{t-1} + \xi_t \tag{4}$$

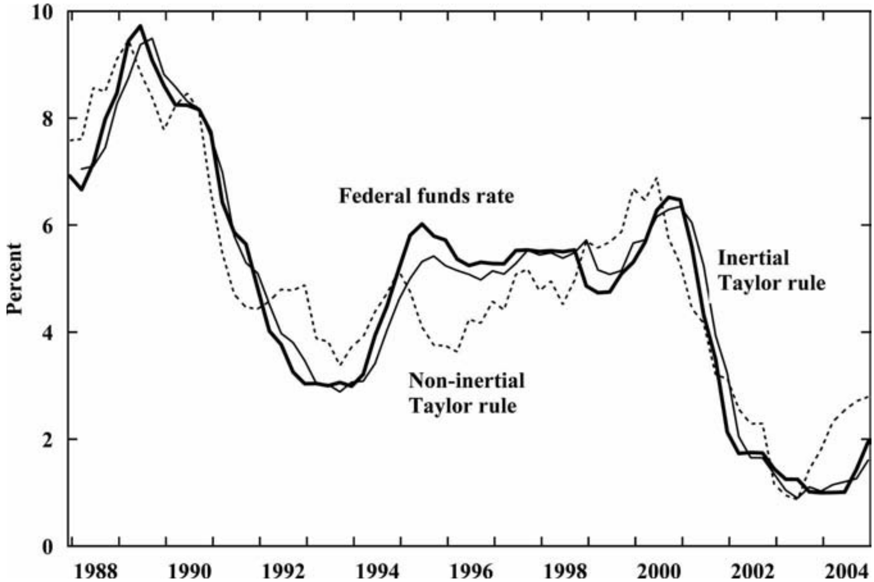
$$\hat{\imath}_t = k + g_\pi \bar{\pi}_t + g_y y_t, \tag{5}$$

where k is a constant incorporating an equilibrium real rate, r^*, and an inflation target, π^*, and g_π and g_y are the central bank response coefficients to (four-quarter) inflation ($\bar{\pi}_t$) and the output gap (y_t).[11]

To provide a benchmark for comparison, first consider an estimated *non-inertial* Taylor rule that assumes $\rho = 0$, as in Taylor (1999) and Yellen (2004). A least-squares regression on U.S. data

[11]The federal funds rate is a quarterly average rate. Inflation is defined using the price index for personal consumption expenditures excluding food and energy (denoted P_t, so $\pi_t = 400(\ln P_t - \ln P_{t-1})$ and $\bar{\pi}_t = \frac{1}{4}\Sigma_{j=0}^{3}\pi_{t-j}$), and the output gap is defined as the percent difference between actual real GDP (Q_t) and potential output (Q_t^*) estimated by the Congressional Budget Office (i.e., $y_t = 100(Q_t - Q_t^*)/Q_t^*$).

Figure 2. Actual and Fitted Federal Funds Rate



from 1987:Q4 to 2004:Q4 yields

$$i_t = \underset{(.28)}{2.04} + \underset{(.09)}{1.39}\, \bar{\pi}_t + \underset{(.06)}{.92}\, y_t + \xi_t^{NI} \equiv \hat{\imath}_t^{NI} + \xi_t^{NI}, \tag{6}$$

$$\sigma_\xi = .97, \quad \bar{R}^2 = .82, \quad DW = .34.$$

The monetary policy response coefficients—namely, $g_\pi = 1.39$ for inflation response and $g_y = 0.92$ for output response—are not too far from the 1.5 and 0.5 that Taylor (1993) originally used. The fitted values from this non-inertial Taylor-rule regression, which will be denoted $\hat{\imath}_t^{NI}$, are shown as the dotted line in figure 2 and show a fairly good fit to the actual funds rate—the thick solid line. However, there are some large persistent deviations between the non-inertial rule and the historical funds rate, especially during 1992, 1993, 1999, and 2004 (when the actual rate was held below the rule) and during 1991, 1995, and 1996 (when the rate was pushed above the rule). As discussed below, the source of these deviations will be a critical element in interpreting the evidence and arguments for and against policy inertia.

A partial-adjustment mechanism is a standard econometric response to such persistent deviations, and a least-squares regression for an inertial policy rule on U.S. data from 1987:Q4 to 2004:Q4 yields

$$i_t = .22\, \hat{\imath}_t^I + \underset{(.04)}{.78}\, i_{t-1} + \xi_t^I, \tag{7}$$

$$\hat{\imath}_t^I = \underset{(.18)}{2.13} + \underset{(.18)}{1.33}\, \bar{\pi}_t + \underset{(.13)}{1.29}\, y_t \tag{8}$$

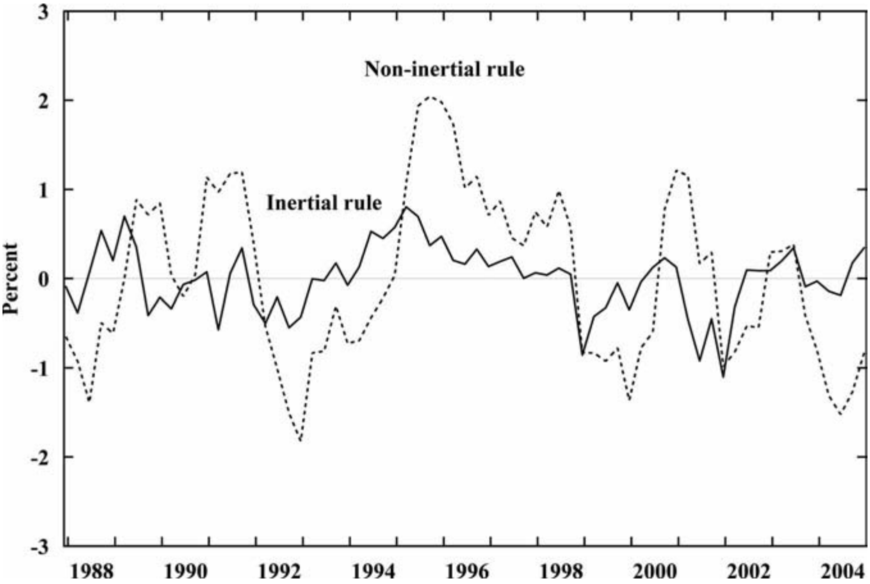
$$\sigma_\xi = .38, \quad \bar{R}^2 = .97.$$

In this regression, the estimated values of the response coefficients are not so different from the non-inertial rule; however, the estimate of the partial-adjustment coefficient ($\hat{\rho} = 0.78$) is economically and statistically significant. Such lagged dependence is an extremely robust empirical result in the literature.[12] Indeed, after taking into account the dynamic adjustment in equation (7), the fitted values in the inertial rule—which are shown as the thin solid line in figure 2—match the historical path of the funds rate much more closely than the non-inertial rule. This difference in fit is also apparent in figure 3, which charts the residuals (ξ_t^I and ξ_t^{NI}) from the inertial and non-inertial rules. The mean absolute residual for the non-inertial rule is .82 percentage point, which is almost three times larger than the .29-percentage-point mean absolute residual for the inertial rule.

The significance of ρ and the dramatic improvement in R^2 have been widely taken to be convincing evidence of monetary policy inertia. However, Rudebusch (2002b) argues that the monetary policy rule estimates are misleading and provide the illusion of monetary policy inertia. In particular, if the desired policy interest rate depends on persistent factors other than the current output and inflation in the Taylor rule, then such a misspecification could result in a spurious finding of partial adjustment. Accordingly, based only on these types of policy rule estimates, it would be very difficult

[12]Similar estimates are discussed by Kozicki (1999) and Rudebusch (2002b) for the United States and by Sauer and Sturm (2003), Gerdesmeier and Roffia (2004), and Castelnuovo (2006) for the euro area.

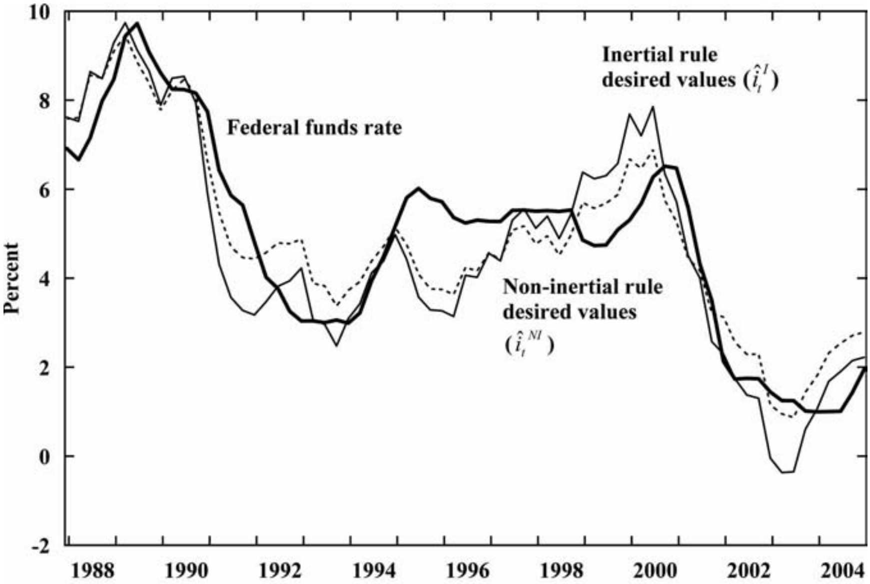
Figure 3. Residuals from Estimated Inertial and Non-Inertial Taylor Rules



to distinguish whether the Federal Reserve's adjustment was sluggish or whether the Federal Reserve generally followed the Taylor rule with no policy inertia but sometimes deviated from the rule for several quarters at a time in response to other factors.

The intuition for this argument is illustrated in figures 4 and 5. Figure 4 displays the actual funds rate (thick solid line) and the "desired" funds rates from the two rules. The non-inertial rule desired rates are the fitted values $\hat{\imath}_t^{NI}$ from equation (6) (shown as the dotted line), and the inertial rule desired values are the $\hat{\imath}_t^{I}$ from equation (8) (shown as the thin solid line). The two desired levels generally move together, so deviations of these desired rates from the actual funds rate are similar across the two rules. Understanding the persistent deviations of the historical interest rate from the two Taylor-rule recommendations is key to interpreting the empirical evidence. Under the monetary policy inertia interpretation, these persistent deviations are the result of sluggish central bank responses to output and inflation gaps; that is, the central bank only gradually adjusts the policy rate to the level it would like to set in the

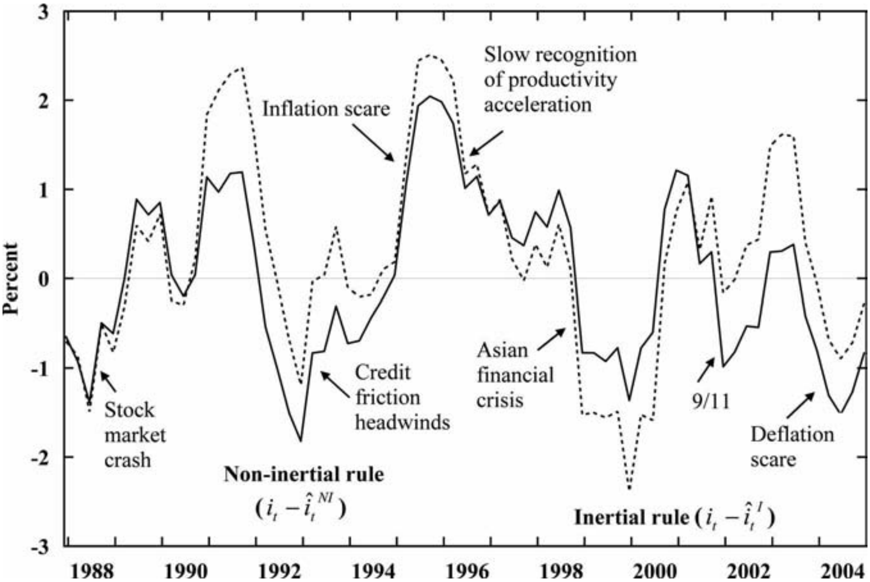
Figure 4. Actual and Desired Federal Funds Rate



absence of some partial-adjustment constraint. However, there are several episodes evident in figure 4 that appear to contradict such an interpretation. For example, at the beginning of 1995, the actual funds rate matched the desired funds rate (as recommended by either rule), but over the rest of that year, the desired funds rate dropped almost 200 basis points, while the actual funds rate jumped 100 basis points. Conversely, after the third quarter of 1998, when the actual rate equaled the desired values, desired rates rose sharply for the next year, while the actual funds rate dropped. Adding a lagged funds rate to the equation will certainly improve the regression fit, but it appears misleading to characterize these episodes as central bank partial adjustment when the actual and desired funds rates moved so dramatically in opposite directions.

The deviations of the two desired funds rate series from the actual funds rate are shown in figure 5 (namely, $i_t - \hat{i}_t^{NI}$ as the solid line and $i_t - \hat{i}_t^{I}$ as the dotted line). Instead of a partial-adjustment explanation for these deviations, an alternative explanation is that the deviations in figure 5 reflect the incomplete description of monetary policy

Figure 5. Deviations of Actual Funds Rate from Desired Rule Value



provided by the Taylor rule. Indeed, it is fairly straightforward to provide a basic narrative history of a variety of macroeconomic developments that the Federal Reserve appeared to respond to in addition to estimates of the contemporaneous output gap and inflation. Some of these developments are indicated in figure 5.[13] For example, relative to what the Taylor rule would have recommended, a response to the stock market crash may have lowered rates in 1988, and inflation worries—at least, as discussed below, when judged using real-time data—appear to have led to a greater-than-Taylor-rule tightening during 1989. The deviations toward looser monetary policy in 1992 and 1993 have been interpreted as the Federal Reserve's response to disruptions in the flow of credit or severe financial headwinds.[14]

[13]The original analysis of Taylor (1993) put forward a description of monetary policy that did not involve interest rate smoothing or partial adjustment. Taylor argued that deviations from the rule during various episodes were an appropriate response to special circumstances. Kozicki (1999) also makes this point.

[14]As then–Chairman of the Board of Governors Alan Greenspan testified to Congress on June 22, 1994: "Households and businesses became much more reluctant to borrow and spend and lenders to extend credit—a phenomenon often

An inflation scare at the end of 1994—evidenced by a rapid rise in long-term interest rates—preceded a sustained period of tight policy. Another factor that emerged during this period was the remarkable increase in the growth rate of productivity and potential output. At the time, most economists didn't recognize these changes and hence overestimated the degree of utilization in labor and product markets, which likely was reflected in tighter policy. In 1998 and 1999, a worldwide financial crisis following the Russian default and devaluation appears to have played a role in lowering rates.[15] Similarly, there was a rapid easing in response to events of September 11, 2001. Finally, 2003 and 2004 were dominated by fears of deflation, which would likely be reflected in lower rates than a simple Taylor rule would recommend, given potential concerns at the zero lower bound for the policy rate (as discussed in McGough, Rudebusch, and Williams 2005).

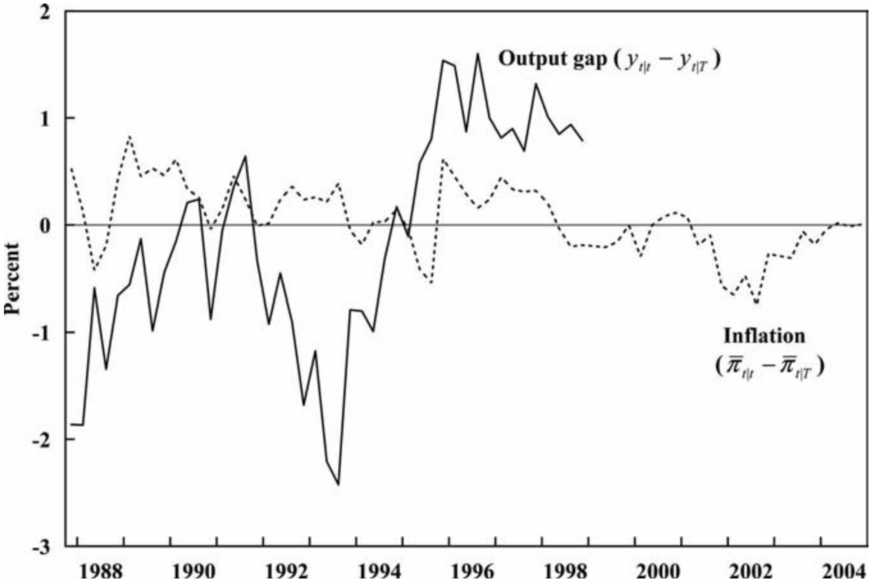
This narrative suggests that some Taylor-rule residuals reflect differences between policy judgments made with real-time data and Taylor-rule estimations conducted with final revised data—a topic that deserves special attention (see Rudebusch 1998, 2001, 2002a, 2002b, and Orphanides 2001, 2003). Figure 6 provides some evidence on the importance of these effects in the United States by showing the difference between real-time and current estimates of the output gap, which is denoted $y_{t|t} - y_{t|T}$, and the difference between real-time and current estimates of inflation, which is denoted $\bar{\pi}_{t|t} - \bar{\pi}_{t|T}$.[16]

referred to as the 'credit crunch.' In an endeavor to defuse these financial strains, we moved short-term rates lower in a long series of steps that ended in the late summer of 1992, and we held them at unusually low levels through the end of 1993—both absolutely and, importantly, relative to inflation."

[15] Federal Reserve Governor Larry Meyer (1999, 7) had this explanation for the easing of policy during late 1998: "There are three developments, each of which, I believe, contributed to this decline in the funds rate relative to Taylor Rule prescription. The first event was the dramatic financial market turbulence, following the Russian default and devaluation. The decline in the federal funds rate was, in my view, appropriate to offset the sharp deterioration in financial market conditions, including wider private risk spreads, evidence of tighter underwriting and loan terms at banks, and sharply reduced liquidity in financial markets."

[16] The output-gap series is Federal Reserve Board staff's real-time estimate—kindly supplied by David Small from the FOMC Secretariat—minus the current (as of 2005) CBO output-gap estimate. The inflation series is the real-time four-quarter GDP deflator inflation rate—obtained from the Federal Reserve Bank of Philadelphia real-time data website—minus the current release.

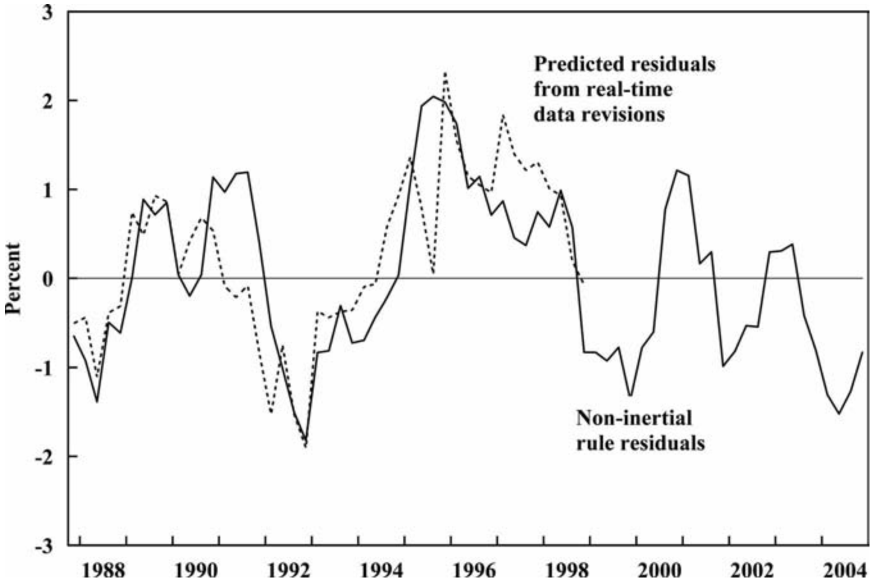
Figure 6. Differences between Real-Time and 2005 Data Vintages



(The output-gap revisions end in 1998 because of data confidentiality.) For example, figure 6 shows that in real time, the output gap from 1996 through 1998 was estimated to be about a percentage point higher than the current estimate (because the estimated level of potential output was lower in real time). This underestimation of the degree of macroeconomic slack would be reflected in higher interest rates in real time than a Taylor rule estimated with current data would recommend. Similarly, during 1989, inflation was thought to be running about half of a percentage point faster than current estimates would indicate, so the actual policy rate would likely be higher than the final-data rule would recommend.

It is possible to provide a rough indication of the importance of the data revisions in accounting for the Taylor-rule residuals. The predicted Taylor-rule residuals based on the real-time to final-data revisions can be constructed under the assumption that the Federal Reserve followed the estimated non-inertial rule (6) in real time. Specifically, if the Federal Reserve used the estimated non-inertial

Figure 7. Matching Non-Inertial Rule Residuals with Real-Time Data Revisions



Taylor-rule coefficients to conduct policy, so $i_t = 2.04 + 1.39\bar{\pi}_{t|t} + .92y_{t|t}$, then the predicted residuals in equation (6) would equal $1.39(\bar{\pi}_{t|t} - \bar{\pi}_{t|T}) + .92(y_{t|t} - y_{t|T})$. These constructed residuals predicted by the data revisions are shown in figure 7, along with the non-inertial rule residuals from equation (6). The fairly close correlation between the predicted residuals from real-time data revisions and the actual residuals from the estimated non-inertial rule suggests that a substantial amount of the deviations of the actual rate from the rule estimated with the current vintage of data can be accounted for by the reactions to real-time data and not to central bank partial adjustment.[17]

[17]Lansing (2002) provides a careful simulation study that demonstrates the potential effectiveness of such real-time output-gap errors to account for spurious evidence of policy inertia. Also, see Mehra (2002) and Apel and Jansson (2005) for the United States and Sauer and Sturm (2003) for the euro area. In addition, given the large policy rule inflation response coefficient, inflation data revisions should not be ignored.

However, while real-time data revisions are undoubtedly part of the story, it is unlikely, as suggested in figure 5, that the Federal Reserve follows a Taylor rule in real time. Instead, like other central banks, it reacts in a less-simplistic fashion to a wide variety of macroeconomic developments; that is, the alternative to partial adjustment is the misspecification of the Taylor rule. This omitted-variables view of the non-inertial Taylor-rule residuals is supported by much contemporaneous press coverage and the narrative policy record. Still, it would be more satisfying to be able to provide econometric evidence distinguishing between the partial-adjustment and omitted-variables interpretations of the policy rule estimates.

Unfortunately, Rudebusch (2002b) argues that conclusive evidence from simple policy rule estimates on the extent of inertia is inherently difficult to obtain. For example, suppose that the non-inertial rule deviations, which presumably represent various persistent factors—credit crunches, financial crises, etc.—that a central bank might respond to, could be modeled as a simple first-order autoregressive process. Then, instead of the inertial model of central bank behavior in equations (4) and (5), the representation of policy would be the serially correlated shock model:

$$i_t = k + g_\pi \bar{\pi}_t + g_y y_t + \xi_t \tag{9}$$

$$\xi_t = \rho^e \xi_{t-1} + \omega_t. \tag{10}$$

The salient question is whether it is possible to distinguish between model (4) and (5) and model (9) and (10). Rudebusch (2002b) estimates a single equation that nests the inertial and serially correlated shocks rules and finds that the evidence distinguishing these two rules appears fragile to even modest changes in the sample period. His argument draws on a large literature in econometrics showing that estimates of partial-adjustment models commonly indicate an unrealistically slow adjustment—whether applied to inventory behavior (Blinder 1986) or money demand (Goodfriend 1985).[18] In particular, a standard policy rule with slow partial adjustment

[18]There is a large literature that argues that partial-adjustment models are difficult to identify and estimate empirically in the presence of serially correlated shocks (e.g., Griliches 1967; Hall and Rosanna 1991; and McManus, Nankervis, and Savin 1994).

and no serial correlation in the errors will be difficult to distinguish empirically from a policy rule that has immediate policy adjustment but highly serially correlated shocks. The choice between these two dynamic structures, which depends crucially on separating the influences of contemporaneous and lagged regressors, is especially difficult to untangle for empirical monetary policy rules for several reasons (also see Carare and Tchaidze 2005). First, the arguments of the rules—four-quarter inflation and the output gap—are highly serially correlated, so distinguishing the effect of, say, $\bar{\pi}_t$ from $\bar{\pi}_{t-1}$ is not easy. Second, the arguments of the rules are not exogenous. Third, only short data samples of plausibly consistent rule behavior are available with a limited amount of business-cycle variation in output and inflation. Fourth, there is some uncertainty about the appropriate arguments of the historical policy rule. Finally, as noted above, the actual interest rates are set on the basis of real-time data on output and inflation, which can also make it difficult to determine the correct dynamics.

There have been several interesting extensions of the analysis in Rudebusch (2002b). English, Nelson, and Sack (2003) and Gerlach-Kristen (2004b) provide two slightly different tests of the inertial and serially correlated shock interpretations that, unlike in Rudebusch (2002b), allow for both partial adjustment and serially correlated shocks to be jointly present. These authors find evidence that both features are significant elements in the data; therefore, the standard policy rule estimates in (7) and (8) are omitting important persistent factors (similar results for the euro area are provided by Castelnuovo 2006). However, considerable uncertainty remains, as illustrated by the insightful small-sample calculations conducted by English, Nelson, and Sack (2003). They investigate how much of the deviations of the actual rate from the desired rate (the $i_t - \hat{\imath}_t^I$ in figure 5) can be accounted for by partial adjustment. They find that a 95 percent confidence interval stretches from 8 percent to 88 percent; therefore, in the context of a single-equation regression, it is difficult to ascertain how economically important partial adjustment is for the policy rule. In addition, this wide range of uncertainty is only for a particular rule specification and estimation sample, so it ignores the broader uncertainty noted above.

Furthermore, the assumption that the persistent omitted variable is an AR(1) appears to be a gross simplification that may bias the results and boost the evidence for partial adjustment. Indeed, the narrative history summarized in figure 5 suggests a more-subtle reaction function than can be captured by equations (9) and (10). A few have tried to augment the estimated Taylor rule with other variables in order to capture directly the omitted persistent influences on policy that spuriously induce the appearance of policy inertia. For example, Gerlach-Kristen (2004b) and Driffill et al. (2006) find evidence that proxies for financial stability concerns, such as a private-public credit spread, have explanatory power in the Taylor rule. Also, expectations appear to play an important role in tempering the policy response to current readings on output and inflation, and Mehra (2002) suggests that expectations of future inflation—and, in particular, inflation scares in the bond market—are an important consideration for policy, which—when omitted—will appear as policy inertia. Finally, as shown by Trehan and Wu (2006), ignoring a true time-varying equilibrium real rate (r_t^*) can lead to finding policy inertia when there is really none.[19] Overall, however, the literature on augmenting the Taylor rule with the important determinants of policy other than current output and inflation appears to be incomplete at best.

3. Rationales for Sluggish Adjustment by Central Banks

The discussion above indicates that, given the distinct possibility of omitted persistent variables from the monetary policy rules, the usual single-equation evidence from estimated policy reaction functions is inconclusive regarding the empirical importance of policy inertia. In this section, I take a different tack and examine the normative case for interest rate smoothing. Presumably, if theory can provide a fairly compelling rationale for the existence of inertia as a feature of optimal monetary policy, then the case for real-world partial adjustment would be strengthened. Therefore, in this section, I consider the empirical relevance of the three most important

[19] In Europe, Gerlach and Schnabel (2000) find that a Taylor rule fits well without partial adjustment but with dummies for the period 1992:Q3–1993:Q3 to control for intra-European exchange market pressures. Gerlach-Kristen (2004a) finds that the long rate is significant in a euro-area Taylor rule, while Gerdesmeier and Roffia (2004) recommend inclusion of a money growth gap.

explanations for why central banks might find partial adjustment attractive.

3.1 Gradualism and Volatility Reduction

One consequence of policy inertia is to produce interest rates that are less volatile than would be suggested by the determinants of policy. As the speed of adjustment coefficient ρ increases, the variances of the level and changes in the policy instrument decline. Therefore, an obvious rationale for policy gradualism would be some desire on the part of the central bank to reduce the volatility in interest rates and, more generally, in asset prices. Such a desire can be modeled directly in the central bank's loss function, and then, together with a model of the economy, the optimal ρ coefficient can be calculated for an optimal simple Taylor rule (as in, for example, Rudebusch and Svensson 1999). If the optimal monetary policy partial-adjustment coefficient matched the high empirical estimates of ρ, then those estimates would have some greater credence.

The most common way to model a desire for smooth interest rates is to specify a loss function in which the central bank minimizes a weighted sum of the squared inflation gap, the squared output gap, and changes in the policy rate (see Clarida, Galí, and Gertler 1999 and Rudebusch and Svensson 1999):

$$L_t = 1/2\left[(\bar{\pi}_t - \pi^*)^2 + \lambda y_t^2 + \nu_{\Delta i}(\Delta i_t)^2\right], \tag{11}$$

where $\Delta i_t = i_t - i_{t-1}$. The parameters $\lambda \geq 0$ and $\nu_{\Delta i} \geq 0$ are the relative weights on output and interest rate stabilization with respect to inflation stabilization. The intertemporal loss function in quarter t is the discounted sum of the expected future per-quarter losses,

$$E_t \sum_{\tau=0}^{\infty} \delta^\tau L_{t+\tau}, \tag{12}$$

with a discount factor δ $(0 < \delta < 1)$. For $\delta = 1$, this loss function can be represented by the unconditional mean of the period loss function (Rudebusch and Svensson 1999)

$$E[L_t] = \text{Var}[\bar{\pi}_t - \pi^*] + \lambda \text{Var}[y_t] + \nu_{\Delta i}\text{Var}[\Delta i_t], \tag{13}$$

which equals the weighted sum of the unconditional variances of the three goal variables and is the standard loss function in the literature.[20]

The presence of an interest rate smoothing motive in the loss function has some superficial plausibility, especially in light of the literature that analyzes changes in policy interest rates on a day-by-day basis. In the United States (e.g., Goodfriend 1991 and Rudebusch 1995) and many other countries (e.g., Goodhart 1997 and Lowe and Ellis 1997), central banks generally make changes in the policy rate at discrete intervals and in discrete amounts. Rudebusch (1995, 264), for example, describes a short-term interest rate smoothing in which the Federal Reserve adjusts interest rates "...in limited amounts ... over the course of several weeks with gradual increases or decreases (but not both)...." This smoothing likely reflects various institutional rigidities, such as a fixed monthly meeting schedule and perhaps certain sociological and political influences.[21] However, as noted in the introduction, short-term partial adjustment within a quarter is essentially independent of whether there is monetary policy inertia over the course of several quarters, and it is this latter issue that is relevant for empirical monetary policy rules. Indeed, if the underlying rationale for reducing interest rate volatility is to reduce instability in financial markets (as described by, for example, Goodfriend 1991, Rudebusch 1995, Cukierman 1996, and Lowe and Ellis 1997), then not wanting to move the policy rate by 50 basis points on a particular day is very different from not wanting to move it by 50 basis points on a quarterly average basis.

This issue is highlighted in trying to specify the weight $\nu_{\Delta i}$ on quarterly interest rate volatility relative to the variability of the output and inflation gaps. If λ and $\nu_{\Delta i}$ are both set equal to 1,

[20] However, the choice of δ is not innocuous. As shown in Dennis (2006), greater discounting may lead to less concern about the future and less interest rate smoothing.

[21] At a single meeting, large interest rate changes may be difficult to achieve politically because of the decision-making process (e.g., Goodhart 1997) or because such changes may be taken as an adverse signal of inconsistency and incompetence (e.g., Goodhart 1999). Indeed, many have noted an "aversion to reversals" in which raising (or lowering) the policy rate at one meeting precludes a lowering (raising) at the next. Again, it appears unlikely that such a meeting-by-meeting aversion would lead to quarterly inertia.

then the loss function equally penalizes a 1 percent output gap, a 1-percentage-point inflation gap, and a 1-percentage-point quarterly change in the funds rate. This penalty on interest rate volatility appears to be implausibly high, given the overwhelming emphasis among central banks on the first two objectives relative to the third (e.g., the "dual mandate" in the United States). Indeed, in practice, central banks have at times implemented large changes in policy rates, which contradicts the notion of a significant penalty. Perhaps the most extreme example occurred in September 1992, when the Swedish central bank raised its policy rate from 20 percent to 500 percent in one week in an attempt to maintain a fixed exchange rate. Also, during the 1979–82 monetary experiment, the United States had much greater interest rate volatility, which did not appear to impose, on its own, large costs. In the academic literature, $\nu_{\Delta i}$ is often set equal to 0.5 or 0.1. These loss functions equally penalize a 1 percent output gap, a 1-percentage-point inflation gap, and a 1.41- or 3.16-percentage-point quarterly change in the funds rate. Such weights still seem at the high end of the plausible range of penalties to reduce volatility, especially in a world with a wide variety of financial market instruments that allow for hedging against interest rate volatility.

Finally, I should note that even the specification of the interest rate smoothing objective in the loss function is unclear. Svensson (2003) notes that if the motive in reducing interest rate volatility is to avoid financial instability, then the loss function should be specified to minimize the *surprise* in the policy rate:

$$E[L_t] = \text{Var}[\bar{\pi}_t - \pi^*] + \lambda \text{Var}[y_t] + \nu_{Ei} \text{Var}[E_{t-1}[i_t] - i_t], \quad (14)$$

where $\nu_{Ei} \geq 0$ is the relative weight on policy rate surprises. A third specification, advocated by Woodford (1999), penalizes the variability in the *level* of the policy rate:

$$E[L_t] = \text{Var}[\bar{\pi}_t - \pi^*] + \lambda \text{Var}[y_t] + \nu_i \text{Var}[i_t - r^* - \pi^*], \quad (15)$$

where $\nu_i \geq 0$ is the weight on deviations of the nominal rate from a neutral level.[22]

[22]Woodford (1999, 2003) argues that smaller interest rate fluctuations reduce the likelihood of reaching the zero bound on nominal interest rates and the

On its own, motivating a large partial-adjustment coefficient through a central bank loss-function desire for interest rate smoothing appears unrealistic (e.g., Svensson 2003). This is particularly true in a model with no explicit forward-looking expectational terms, as in Rudebusch and Svensson (1999), where an optimal ρ in a dynamic Taylor rule of greater than .2 or .3 is difficult to obtain. However, results can be very different in forward-looking models, which are considered in the next subsection.

3.2 Central Bank Inertia as a Lever on Expectations

The most passionate advocates for optimal monetary policy partial adjustment base their case on the ability of such inertia to allow the central bank to influence the current state of the economy by promising future actions; that is, sluggish adjustment can be a lever to help move and manage expectations. In particular, partial adjustment can be optimal if the private sector is forward looking and the monetary policymaker is credibly committed to a gradual policy rule (see Levin, Wieland, and Williams 1999; Rotemberg and Woodford 1999; Woodford 1999, 2003; and Sack and Wieland 2000). In such a situation, the small inertial changes in the policy interest rate that are expected in the future can have a large effect on current supply and demand and can help the central bank control macroeconomic fluctuations.[23]

This argument can be elucidated and assessed within a simple expectational model. Rudebusch (2002b, 2005) describes an

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associated adverse effects on macroeconomic stability; however, with a properly specified model, such concerns should be captured in the output and inflation stabilization concerns in the loss function. Woodford (2003) also tries to motivate this specification of the loss function by appealing to the transactions frictions underlying money demand (so-called shoe-leather costs).

[23]This argument can be thought of as a special case of the more general rationale that i_{t-1} is likely an important state variable given the dynamic structure of the economy, so the optimal instrument rule would include a response to it (e.g., Rudebusch and Svensson 1999). However, it should be noted that Woodford considers fully optimal policy, not an optimal simple rule of the form (1) and (2). Persistence of optimal policy under commitment arises because of the response of policy to previous promises through the lagged Lagrange multipliers (Dennis 2005). Some might interpret these lagged Lagrange multipliers as the unobserved persistent factors omitted from the simple policy rules.

empirical version of the New Keynesian model[24] suitable for quarterly data, where inflation and output are determined by future expectations and lags on the past:

$$\pi_t = \mu_\pi E_{t-1}\bar{\pi}_{t+3} + (1-\mu_\pi)\Sigma_{j=1}^{4}\alpha_{\pi j}\pi_{t-j} + \alpha_y y_{t-1} + \varepsilon_t, \quad (16)$$

$$y_t = \mu_y E_{t-1}y_{t+1} + (1-\mu_y)\Sigma_{j=1}^{2}\beta_{yj}y_{t-j} - \beta_r(r_{t-1} - r^*) + \eta_t, \quad (17)$$

where $E_{t-1}\bar{\pi}_{t+3}$ represents the expectation of average inflation over the next year and $E_{t-1}y_{t+1}$ represents the expectation of period $t+1$ output conditional on a time $t-1$ information set. The real rate relevant for output, r_{t-1}, is defined as a weighted combination of an ex ante one-year rate and an ex post one-year rate:

$$r_{t-1} = \mu_r(E_{t-1}\bar{\imath}_{t+3} - E_{t-1}\bar{\pi}_{t+4}) + (1-\mu_r)(\bar{\imath}_{t-1} - \bar{\pi}_{t-1}), \quad (18)$$

where $\bar{\imath}_t$ is a four-quarter average of past interest rates, i.e., $\bar{\imath}_t = \frac{1}{4}\Sigma_{j=0}^{3} i_{t-j}$.

This model allows consideration of a wide range of explicit forward-looking behavior. At one extreme, the model with μ_π, μ_y, and μ_r set equal to zero matches the completely adaptive expectations model of Rudebusch and Svensson (1999) and Rudebusch (2001), which has had some success in approximating the time-series data in the manner of a small estimated vector autoregression (VAR) (see Estrella and Fuhrer 2002; Fuhrer and Rudebusch 2004). However, estimated forward-looking models also have had some success in fitting the data, as in Rotemberg and Woodford (1999) and Fuhrer (2000). The analysis below takes an eclectic view and conditions on a wide range of possible values for μ_π, μ_y, and μ_r.[25]

Table 1 summarizes the optimal amount of monetary policy inertia for various models and loss functions. The table displays the lag coefficients ρ from the *optimal* versions of the inertial Taylor rule in equations (4) and (5) across models with a range of forward-looking behavior and using the three different loss functions in

[24]Much of the appeal of the New Keynesian model lies in its foundations in a dynamic general equilibrium model with nominal price rigidities; see Walsh (2003) and Woodford (2003).

[25]In contrast, there is less contention regarding the values of the other parameters in the model, and these are set equal to the values given in table 1 of Rudebusch (2002b).

Table 1. Partial-Adjustment Coefficients for Optimal Inertial Taylor Rules

Model			**Optimal ρ for Different Loss Functions**					
μ_r	μ_π	μ_y	$\nu_{\Delta i} = .1$	$\nu_{\Delta i} = .5$	$\nu_{Ei} = .1$	$\nu_{Ei} = .5$	$\nu_i = .1$	$\nu_i = .5$
.0	.0	.0	−.12	.19	−.04	.34	−.57	−.51
.3	.3	.3	.18	.37	.27	.48	−.27	−.12
.5	.5	.5	.64	.70	.63	.68	.70	.80
.8	.8	.8	.90	.94	.90	.92	.93	.96
.0	.0	.5	.03	.17	.05	.26	−.34	−.23
.0	.5	.0	−.12	.16	−.04	.31	−.54	−.44
.5	.0	.0	.49	.61	.49	.67	.28	.30

Notes: The optimal lag coefficients for an inertial Taylor rule are reported for each of seven parameterizations of the model, which have varying μ_π, μ_y, and μ_r weights on expectational terms, and for six variations of the loss function. The loss functions have equal weight on output and inflation volatility ($\lambda = 1$) but a stronger or weaker interest rate smoothing motive—which may take the form of minimizing $\nu_{\Delta i}\text{Var}[\Delta i_t]$, $\nu_{Ei}\text{Var}[E_{t-1}[i_t] - i_t]$, or $\nu_i\text{Var}[i_t - r^* - \pi^*]$. The associated optimal g_π and g_y are not reported.

equations (13), (14), and (15). For each loss function, the weight on the interest rate smoothing ($\nu_{\Delta i}$, ν_{Ei}, or ν_i) is set equal to .5 or .1, while $\lambda = 1$.[26] Clearly in table 1, a large range of optimal lag coefficients—between –.6 and 1.0—can be rationalized for some combination of model and loss function. Most interesting, however, is how the expectational channel can magnify even a small cost of interest rate fluctuations in the central bank loss function to produce a sizable partial-adjustment coefficient in the policy rule. Also, note that the degree of optimal monetary policy inertia varies most strongly with the value of μ_r, which determines the degree to which interest rate expectations are forward looking. Such variation is consistent with the interpretation of Woodford (1999, 2003) and Levin,

[26]The results in table 1 are obtained by numerically minimizing the loss function over the parameters g_π, g_y, and ρ in the model. The results are obtained using the “AIM” algorithm (Anderson and Moore 1985), available at www.federalreserve.gov/pubs/oss/oss4/aimindex.html.

Wieland, and Williams (1999) that policy inertia is optimal when it alters expectations of future interest rates that are also important determinants of current demand.

While an expectational channel for optimal monetary policy inertia is valid in principle, it seems unlikely that such a channel is responsible for empirical monetary policy inertia, because its underlying assumption of a fully credible policy rule seems so unlikely historically. That is, even if economic agents were sufficiently forward looking (which is a separate, unresolved issue), the monetary policy rule must also be assumed to be perfectly credible, so agents know the rule and correctly assume that it will be followed.[27] This seems an unlikely description even for the relatively homogeneous 1987–2004 U.S. sample period underlying the above inertial policy rule estimates. In practice, the Federal Reserve may exhibit some transparency, but it does not appear to have a commitment technology.[28]

3.3 Uncertainty and Partial Adjustment

Uncertainty is the third general rationale often used to motivate optimal monetary policy inertia. The intuition appears clear: uncertainty breeds caution, and caution suggests a gradual adjustment of the policy rate. As noted by Bernanke (2004), "Because policymakers cannot be sure about the underlying structure of the economy or the effects that their actions will have on economic outcomes, and because new information about the economic situation arrives continually, the case for policymakers to move slowly and cautiously when changing rates seems intuitive." However, the implication that greater uncertainty produces greater inertia is not a general theoretical result, and the empirical evidence for this proposition appears weak as well.

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[27]Still, this rationale may be a fruitful area for further research, particularly in examining cases, as in Kara (2003), of partial credibility and an intermediate amount of inertia.

[28]Informally, note that the Federal Reserve does not seem to have the requisite control over forward interest rates (as evidenced most recently by central banks' consternation regarding the "conundrum" of low long-term bond yields described in Rudebusch, Swanson, and Wu 2006). A formal commitment counterfactual is given in Dennis (2005).

Because economic data can be quite noisy, policymakers inevitably operate with imperfect knowledge about the current state of the economy. In addition, it may be the case that the noisier the economic data are, the less aggressive policymakers should be in responding to current readings on the economy (Rudebusch 2001; Orphanides 2003).[29] However, in empirical models, as noted by Rudebusch (2001), any such inducement toward timidity (that is, a low g_π and g_y) appears fairly modest and does not necessarily translate into greater sluggishness (that is, a high ρ).

Uncertainty about the model provides another rationale for caution. Indeed, ever since the classic Brainard (1967) analysis, uncertainty about the quantitative impact of policy and the dynamics of the economy has been widely cited as a rationale for damped policy action. However, in the general case, as Chow (1975, chap. 10) makes clear, *almost nothing can be said even qualitatively* about how the optimal rule under model uncertainty changes relative to the optimal rule under certainty. For example, the optimal policy response parameters are not necessarily reduced in the presence of uncertainty about several parameters. Thus, quantitative answers are required. Rudebusch (2001) provides some simple but instructive evidence that suggests that parameter uncertainty is not responsible for policy inertia. The policymaker is assumed to face an economy like (13), (14), and (15) *on average* (with μ_π, μ_y, and μ_r set equal to zero), but in any given quarter, the coefficients may take on a random value. These parameter shifts occur every quarter or every few years. The policymaker has to choose the g_π, g_y, and ρ parameters of the inertial Taylor rule (1) and (2), so that the loss function (10) is minimized. After allowing for uncertainty about all of the coefficients of the model, the optimal partial-adjustment coefficient actually falls a bit.[30]

[29]The general certainty-equivalence guideline is that optimal policy requires the same response under both partial and full information about the state of the economy. However, as discussed in Rudebusch (2001), the use of simple rules and inefficient output-gap estimates are two relevant exceptions for this analysis.

[30]This conclusion accords with much research on parameter uncertainty. Notably, in Estrella and Mishkin (1999), Peersman and Smets (1999), Shuetrim and Thompson (1999), and Tetlow and von zur Muehlen (2001), there is no significant attenuation of the rule parameters. Some attenuation is found in Salmon and Martin (1999), Söderström (1999), and Sack (2000).

Overall, although perhaps intuitive, the argument that uncertainty could account for the very gradual persistence in the data remains unproven.

4. Term-Structure Evidence on Inertial Policy Rules

To summarize the discussion so far, the single-equation estimation of policy rules has yielded inconclusive results regarding the existence of policy inertia, and the theoretical case for substantial interest rate smoothing appears unconvincing as well. To make some progress, this section turns to a vast and rich set of information about central bank reaction functions: the yield curve of interest rates. The yield curve contains such information because if financial market participants understand the policy rule that links short-term interest rates to the realizations of macroeconomic variables, then they will also use that rule in forming expectations of future short-term interest rates, which will be priced into long-term bonds.[31] In particular, any deviations from the policy rule embedded in expected future short-term rates and expected macroeconomic conditions would be arbitraged away. Therefore, at any point in time, multiperiod interest rates, which embody expectations of future short rates, contain much information about the properties of the reaction function (also see Ang, Dong, and Piazzesi 2005). In this section, I outline three different methods by which this information can be extracted to inform the debate on policy inertia. These methods differ primarily by the amount of economic structure imposed and by the frequency of data employed.[32]

[31] Note that the assumption is not one of credibility and commitment as in subsection 4.2 but one of transparency and learnability.

[32] For example, the three methodologies below use three different treatments of interest rate risk premiums. In the first one, a time-varying term premium is modeled in a simple ad hoc empirical fashion. In the second, a theoretical no-arbitrage consistency is enforced between the underlying factor dynamics and the term premium. In the final one, the term premium is assumed constant (i.e., the expectations hypothesis is assumed) over short thirty-minute windows.

4.1 Interest Rate Predictability at a Quarterly Frequency

Policy inertia has important implications for interest rate forecastability: in brief, the greater the delayed adjustment of the policy rate in reaction to current information, the greater the amount of forecastable future variation. Intuitively, if the funds rate typically is adjusted 20 percent toward its desired target in a given quarter, then the remaining 80 percent of the adjustment should be expected to occur in future quarters. Furthermore, assuming financial markets understand the inertial nature of monetary policy, they should anticipate the future partial adjustment of the funds rate and incorporate it into the pricing of longer-term maturities.

Rudebusch (2002b) shows that this general intuition is true in a wide variety of macroeconomic models. The amount of such forecastable variation in interest rates can be measured via a standard term-structure regression at a quarterly frequency such as

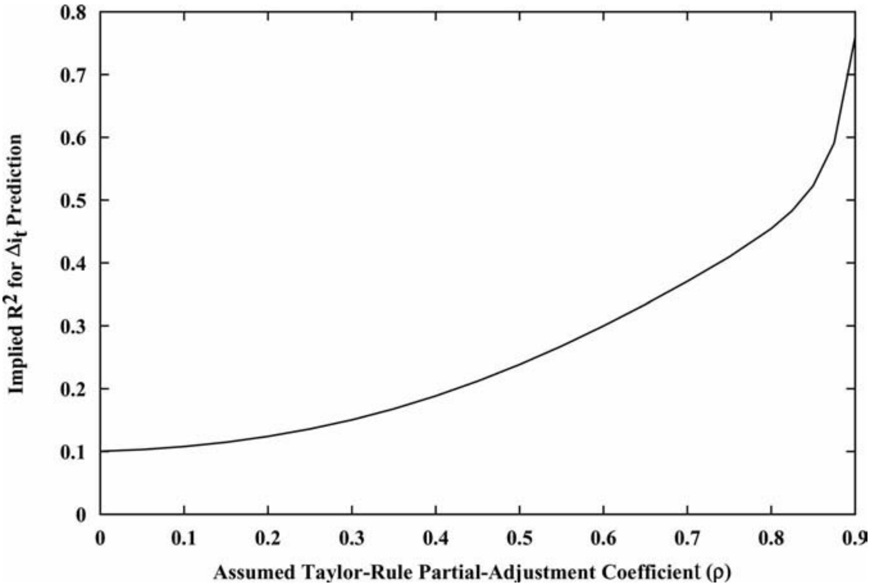
$$\Delta i_t = \delta + \gamma E_{t-2}(\Delta i_t) + \psi_t. \tag{19}$$

This equation regresses the realized change in the policy rate in quarter t (i.e., $\Delta i_t = i_t - i_{t-1}$) on the change that was expected two quarters earlier at the end of period $t-2$. Under rational expectations, this interest rate forecasting regression would yield in the limit an estimate of $\hat{\delta} = 0$ and $\hat{\gamma} = 1$. However, for assessing the forecastable variation in the interest rate and hence the degree of monetary policy inertia, the statistic of particular interest is the R^2 of this regression, which provides a natural measure of forecastability.

The theoretical relationship between the forecastable variation in the interest rate, as measured by the R^2 of the above prediction equation, and quarterly policy inertia, as measured by the ρ in the Taylor rule (1) and (2), is illustrated in figure 8. This figure graphs the implied (population) value of the R^2 of the regression (19) as a function of ρ for a representative case of the model described in section 3, namely, with $\mu_\pi = .3$, $\mu_r = .5$, and $\mu_y = 0$.[33] Note

[33] Also, g_π and g_y are set equal to 1.5 and 0.8, respectively. As in table 1, the unique stationary rational expectations solution for each specified policy rule and model is solved via AIM (see Anderson and Moore 1985 and Levin, Wieland, and Williams 1999). The reduced-form representation of the saddle-point solution is computed, the unconditional variance-covariance matrix of the

Figure 8. Implications for Interest Rate Forecastability from Policy Inertia



that even for the non-inertial policy rules, there is some predictable future movement in interest rates (with $R^2 = .10$ when $\rho = 0$), since there are predictable changes two quarters ahead in the output gap and in the four-quarter inflation rate, which partly determine future changes in interest rates. Even though the output gap and inflation are highly persistent in levels, the associated slow mean reversion implies only a modest predictability of future quarterly *changes* in these series and the desired funds rate. However, as ρ increases, the amount of predictable variation in Δi_{t+2} also increases, with an R^2 value of .45 at $\rho = 0.8$.

Rudebusch (2002b) shows that this theoretical relationship between partial adjustment and predictability is robust across a wide variety of models (and for forecast-based policy rules as well). This relationship can be empirically assessed by examining the extent of

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model variables and the term spreads is obtained analytically, and the term-structure regression asymptotic R^2 is calculated using the appropriate variances and covariances.

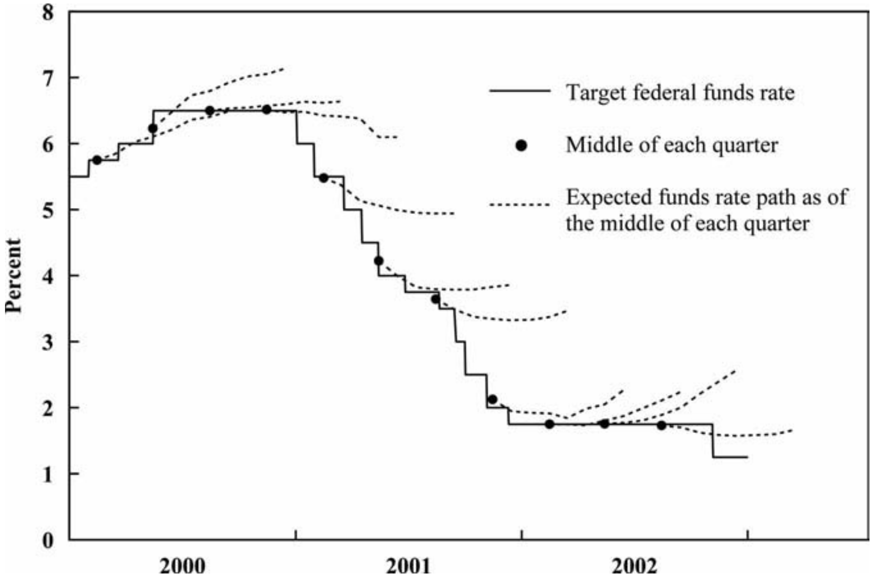
forecastable future movements in the policy interest rate in the data. Specifically, if policy is highly inertial, as the single-equation reaction functions suggest, then financial markets should anticipate the future partial adjustment of the funds rate. In that case, a regression of actual changes in the funds rate on predicted changes embedded in the yield curve should provide a good explanatory fit and a fairly high R^2. In fact, researchers have found the opposite. They have estimated a variety of interest rate forecasting regressions and, using financial market expectations, have found little predictive information at quarterly frequencies with R^2s very close to zero.[34] For example, Rudebusch (2002b) shows that eurodollar futures from 1988 to 2000 have very little ability to predict the quarterly change in the funds rate two quarters ahead. The R^2 of such a regression is .11, which from figure 8 suggests that ρ is probably close to zero.[35]

This lack of predictive ability is well illustrated by the most recent episode of monetary policy *easing*. Figure 9 gives the actual target federal funds rate and various expected funds rate paths as of the middle of each quarter based on federal funds futures. Under quarterly policy inertia, the long sequence of target changes in the same direction in 2001 would be viewed as a set of gradual partial adjustments to a low desired rate. However, although the funds rate gradually fell in 2001, market participants actually anticipated few of these declines at a six- to nine-month horizon, as they would have if policy inertia were in place. Instead, markets assumed at each point in time that the Federal Reserve had adjusted the funds rate down to just about where it wanted the funds rate to remain based on current information available. Under this interpretation, the long sequence of declines is the result of a series of fairly prompt responses to new information that turned progressively more pessimistic. That is, the

[34]See, for example, Mankiw and Miron (1986) and Rudebusch (1995).

[35]Rudebusch (2002b) used a variety of structural models to show that the large estimated lag coefficients in the empirical inertial policy rules provided were inconsistent with the very low interest rate forecastability in the term structure of interest rates and that rules with highly serially correlated errors do not imply such forecastability. Söderlind, Söderström, and Vredin (2005) examine the former issue using a VAR model and survey data on macroeconomic forecasts and find evidence inconsistent with the standard inertial Taylor rule. In contrast, in a highly forward-looking empirical model, Berkelmans (2006) argues that a very inertial policy rule could be consistent with the interest rate predictability evidence.

Figure 9. Actual and Expected Federal Funds Rate

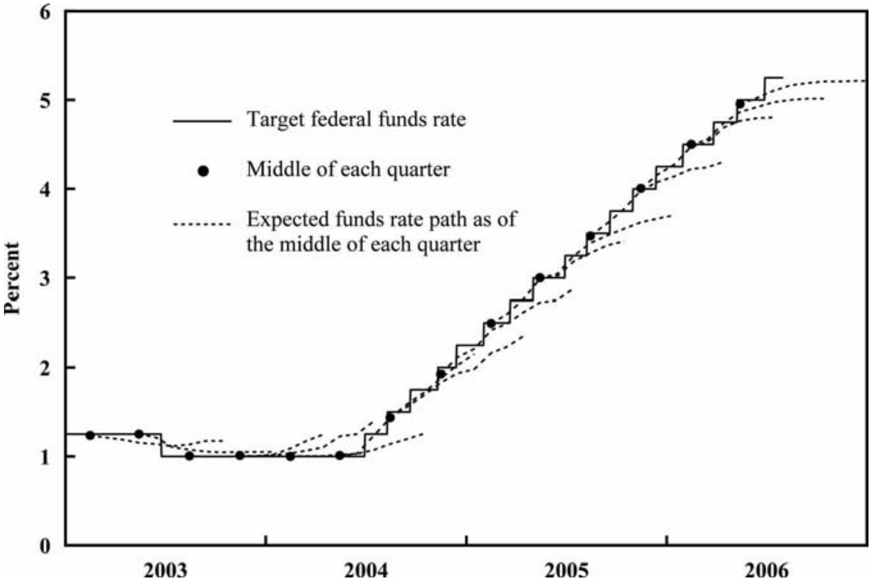


presence of quarterly partial adjustment or policy inertia is contradicted by the lack of forecastability of changes in the funds rate.

The latest episode of monetary policy *tightening* in the United States may at first glance seem to offer more support for gradualism and predictability in interest rates. During this episode, the FOMC raised the target federal funds rate by 25 basis points at each of the seventeen FOMC meetings that occurred during the two years from June 2004 through June 2006. Of course, the mere fact that the Federal Reserve engaged in a long series of interest rate increases is not informative regarding quarterly monetary policy inertia. Such persistent cyclical movements could reflect persistent changes in the determinants of policy rather than the gradual adjustment of the Federal Reserve to those determinants.[36] However, as described in

[36]Occasionally, the argument is made that long sequences of interest rate increases and decreases necessarily imply that changes in interest rates are predictable. This is the perennial argument of chartists and would suggest, for example, that equity prices, the dollar exchange rate, and commodity prices are all forecastable. Also, see the discussion in Goodhart (2005).

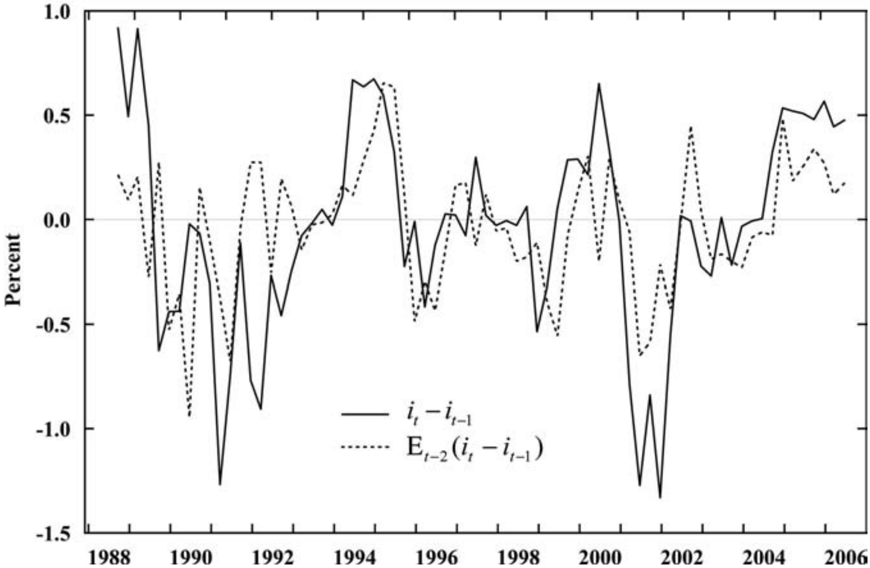
Figure 10. Actual and Expected Federal Funds Rate



Rudebusch and Williams (2006), this latest episode was unprecedented in that the FOMC provided direct verbal signals about future policy rate changes. Starting in May 2004, the FOMC introduced the following language into its public statement: "The Committee believes that policy accommodation can be removed at a pace that is likely to be measured." This was a direct, though not unambiguous, indication that the FOMC anticipated that the policy interest rate could be gradually increased, and it was replaced in December 2005 by "some further policy firming is likely to be needed," and in January 2006 by "further policy firming may be needed."

These verbal signals of future policy intentions would seem likely to boost the predictability of interest rates, and, to a large extent, this appears to have occurred but—importantly—largely at very short horizons. This effect can be discerned in figure 10, which gives the actual target federal funds rate and various expected funds rate paths as of the middle of each quarter based on federal funds futures from 2003 to 2006. It is apparent that many of the expected interest rate paths are remarkably well aligned with the actual path for the first three or four months into the future; however, after about four

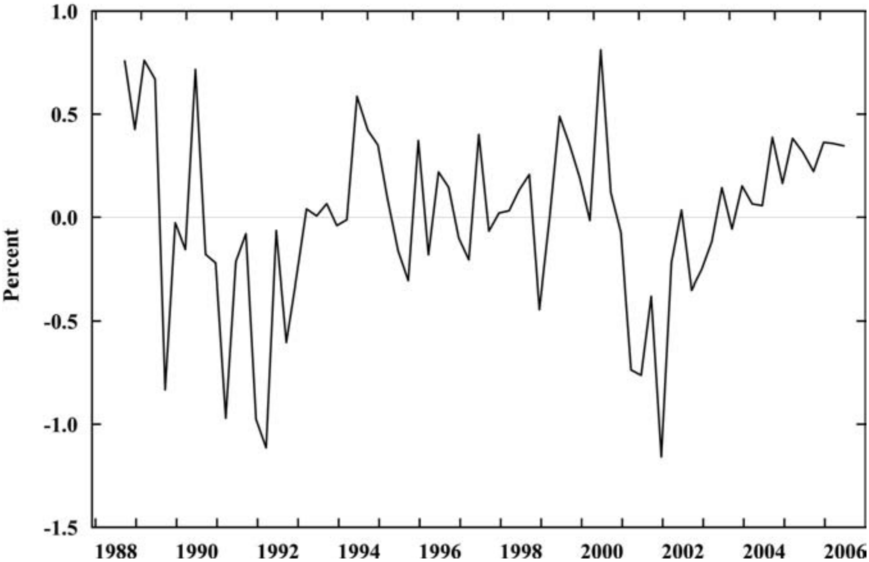
Figure 11. Actual and Expected Change in the Funds Rate



months, financial markets consistently underestimated the extent of the future tightening. That is, markets expected an even more gradual pace for the policy tightening than actually occurred. This is not too surprising, since FOMC members made it clear that future policy depended importantly on how the economic data unfolded in real time, and during much of this episode the economic recovery was not viewed as well established. For example, as the then–Vice Chairman of the Board of Governors noted (Ferguson 2004): "I believe it to be very important that the FOMC not go on a forced march to some point estimate of the equilibrium real federal funds rate. In my judgment, we should remove the current degree of accommodation at a pace that is importantly determined by incoming data and a changed outlook."

With respect to the forecasting regression (19), which is crucial for judging the extent of quarterly policy inertia, figure 11 displays the regression data, Δi_t and $E_{t-2}(\Delta i_t)$, updated through 2006:Q2. From this perspective, the past few years do not look that unusual. Indeed, the residuals from the forecasting regression, ψ_t, are plotted

Figure 12. Residuals from Funds Rate Forecast Regression



in figure 12, and the last two years of the sample are not notable for exhibiting extreme accuracy. Therefore, it appears that the recent tightening episode was an example of short-run smoothing of policy rates in the United States but is not inconsistent with the view that policymakers engage in a limited amount of quarterly policy inertia.

4.2 Term-Structure Model Estimation at a Monthly Frequency

While the evidence in section 4.1 on the predictability of interest rates is quite intuitive, it is somewhat indirect; that is, the absence of policy inertia is inferred from the lack of interest rate predictability evident in financial markets. More-direct estimates of the degree of interest rate smoothing would perhaps be more compelling, and this section considers direct estimates of ρ. However, these estimates of ρ differ from the single-equation ones given in section 2 because they are obtained in a complete system that combines key macroeconomic equations and information from the yield curve. The particular structure employed is from Rudebusch and Wu (2006). Their analysis uses monthly data to formally estimate a model that combines a fairly standard macroeconomic model with an off-the-shelf, no-arbitrage finance representation from the empirical bond-pricing literature. Again, it is the incorporation of yield-curve information that allows precise inference about the absence of monetary policy inertia.

Almost all movements in the yield curve can be captured in a no-arbitrage framework in which yields are linear functions of a few unobservable or latent factors (e.g., Duffie and Kan 1996; Dai and Singleton 2000). The Rudebusch-Wu macrofinance model employs such a framework: specifically, it features a constant factor volatility with state-dependent risk pricing of volatility, which implies conditionally heteroskedastic risk premiums. The one-month short rate is the sum of a constant and two unobserved term-structure factors,

$$i_t = \delta_0 + L_t^m + S_t^m, \tag{20}$$

where L_t^m and S_t^m are termed level and slope factors. The dynamics of these latent factors are given by

$$L_t^m = \rho_L L_{t-1}^m + (1-\rho_L)\pi_t + \varepsilon_{L,t} \tag{21}$$

$$S_t^m = \rho_S S_{t-1}^m + (1-\rho_S)\big[g_y y_t + g_\pi(\pi_t - L_t^m)\big] + u_{S,t} \tag{22}$$

$$u_{S,t} = \rho_u u_{S,t-1} + \varepsilon_{S,t}, \tag{23}$$

where π_t and y_t are inflation and the output gap.[37] These equations can be given a Taylor-rule interpretation, with the factor L_t^m interpreted as the inflation rate targeted by the central bank, as perceived by private agents. Private agents slowly modify their views about L_t^m as actual inflation changes, so L_t^m is associated with an interim or medium-term inflation target (as in Bomfim and Rudebusch 2000) with associated underlying inflation expectations over the next two to five years. The slope factor S_t^m captures the central bank's dual mandate to stabilize the real economy and keep inflation close to its target level. In addition, the dynamics of S_t^m allow for both partial adjustment and serially correlated shocks. If $\rho_u = 0$, the dynamics of S_t^m arise from monetary policy partial adjustment, as in an inertial Taylor rule. Conversely, if $\rho_S = 0$, the dynamics reflect the Federal Reserve's reaction to autocorrelated information or events not

[37] In this substitution with monthly data, π_t is the twelve-month inflation rate and y_t is capacity utilization.

captured by output and inflation, as in the Taylor rule with AR(1) shocks.

Appended to the above equations is a small macroeconomic model of inflation and output suitable for estimation with monthly data, which also has some New Keynesian justification:

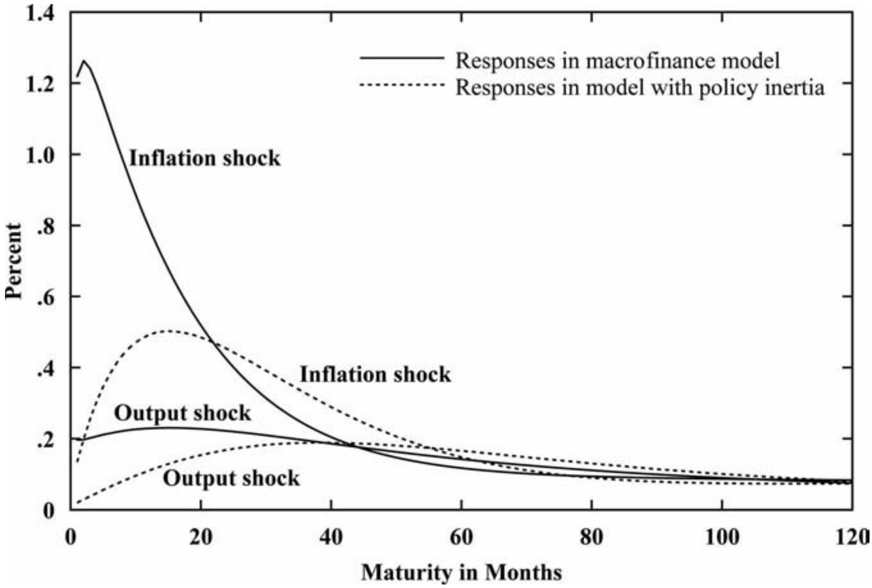
$$\pi_t = \mu_\pi L_t^m + (1-\mu_\pi)[\alpha_{\pi_1}\pi_{t-1} + \alpha_{\pi_2}\pi_{t-2}] + \alpha_y y_{t-1} + \varepsilon_{\pi,t}. \quad (24)$$

$$y_t = \mu_y E_t y_{t+1} + (1-\mu_y)[\beta_{y1} y_{t-1} + \beta_{y2} y_{t-2}] - \beta_r (i_{t-1} - L_{t-1}^m) + \varepsilon_{y,t}. \quad (25)$$

That is, inflation in the current month is set as a weighted average of the public's expectation of the medium-term inflation target, identified as L_t^m, and two lags of inflation. Also, there is a one-month lag on the output gap to reflect adjustment costs and recognition lags. Current output is determined by expected future output, $E_t y_{t+1}$, lagged output, and the ex ante real interest rate, which is proxied by $i_{t-1} - L_{t-1}^m$ (that is, agents judge nominal rates against their view of the underlying future inflation rate, not just next month's inflation). Finally, the specification of longer-term yields follows the standard no-arbitrage formulation. For pricing longer-term bonds, the risk price associated with the structural shocks is assumed to be a linear function of L_t^m and S_t^m.

The above macrofinance model was estimated by maximum likelihood (ML) for the sample period from January 1988 to December 2000. The complete parameter estimates and details are in Rudebusch and Wu (2006); however, of particular interest for policy inertia are the estimates of ρ_S, which is a minuscule .026, and of ρ_u, which is .975. These estimates decisively dismiss the interest rate smoothing or monetary policy inertia interpretation of the Taylor rule. The persistent rule deviations occur not because the Federal Reserve was slow to react to output and inflation, but because the Federal Reserve responds to a variety of persistent determinants beyond current output and inflation. Some intuition for this result is given in figure 13, which displays the initial response of the entire yield curve to inflation and output shocks from the estimated macrofinance model. Positive shocks to inflation and output in this model are followed by immediate increases in short-term interest rates, and, for the inflation shock, these increases are more than one-for-one. These responses—shown as the solid lines—reflect the absence

Figure 13. Initial Yield-Curve Response to Output and Inflation Shocks



Note: The solid lines show the impact responses on the entire yield curve from a 1-percentage-point increase in inflation or output in the estimated macrofinance model in Rudebusch and Wu (2006). The dashed lines give similar responses in a macrofinance model that assumes substantial monetary policy inertia ($\rho_S = 0.9$) and serially uncorrelated policy shocks ($\rho_u = 0$).

of monetary policy partial adjustment or inertia. In contrast, the dashed lines in figure 13 display the yield-curve responses from a model that is identical to the estimated macrofinance model except that ρ_S is set equal to .9 and ρ_u equals 0. This hypothetical alternative model has substantial monetary policy inertia, and it displays markedly weaker responses to inflation and output shocks of yields that have maturities of less than two years. The two quite different responses of the yield curve in these models illustrate the potential importance of the information contained in the term structure for discriminating between the two models. Given the system ML estimates, it is clear that the data prefer the macrofinance model without policy inertia.

4.3 Intraday Interest Rate Reactions to Macroeconomic Data

As a third illustration of the power of the term structure to illuminate the nature of the monetary policy reaction function, I provide some new evidence on interest rate smoothing based on intraday movements of the yield curve. The underlying insight exploited here is similar to the one above: an inertial policy rule has important implications for the evolution of the entire term structure through time. Again, this approach is extremely powerful, because financial markets will enforce their understanding of the monetary policy reaction function at each point in time and across interest rates at all maturities. However, while the above results implement this idea with models estimated at a monthly or quarterly frequency and substantial economic structure, the results in this section are based on the intraday response of the yield curve to macroeconomic data releases and impose minimal structure. The resulting event study provides further compelling evidence against the existence of monetary policy inertia using very different data and information.

Intuitively, changes in the path of expected future interest rates following the release of news about the state of the economy should reveal the degree of interest rate smoothing, because financial markets will expect an inertial central bank to distribute the policy rate changes over several periods. To illustrate this mechanism in a simple formal structure, consider the policy inertia framework

$$i_t = (1-\rho)\beta\bar{\pi}_t + \rho i_{t-1}, \tag{26}$$

where i_t is the average short-term (daily) policy rate during quarter t, which is set by the central bank to respond gradually over time to the annual inflation rate, $\bar{\pi}_t$ (the four-quarter percent change). Also, annual inflation is assumed to be a simple AR(1) process,

$$\bar{\pi}_t = \delta\bar{\pi}_{t-1} + \varepsilon_{1,t} + \varepsilon_{2,t}, \tag{27}$$

with two sources of independent random variation. These two shocks are distinguished by the timing of their release dates during the quarter. News about inflation in $\varepsilon_{1,t}$ is revealed at the very beginning of quarter t, while the news in $\varepsilon_{2,t}$ is revealed sometime later in quarter t. This analysis just explores the effects of news in $\varepsilon_{1,t}$, while $\varepsilon_{2,t}$ is only included in the model to emphasize that knowledge of $\varepsilon_{1,t}$ does not determine $\bar{\pi}_t$. Also, one of the key elements of the methodology in this section is that δ can be pinned down by macroeconomic time-series data. In particular, for the inflation and output series shown in figure 1, which are the relevant policy determinants in the Taylor rule, the OLS estimates of δ, which have a well-known downward bias, are .97 for inflation and .95 for output. This evidence is consistent with the large literature examining the persistence of various macroeconomic series that indicates that δ is very close to 1.[38]

To calculate the immediate response of interest rates to the revelation of $\varepsilon_{1,t}$, note that at the end of period $t-1$, the expected value of the average interest rate over the next quarter is

$$E[i_t|e(t-1)] = \rho i_{t-1} + (1-\rho)\beta E[\pi_t|e(t-1)] \tag{28}$$

$$= \rho i_{t-1} + (1-\rho)\beta\delta\pi_{t-1}, \tag{29}$$

where $E[\cdot|e(t-1)]$ is the expectation conditional on the information set at the end of quarter $t-1$. Similarly, just after the revelation of $\varepsilon_{1,t}$ at the beginning of quarter t, the expected value of the quarter-t interest rate is

$$E[i_t|b(t)] = \rho i_{t-1} + (1-\rho)\beta E[\pi_t|b(t)] \tag{30}$$

$$= \rho i_{t-1} + (1-\rho)\beta(\delta\pi_{t-1} + \varepsilon_{1,t}), \tag{31}$$

where $E[\cdot|b(t)]$ is the expectation conditional on the information set at the beginning of quarter t. Therefore, the size of the revision to the expectation of i_t in response to $\varepsilon_{1,t}$ news about inflation equals

$$\Delta E[i_t|\Delta] \equiv E[i_t|b(t)] - E[i_t|e(t-1)] = (1-\rho)\beta\varepsilon_{1,t}. \tag{32}$$

That is, the change in the expectation of i_t equals the amount of inflation news multiplied by the policy response coefficient and reduced by a fraction for interest rate smoothing. Still, even with data on the change in interest rate expectations, it is difficult to determine the size of ρ from this equation, on its own, because $\beta\varepsilon_{1,t}$ must be measured in some way.[39]

[38] For evidence on this point and references to the voluminous literature, see Rudebusch (1992), Rudebusch and Svensson (1999), and Pivetta and Reis (2006).

[39] Macroeconomic data surprises relative to surveys of market participants may help but are clouded by information in revisions to earlier data.

However, combining the revisions in expectations of i_t with revisions of other expected future interest rates does allow the partial-adjustment coefficient to be determined. Specifically, note that at the end of quarter $t-1$, the expected value of i_{t+1} is

$$E[i_{t+1}|e(t-1)] = \rho E[i_t|e(t-1)] + (1-\rho)\beta E[\pi_{t+1}|e(t-1)] \quad (33)$$
$$= \rho^2 i_{t-1} + (\delta+\rho)(1-\rho)\beta\delta\pi_{t-1}. \quad (34)$$

At the beginning of quarter t, the expected value of i_{t+1} is

$$E[i_{t+1}|b(t)] = \rho E[i_t|b(t)] + (1-\rho)\beta E[\pi_{t+1}|b(t)] \quad (35)$$
$$= \rho^2 i_{t-1} + (\delta+\rho)(1-\rho)\beta(\delta\pi_{t-1} + \varepsilon_{1,t}), \quad (36)$$

so the revision to expectations of i_{t+1} in response to $\varepsilon_{1,t}$ is equal to

$$\Delta E[i_{t+1}|\Delta] \equiv E[i_{t+1}|b(t)] - E[i_{t+1}|e(t-1)] = (\delta+\rho)(1-\rho)\beta\varepsilon_{1,t}. \quad (37)$$

Finally, the ratio of the two revisions provides a straightforward expression:

$$\Delta E[i_{t+1}|\Delta]/\Delta E[i_t|\Delta] = \delta + \rho. \quad (38)$$

If, as noted above, the value of δ is pinned down by the well-known macroeconomic dynamics of inflation, then this ratio of revisions in expected future rates will identify ρ.

To estimate the ratio above, I use intraday data on yields of three- and six-month U.S. Treasury securities.[40] The revisions in these two yields are calculated over the half-hour period from five minutes before a release of macroeconomic data to twenty-five minutes after that release.[41] Changes in the three-month yield during this window

[40] I also obtained similar results using interest rate expectations from daily federal funds futures and eurodollar futures. However, an advantage to using the Treasury yields is that they enforce a consistent timing so that the macroeconomic news always occurs at the beginning of the monetary policy adjustment. In addition, Treasury markets are the most liquid ones.

[41] This thirty-minute window eliminates noise from extraneous sources, such as other data releases or monetary policy actions or communications. The data are discussed in Gürkaynak, Sack, and Swanson (2005a, 2005b) and were kindly supplied by the authors. They obtained tick-by-tick, on-the-run Treasury yield data back to 1991 from a consortium of interdealer brokers. They also show that a thirty-minute window is sufficiently wide to capture the full response of financial markets to news.

provide a reading on $\Delta E[i_t|\Delta]$, while changes in a combination of the two yields give $\Delta E[i_{t+1}|\Delta]$ via the expectations hypothesis—namely, twice the six-month yield minus the three-month yield.[42] For example, if the three-month rate increases by 5 basis points in response to a release of higher-than-expected consumer price inflation, and the three-month rate expected three months ahead increases by 9 basis points, then their ratio provides an estimate of $\delta + \rho$ equal to 1.8. Assuming inflation follows a unit-root process, so $\delta = 1$, then the monetary policy partial-adjustment coefficient is 0.8. That is, in response to news about persistently higher inflation, financial markets assume that an inertial central bank will boost the policy rate higher over the next few months but will also gradually raise it even higher in subsequent months. Alternatively, at the opposite end of the spectrum, if three- and six-month yields change by an identical amount in response to a persistent shock (so $\Delta E[i_t|\Delta] = \Delta E[i_{t+1}|\Delta]$), then $\delta + \rho = 1$ and financial markets assume that there is no monetary policy partial adjustment by central banks.

In fact, the data indicate quite clearly that the case of little or no inertia is the relevant one. I consider 315 macroeconomic data releases from July 1991 to September 2004 for the unemployment and CPI series, which are two of the most important and closely watched data releases. Of course, the formal structure outlined above applies to any persistent macroeconomic determinant of monetary policy, so the unemployment and CPI releases are pooled to increase the precision of the estimates. The median value of $\Delta E[i_{t+1}|\Delta]/\Delta E[i_t|\Delta]$ is 1.00; the mean value is 1.06 with a standard error of 0.15.[43] Again, with the assumption that macroeconomic time series are highly persistent, these results imply a central tendency for ρ of around 0 to .1 and a 95 percent confidence interval that lies entirely below .4.[44]

[42]This calculation ignores the time-varying term premium modeled in Rudebusch and Wu (2006) and discussed above; however, changes in the ratio of these premiums at these very short maturities are likely insignificant.

[43]The median expectational revision ratios for inflation and unemployment releases separately are also both equal to 1.0.

[44]These results also appear robust to consideration of longer maturities, as in $\Delta E[i_{t+k}|\Delta]/\Delta E[i_t|\Delta]$.

5. Conclusion

Does the persistence of the short-term policy interest rate reflect deliberate "partial adjustment" or "inertia" on the part of the central bank? As in many other areas of economics, understanding the nature of dynamic adjustment is a hard problem that simple regression estimates often cannot solve. However, in contrast to many other macrodynamic puzzles, interest rates have a rich set of term-structure information that can help provide answers. One of the key insights above is that although the short rate is a policy instrument, it is also a fundamental driver of long yields, so a joint macrofinance perspective can sharpen inference about the policy reaction function. The yield-curve results above—for quarterly predictability, monthly system estimation, and intraday responses to news—all point to fairly rapid central bank reactions to news and information and little real-world policy inertia. In essence, quarterly monetary policy partial adjustment does not appear to be consistent with the financial market's understanding of the monetary policy rule. This absence of intrinsic inertia appears in accord with the views of many central bankers, who often note that future policy actions will largely be contingent on incoming data and future changes in the economic outlook.

In terms of future research, much work can still be done to exploit yield-curve information about the monetary policy reaction function, especially in countries other than the United States. In addition, further policy rule estimation and investigation is recommended. The lagged policy rate in empirical monetary policy rules, although perhaps useful in mopping up residual serial correlation, should not be given a structural partial-adjustment interpretation with regard to central bank behavior. A better strategy is to identify and model the underlying persistent factors that influence central bank actions. This task will not be easy. As Svensson (2003, 467) argues, the missing elements may be largely judgmental in nature:

> Whereas simple instrument rules, like variants of the Taylor rule, may to some extent serve as very rough benchmarks for good monetary policy, they are very *incomplete* rules, because they don't specify when the central bank should or should not

> deviate from the simple instrument rule. Such deviations, by discretion and judgement, have been and will be frequent....

In this case, policymakers should not be misled into viewing a Taylor rule, or any simple representation of policy, as a completely reliable guide to future actions.

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