Beyond the Taylor Rule

Emi Nakamura — UC Berkeley
Venance Riblier — UC Berkeley
Jón Steinsson* — UC Berkeley

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Abstract

The Federal Reserve partially "looked through" the post-Covid rise in inflation and ultimately managed to bring about an "immaculate disinflation." The Fed's policy deviated strongly from the Taylor rule during this period. More generally, central banks with strong inflation-fighting credentials looked through post-Covid inflationary shocks yet experienced less inflation than more hawkish but less credible central banks. In light of this episode, we assess the degree to which the Taylor rule is *descriptive*, and the degree to which it should be viewed as *prescriptive*. While the Taylor rule (generally) fits well during the Greenspan period, it (generally) fits poorly in the early 1980s and after the early 2000s. Academic work has emphasized the role of the Taylor rule in preventing self-fulfilling fluctuations (guaranteeing determinacy). These concerns can be addressed with a shock-contingent commitment and are fragile to deviations from fully rational expectations. We discuss three reasons why optimal policy may not always imply a one-for-one response of interest rates to inflation (forward guidance, correlated shocks, and "long and variable lags"). The main challenge arising from such policies is not indeterminacy but erosion of inflation-fighting credibility and potential deanchoring of long-run inflation expectations. Only central banks with strongly anchored inflation expectations and large amounts of inflation-fighting credibility are likely to be able to look through inflationary shocks.

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1 Introduction

When the Taylor rule was originally proposed in 1992, the credibility of the Federal Reserve (and other central banks) was modest. Only a dozen years earlier, the Fed's credibility was in tatters after a long period of high and volatile inflation. Paul Volcker's Fed brought down inflation in the early 1980s and maintained very tight policy through the middle of the 1980s. Alan Greenspan's Fed tightened policy again in the late 1980s when inflation rose above 5%. These actions substantially improved the Fed's credibility. But the memory of the 1970s was still fresh and the Fed's track record as a serious inflation fighter still relatively short.

At this time—the early 1990s—the notion that optimal policy might involve looking through supply shocks likely seemed for the most part rather far fetched. The focus was on establishing a reputation for fighting inflation whenever it rose above modest levels and thereby building credibility. In modern parlance, the focus was on anchoring long-run inflation expectations. Taylor's (1993) paper reflects this focus. His primary concern was to limit discretionary policy by establishing systematic monetary policy. His policy rule was an attempt to inform the nature of that systematic monetary policy, emphasizing in particular that the Fed should raise not just nominal but real interest rates in response to inflation, i.e., raise nominal rates more than one-for-one with inflation.

By the late 2010s, however, the situation was quite different. The Fed had maintained low and stable inflation for 30 years. Long-run inflation expectations had been firmly anchored for more than 15 years (see Figure 1). The Fed had, by then, built up a very substantial degree of credibility. This credibility arguably allowed the Fed to consider a more sophisticated approach to optimal monetary policy. Perhaps the Fed's credibility was large enough that it could, on a rare occasion, look through a substantial supply shock without losing control of long-run inflation expectations.

Most commentators agree that the Fed got behind the curve in late 2021 and early 2022. The Covid shock had caused a huge shift in demand away from contact-intensive services and towards goods (Stock and Watson, 2025). The relative price of goods needed to rise temporarily. This could happen by goods prices rising, services prices falling, or some combination. Should the Fed tighten policy in accordance to the Taylor rule and push services prices down, likely at the cost of a substantial recession? Or should the Fed deviate from the Taylor rule and allow the relative price adjustment to occur mostly though the price of goods rising, implying a temporary increase in inflation? The Fed chose the latter course, avoided a recession, but was criticized for the largest deviation from the Taylor rule on record (e.g., Bullard, 2022; Taylor, 2023).

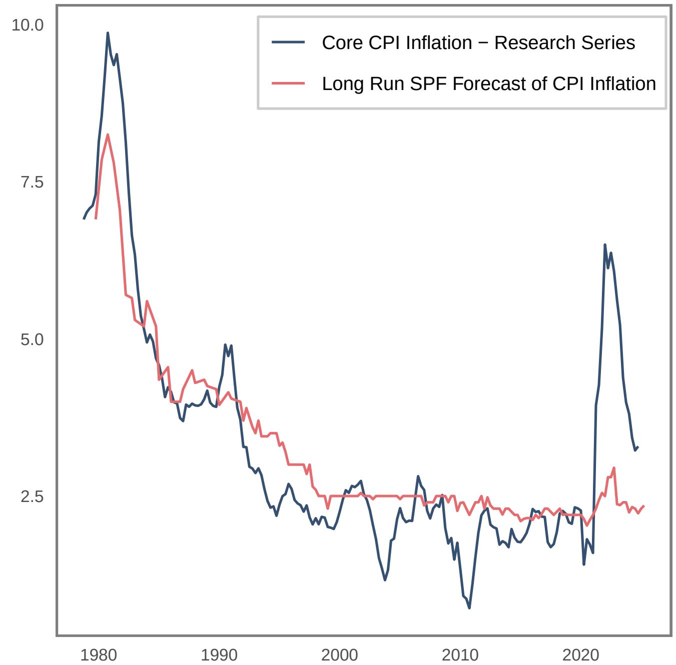

Figure 1: Inflation and Long-Run Inflation Expectations

Note: The figure plots core CPI inflation (dark blue line) and long-term inflation expectation of professional forecasters for the CPI (light red line). From 1991 onward, inflation expectations are from the Survey of Professional Forecasters. Before 1991, these come from Blue Chip. The long-term inflation expectation is a forecast of annual-average inflation over the next 10 years.

Motivated by this episode, we seek to reassess the degree to which the Taylor rule is *descriptive*, and the degree to which it should be viewed as *prescriptive*. We start with the former. Taylor (1993) showed that his famous rule described policy well in the United States over the six year period from 1987 to 1992. While the original Taylor rule (generally) fits well during the Greenspan era (1987-2006), it (generally) fits poorly during the preceding Volcker era (1980-1987) and since the early 2000s. The 2000s have seen episodes when monetary policy was constrained by the zero lower bound necessitating that central bankers go "beyond" the Taylor rule. They have also seen long periods when the federal funds rate was substantially below the value implied by the Taylor rule.

Modifications to the original Taylor rule can improve the fit to actual policy somewhat. These involve reestimating the coefficients in the Taylor rule, incorporating time-varying series for r^*, and judiciously choosing measures of inflation and the output gap. These ex post modifications are, however, subject to overfitting concerns. It is not clear whether such backward-engineered rules will fit well out of sample.

Interestingly, as Orphanides (2003, 2004) has emphasized, the original Taylor rule fits well with real-time data over the period 1966-1979, a period that is widely considered the largest monetary policy mistake since the Great Depression. Viewed through the lens of the Taylor rule, the main culprit for poor policy in this episode was an excessively optimistic view of potential output. This concern arose again during the Covid recovery, a time when many economists argued ex post that the labor market was far tighter than the Fed's contemporaneous assessment suggested. Evidently, the Taylor rule can only be as good a guide to policy as the inputs we plug into it.

The Taylor rule characterizes monetary policy in other G7 countries even less well than monetary policy in the US. The exception to this is the UK, where the fit of the Taylor rule is similar to the US. For other countries, there are only a few sporadic periods when the Taylor rule provides a somewhat close fit to monetary policy. For Japan, the fit of the Taylor rule is particularly poor. The Bank of Japan has systematically varied its policy rate by much less than the Taylor rule prescribes (without losing control of inflation). One reason for the poor fit in G7 countries is that it is difficult to find an appropriate measure of the output gap for these countries. Another is that some of these countries operated a fixed exchange rate regime for periods of time during our sample period.

The response of central banks around the world to the post-Covid inflation is particularly interesting. Some central banks responded early and forcefully, while other responded later and by less. Perhaps surprisingly, the countries in which monetary policy responded the most ended up experiencing the most inflation. We show that the degree to which central banks were able to "look through" the Covid supply shocks is highly correlated with their inflation fighting credibility as proxied by average inflation over the previous 30 years (Figure 12).

Central banks with strong inflation-fighting credentials (such as the Federal Reserve) were able to look through supply shocks during this episode (and focus their response on second round effects) without losing control of long-run inflation expectations. Figure 1 shows that long-run inflation expectations in the US were remarkably immune to the post-Covid inflation surge. In contrast, central banks with more checkered inflation histories were compelled to raise rates more to avoid sharp responses of inflation expectations. They therefore faced a less favorable inflation-output trade-off during this period. In the 1980s and early 1990s (when the Taylor rule was originally proposed), all countries had checkered inflation histories (including the United States) implying that looking through supply shocks risked inflation spiraling out of control.

We next turn to the question of how *prescriptive* the Taylor rule is. Over the course of the past 30 years, the Taylor rule has gained mythical status, becoming virtually synonymous with good monetary policy in the minds of many economists. A key feature that the Taylor rule prescribes is that the nominal interest rate should rise and fall more than one-for-one with inflation (conditional on the output gap). Monetary theory provides a strong rationale for this in the case of inflationary pressure arising from demand shocks. However, our empirical results show that policymakers have deviated sharply and persistently from the Taylor rule at various times. Many policymakers have an intuitive sense that they should "look through" inflation arising from temporary supply shocks or sectoral shocks. Is this idea supported by monetary theory?

The theoretical literature is confounded when it comes to the notion of looking through supply shocks by a separate theoretical notion: that nominal interest rates *must* rise more than one-for-one with inflation to avoid self-fulfilling economic fluctuations (equilibrium indeterminacy). This *Taylor principle* is so ingrained in monetary theory that many researchers believe they cannot even consider policies that look through supply shocks since such policies would risk indeterminacy. This makes for a confusing situation. Is looking through supply shocks optimal, or is it a recipe for self-fulfilling fluctuations?

We provide two arguments for why concerns about self-fulfilling fluctuations are overstated in the theoretical literature. First, self-fulfilling fluctuations can be avoided (i.e., determinacy guaranteed) with a shock-contingent policy rule that responds strongly to "non-fundamental" shocks. We refer to this as a minimalist Taylor principle. A central bank that acts in this way is then free to respond to fundamental shocks (demand and supply shocks) in any manner it finds optimal without concern for indeterminacy. Second, the determinacy problem is extremely fragile to small deviations from fully rational expectations. Even tiny deviations from fully rational expectations completely kill the indeterminacy problem. This raises questions about the practical relevance of the indeterminacy problem.[1]

The traditional concern with passive interest rate policy was not indeterminacy but rather inflation spirals. This concern was famously articulated by Friedman (1968) and goes back at least to Wicksell (1898). If inflation rises persistently and the nominal interest rate responds less than one-for-one, the real rate falls, inflation rises further, and can potentially spiral out of control. This concern does not arise in standard rational expectations models because these models implicitly

[1]There are two global indeterminacy issues that arise in monetary economics in addition to the local indeterminacy issue associated with the Taylor principle. One—emphasized recently by Cochrane (2011)—relates to unbounded increases in inflation—i.e., speculative hyperinflation. The classic solution to this problem is a state-contingent fiscal backstop in extreme circumstances (Obstfeld and Rogoff, 1983, 1986, 2021). The other arises due to the zero lower bound on the nominal interest rate. The classic reference for this issue is Benhabib, Schmitt-Grohé, and Uribe (2001). It can be avoided with an appropriate fiscal policy (Benhabib et al., 2002; Woodford, 2003). Importantly, both of these global determinacy problems arise whether monetary policy is formulated as an interest rate rule or rule for the money supply. The local indeterminacy problem we focus on, however, is special to monetary policy being formulated in terms of interest rates.

assume that long-run inflation expectations are completely anchored (Carvalho et al., 2023). It does arise in models that allow for imperfectly anchored long-run inflation expectations and provides a strong rationale for central banks responding forcefully to instability in long-run inflation expectations.

We present three reasons why a central bank with firmly anchored long-run inflation expectations optimally varies the nominal interest rate less than one-for-one with inflation in certain circumstances. First, in response to cost-push and sectoral shocks, optimal policy calls for a substantial amount of forward guidance, which weakens the contemporaneous relationship between the nominal interest rate and inflation. Second, a combination of inflationary cost push shocks and negative demand shocks calls for a muted response of interest rates. Third, "long and variable" lags imply that there may be little monetary policy can do in response to transitory shocks.

The primary risk associated with looking through inflationary shocks is not indeterminacy but rather loss of inflation-fighting reputation and the risk that long-run inflation expectations will become deanchored. The public will rightly be skeptical when the central bank looks through an inflationary shock. Whether the shock is due to supply or demand (or purely speculative) is hard to demonstrate conclusively in real time. The central bank has a well-known short-run incentive to avoid tightening policy (at times amplified by political pressure). This type of concern about discretionary policy was exactly what motivated Taylor and others to propose simple observable rules. One response to this is to articulate observable metrics for shocks that call for muted responses. An important example of this is the emphasis that many central banks put on core inflation (which deemphasizes commodity shocks).

Even a central bank with a high degree of inflation-fighting credibility can only attempt to look through a non-oil inflationary supply shocks at a modest frequency. Attempting this will inevitably cost the central banks a significant amount of credibility in the short run. While the Fed and several other central banks with high credibility succeeded in implementing this strategy and achieving a soft-landing in 2022-2024, it is by no means obvious that this would work well a second time while the memory of the post-Covid inflation is fresh in the minds of consumers, firms, and financial markets. However, the ability to look through inflationary supply shocks on rare occasion is an important dividend of public trust in central banks' inflation fighting resolve.

That optimal monetary policy dictates more nuance in responses to different shocks than simple rules does not imply that simple rules have no place in the cannon of monetary policy. Simple rules embody certain key intuitions and they can be valuable guideposts, as Taylor argued. For central banks with modest credibility, they may even be close to optimal. Also, the literature on simple monetary policy rules no doubt played an important role in the development of the science of monetary policy and thereby contributed to the triumph over inflation over the past four decades in many developed countries. But a central banks with a high degree of credibility have earned the right to venture beyond the Taylor rule.

2 How Descriptive is the Taylor Rule?

Taylor (1993) argued that the following simple rule described the monetary policy of the Federal Reserve remarkably well over the period 1987 to 1992:

$$i_t = 2.0 + \pi_t + 0.5(\pi_t - 2.0) + 0.5(y_t - y_t^*). \quad (1)$$

Figure 2 replicates the main figure in Taylor (1993) (Figure 1 in that paper). The fit is clearly very close. Taylor argued that his simple rule described policy well over a period when policy was generally considered good. He stressed that it is "practically impossible" to mechanically follow such a simple rule. But argued that the rule could serve as a "guide" for central banks aiming to avoid the pitfalls of discretionary policy.

2.1 Does the Taylor Rule Fit Out of Sample?

The sample period Taylor considered in his 1993 paper is quite short. A large body of subsequent work has assessed the degree to which Taylor's simple rule (and variants of this rule) track the actions of the Fed during other periods. Extending Taylor's analysis to other periods raises a number of practical and conceptual issues. Many of these issues concern how closely the analysis should follow Taylor's original specification. Should the analysis use Taylor's original measure of inflation and output? Should it use the same values for r^* and π^*? Should it use the same method to construct y^*? Should it use the same coefficients on inflation and the output gap? Should r^* be allowed to vary over time? Should the rule allow for policy inertia? Should other variables be used (e.g., expected future inflation, output growth, etc.)?

While it is valuable to consider other specifications of a policy rule than Taylor's exact specification, the freedom to do so raises serious overfitting concerns. The sample period that is typically employed to estimate simple policy rules is modest in length—spanning only about a half dozen business cycles (often less). Even just the reestimation of the intercept and the coefficients on in-

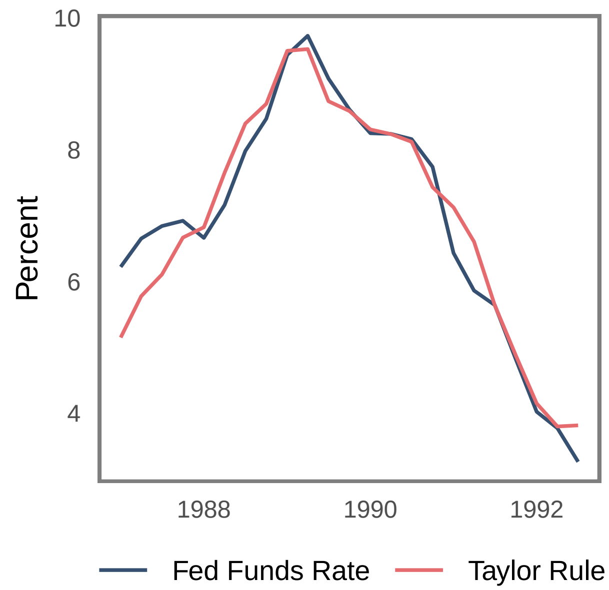

Figure 2: Fit of Original Taylor Rule, 1987-1992

Note: This figure plots the fit of the original Taylor rule on the sample used in Taylor (1993). It is our replication of Figure 1 in Taylor (1993).

flation and the output gap for different sample periods yields quite a bit of scope for spuriously good fit. Freedom to optimize over the chose of the inflation measure, the output gap measure, a time-varying r^*, and the degree of policy inertia seriously compounds this overfitting concern.

Guided by these considerations, we begin by assessing the fit of the original Taylor rule over a longer sample period. Our goal is to make as few changes to Taylor's methodology as possible. In this sense, our analysis is an out-of-sample test of the Taylor rule. We use the same value of r^* as Taylor did (2%); we use the same coefficients on inflation and the output gap that he used (1.5 and 0.5, respectively); we use the same measure of inflation as he used (the 12-month change in the GDP deflator). The only changes we make are to the measure of the output gap and the data vintage.

Taylor's measure of the output gap was the difference between GDP and the trend of GDP between 1984Q1 and 1992Q3. Extending this methodology to a longer sample works poorly.[2] We instead use the output gap estimate from the Federal Reserve's Greenbook and Tealbook (Greenbook for short). For the last few years of our sample period we use the output gap estimate of the CBO since the Tealbooks for these years have not been made public.

[2]Proxying for potential output with a trend in the level of GDP over our sample period (1965Q4-2025Q1) yields extremely persistent variation in the output gap that does not correspond well with other measures of the output gap such as estimates in the Greenbook, CBO, or the unemployment rate. Using a linear trend for log GDP is somewhat better in this regard, but also suffers from this problem.

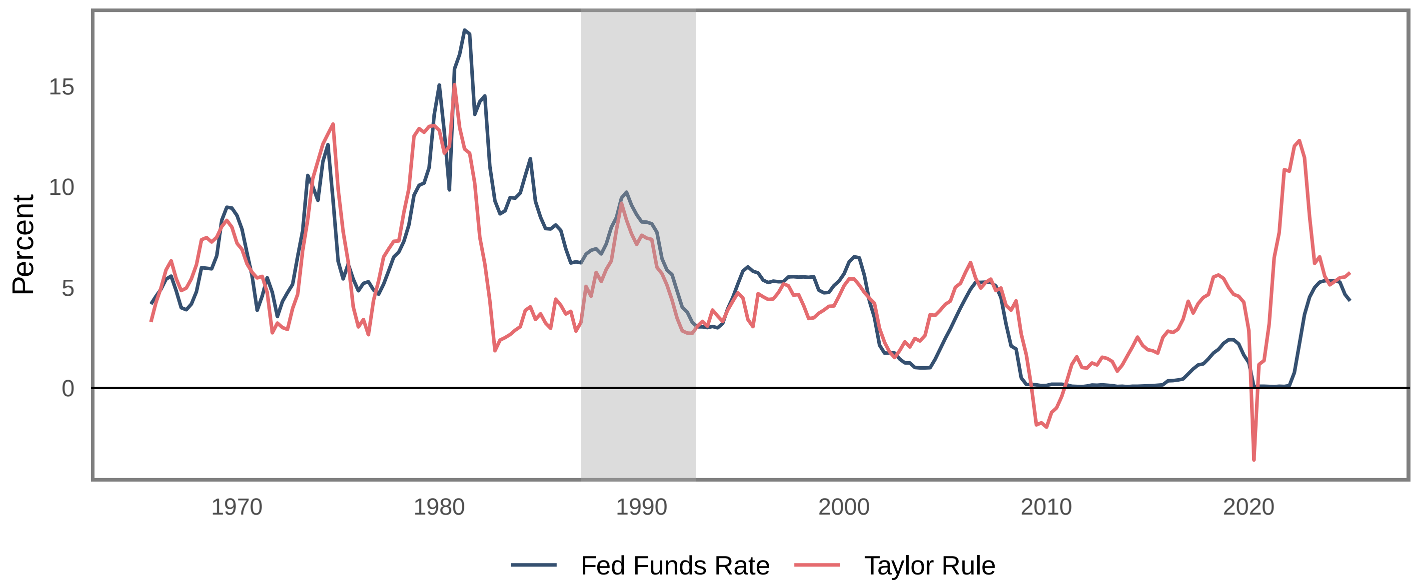

Figure 3: Original Taylor Rule with Real-Time Data

Note: The (light) red line shows the policy rate implied by the original Taylor rule—equation (1). We use real-time data for the GDP deflator and the Greenbook's measure of the output gap (CBO output gap for last few years). The sample period is 1965Q4-2025Q1. The shaded area shows the sample period considered in Taylor (1993).

Orphanides (2001, 2003, 2004) has emphasized the importance of using the real-time data that policymakers have access to when evaluating monetary policy rules. Importantly, real-time data differ from retrospective data not only (or even mainly) due to data revisions. The most consequential difference between real-time data and retrospective data for monetary policy arises from changing views about potential output over time. Real-time assessments of potential output (and therefore also the output gap) are based only on history up to that point, while retrospective assessments are influenced by (then) future events as well as changes in intellectual currents over time.

Figure 3 plots the federal funds rate and the rate implied by the Taylor rule using real-time data for the sample period 1965Q4-2025Q1. (Appendix A discusses the data we use in more detail.) We see that the fit of the Taylor rule over this long period is quite uneven. The Taylor rule fits reasonably well between 1987 and 2002. A persistent gap of up to 250bp opened up between the federal funds rate and the Taylor rule between 2003 and 2006. John Taylor referred to this as the Great Deviation and argued that it caused the housing boom that ended with the Great Recession (Taylor, 2012). The Taylor rule fits well again from 2006 until the federal funds rate hits the zero lower bound (ZLB) in 2008.

After 2008, the Taylor rule does not fit well. It implies substantially negative rates from 2009-

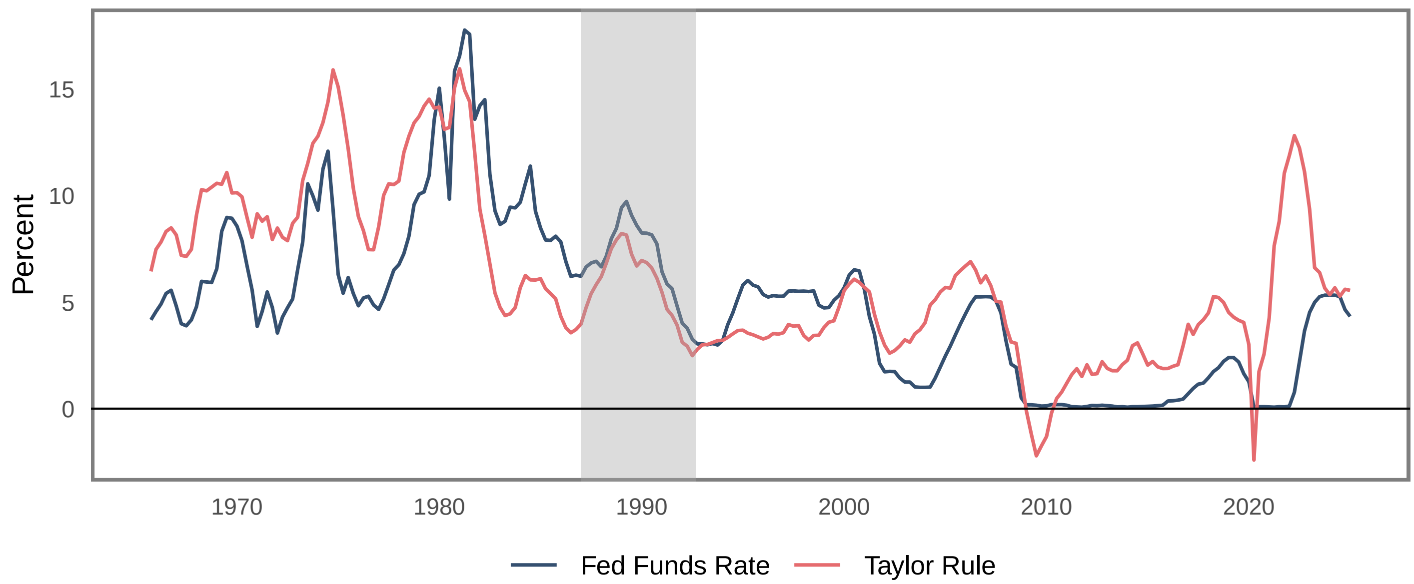

Figure 4: Original Taylor Rule with Retrospective Data

Note: The (light) red line shows the policy rate implied by the original Taylor rule—equation (1). We use retrospective data (i.e., the current data vintage) for the GDP deflator and the Greenbook's measure of the output gap (CBO output gap for last few years). The sample period is 1965Q4-2025Q1. The shaded area shows the sample period considered in Taylor (1993).

2011. By 2012, the Taylor rule implies rates considerably above zero, while the Fed maintained rates at the ZLB until 2015. Even as the Fed raised rates between 2015 and 2018, the Taylor rule implies that rates should have been substantially higher. The average difference between the Taylor rule and the federal funds rate between 2012 and 2019 was 222bp and the maximum difference at a quarterly frequency was 370bp.

In the aftermath of Covid, a particularly large deviation opened up between the Taylor rule and the federal funds rate. The maximum deviation was 1125bp in early 2022, which is by far the largest Taylor rule deviation over our entire sample. This large deviation closed as rapidly as it had opened up as the Fed raised rates and inflation fell over the course of 2022 and 2023.

The fit of the Taylor rule is even worse using retrospective data. Figure 4 plots the federal funds rate and the rate implied by the Taylor rule using retrospective data (i.e., the current data vintage) for the sample period 1965Q4-2025Q1. In this case, the fit during the 1990s is quite poor apart from brief periods, the deviation between 2002 and 2006 is even larger, and the post-2012 deviations are similar in magnitude.

Turning to the period prior to 1987, the Taylor rule fits very poorly during Paul Volcker's chairmanship of the Fed (1979-1987). Volcker famously kept rates very high despite a deep recession and after inflation had fallen substantially. The average absolute Taylor rule deviation over Vol-

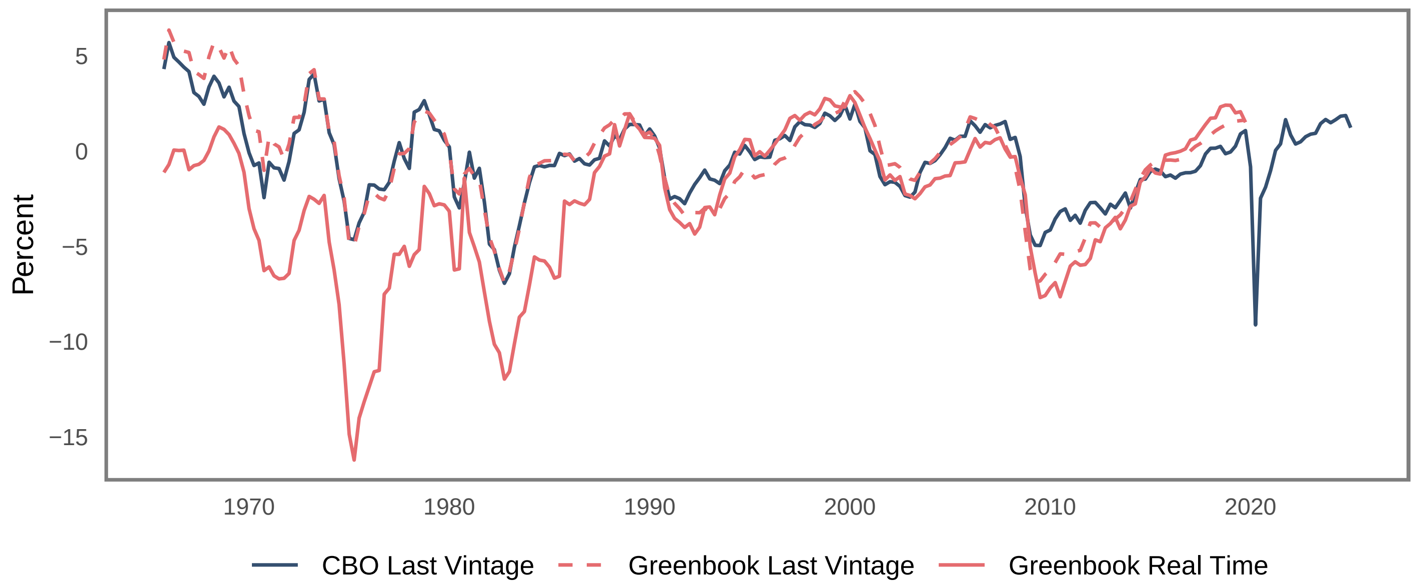

Figure 5: Estimates of the Output Gap in the U.S.

cker's reign was about 450bp. The largest deviation occurred in 1982 and was 835bp. The rationale for this tight policy was surely that the Fed's credibility was very poor at this time and Volcker felt that he needed to keep rates high to prevent resurgence of inflation and to build up the credibility of the Fed.

Interestingly, the Taylor rule fits very well from 1966 to 1979 when we use real-time data (Figure 3).[3] This is the period of the Great Inflation, widely considered the period of most serious monetary policy error since the Great Depression (DeLong, 1997; Romer and Romer, 2002; Blinder, 2022). As Orphanides (2003) originally emphasized, the good fit of the Taylor rule over this period is highly dependent on using real-time data, in particular the Fed's real-time measure of the output gap (see Figure 4).

In the case of policy in the 1970s, real-time assessments of y^* were substantially higher than retrospective assessments. This meant that real-time assessments of the output gap were much more negative than retrospective assessments. Figure 5 plots real-time and current vintage assessments of the output gap from the Greenbook as well as current vintage assessments from the CBO. The average difference between the real time and current vintage Greenbook assessments from 1966 to 1979 was 6 percentage points. This difference peaked at 11 percentage points in 1975.

[3]Clarida, Galí, and Gertler (2000) argue that the Fed's policy responded substantially less strongly to inflation prior to Volcker taking office than it did after he took office. In particular, their estimates suggest that the response of the federal funds rate to inflation prior to 1979 was less than one. Importantly, they reach these conclusions using retrospective data. Orphanides (2004) shows that the response of the federal funds rate to inflation prior to 1979 was larger than one when real-time data is used to estimate that relationship.

Figure 5 suggests that the Fed's persistently optimistic view of potential output (and persistently negative view of the output gap) in the 1960s and 1970s contributed substantially to excessively loose monetary policy over this period. Following the Taylor rule would not have solved that problem. Clearly, the prescriptions of the Taylor rule (or any other simple policy rule) cannot be better than the inputs that go into them. Romer and Romer (2024) argue that this same issue—an excessively optimistic estimate by the Fed of full employment—contributed to loose monetary policy in 2021.

2.2 Do Modified Taylor Rules Fit Better?

Many authors have presented variants of the Taylor rule that fit better over particular sample periods. However, seeking to maximize the fit of a policy rule over a given sample period ex post raises serious overfitting concerns. One way to limit overfitting concerns is to consider alternative policy rules that were proposed some time ago and for which a substantial sample period is available to do out-of-sample analysis.

A prominent example of such a policy rule is the forward-looking policy rule proposed and estimated by Clarida, Galí, and Gertler (2000). This policy rule takes the form

$$i_t^* = -0.006 + 2.15 E_t \pi_{t+1} + 0.93 E_t (y_{t+1} - y_{t+1}^*). \quad (2)$$

Clarida, Galí, and Gertler allow for partial adjustment of the federal funds rate towards its target level. Equation (2) is the equation for the target level of the funds rate (i_t^*) that they estimate.[4] The coefficients on inflation and the output gap that they estimate are somewhat larger than those that Taylor chose. Their sample period ends in 1996Q4. This means that we now have almost thirty years of out-of-sample data to assess this policy rule.

Figure 6 plots the federal funds rate and the target rate implied by Clarida, Galí, and Gertler's policy rule. For inflation, we use the time t Greenbook forecast for inflation over the next 12 months. For the output gap, we use the Greenbook nowcast in period $t+1$. For the last few years, when the Greenbook is not available, we use SPF forecasts for inflation and CBO estimates of the output gap. The average absolute deviation of Clarida, Galí, and Gertler's policy rule versus the federal funds rate is very similar to that of Taylor's original rule for the period 1987-1996. It fits better than the Taylor rule between 1996 and 2006 (about 25% smaller average absolute

[4] The policy rule that they estimate is $i_t = \alpha + \rho i_{t-1} + \beta E_t \pi_{t+1} + \gamma E_t (y_{t+1} - y_{t+1}^*) + \varepsilon_t$. Their estimate of ρ is 0.32.

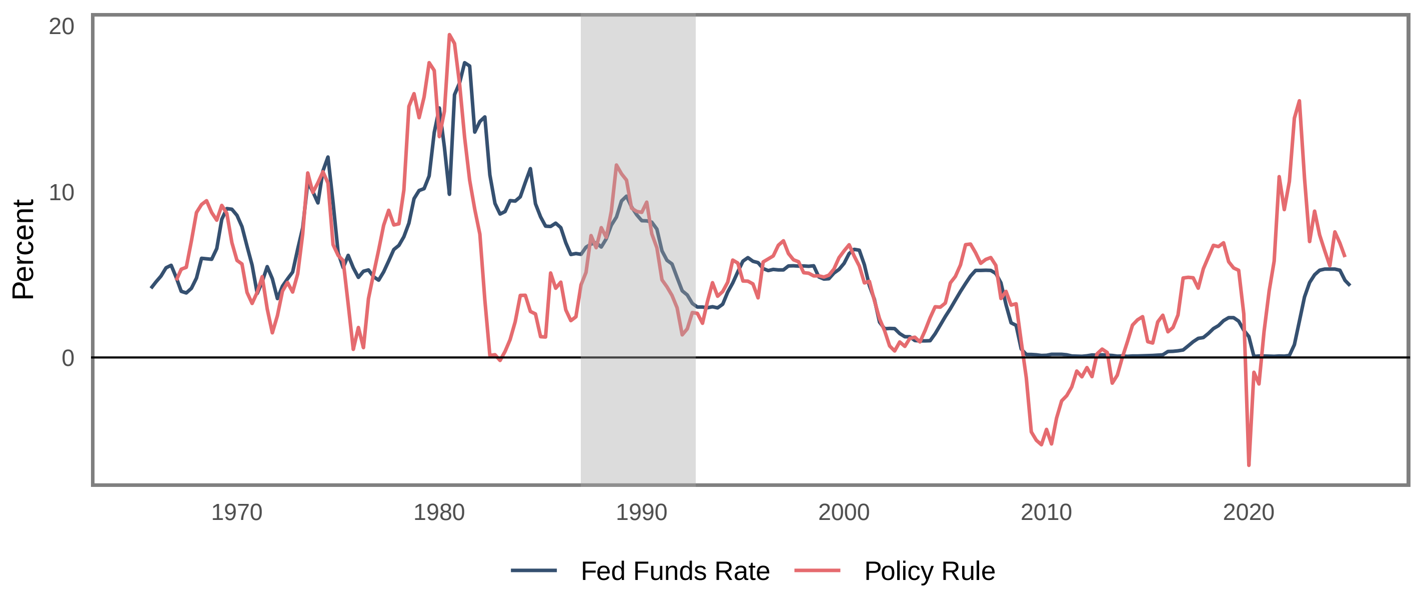

Figure 6: Clarida, Galí, Gertler Policy Rule with Real-Time Data

Note: The (light) red line shows the target policy rate implied by Clarida, Galí, and Gertler's 2000—equation (2). We use real-time data from the Greenbook for the inflation and output gap forecasts (SPF and CBO data, respectively, for the last few years). The sample period is 1965Q4-2025Q1. The shaded area shows the sample period considered in Taylor (1993).

deviations). After 2006, the average absolute deviations are again similar in magnitude to those for the Taylor rule.

Another policy rule that was originally proposed in the 1990s and has been prominent in policy discourse since is the policy rule that the Fed Board refers to as the "balanced-approach" rule in its Monetary Policy Reports. The simplest variant of this rule is the same as Taylor's original rule except that it has a coefficient of 1.0 rather than 0.5 on the output gap. This rule was proposed by Taylor (1999). A variant of this rule is the second rule listed in Fed's Monetary Policy Reports (e.g., Board of Governors, 2025) and also the second rule listed by the Cleveland Fed in its analysis of simple monetary policy rules (Cleveland Fed, 2025). It was furthermore highlighted by Yellen (2012) and Bernanke (2015) among many others.

For this policy rule, we make two additional modifications relative to the earlier policy rules we have considered. First, we use core PCE inflation rather than inflation in the GDP deflator. PCE inflation is the preferred inflation measure of the Federal Reserve. Prices of food and energy are highly volatile and are often driven by sector-specific supply shocks. Focusing on core inflation goes some way towards "looking through" supply shocks. Also, the theoretical literature has argued that focusing on inflation in sectors with sticky prices is optimal (Aoki, 2001; Benigno, 2004; Eusepi, Hobijn, and Tambalotti, 2011). Food and energy have relatively flexible prices.

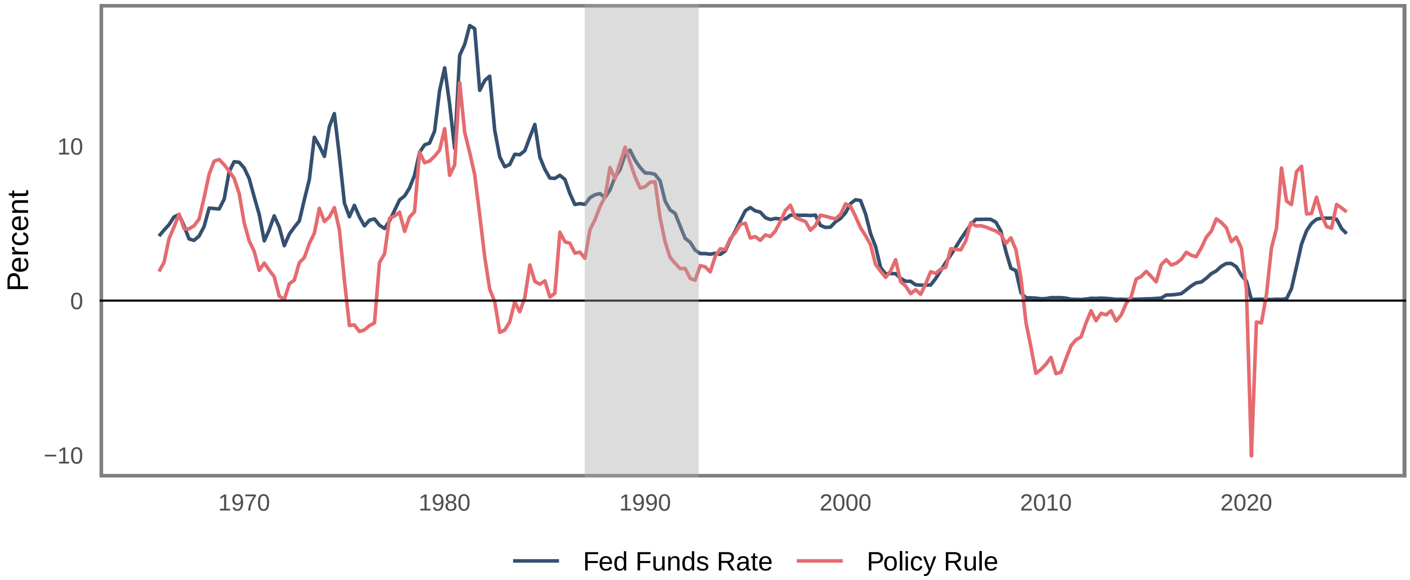

Figure 7: Balanced-Approach Rule with Core-PCE Inflation, and Time-Varying R^*

Note: The (light) red line shows the following policy rule $i_t = r_t^* + \pi_t + 0.5(\pi_t - 2.0) + 1.0(y_t - y_t^*)$. We use real-time data on core PCE inflation (12-month change in price level) back to 1996. Current vintage core PCE inflation for earlier period. We use real-time estimates of the output gap from the Greenbook (CBO for the last few years). We set $r_t^* = 2.0$ before 2012. After 2012, we use the median value of the long-run estimate of the nominal interest rate minus the inflation target of 2% from the latest FOMC Survey of Economic Projections. The sample period is 1965Q4-2025Q1. The shaded area shows the sample period considered in Taylor (1993).

The second change we make is to allow the natural real rate of interest r^* to vary. Taylor fixed its value at 2.0. A large literature has argued that the value of r^* has fallen over the past few decades (e.g., Laubach and Williams, 2003; Holston, Laubach, and Williams, 2017). The Cleveland Fed defines r^* as the latest value from the FOMC's Survey of Economic Projections of the median of the long-run nominal interest rate less the Fed's 2% inflation target. We adopt this approach back to 2012 and fix r^* at 2.0 before 2012.

Figure 7 plots the federal funds rate and the rate implied by the balanced-approach rule. The fit of this rule is again comparable to the original Taylor rule between 1987 and 1996. However, this rule fits significantly better after 1996. It fits quite well until the federal funds rate hits the ZLB in 2008 (eliminating Taylor's Great Deviation for 2003-2006). After that, the fit is relatively poor, but better than for the earlier rules we consider. If we focus on the period after 1996 and exclude periods when the ZLB binds, the average absolute deviation is about 80bp smaller than for the original Taylor rule (137bp versus 215bp).[5] Including the ZLB periods, the difference in fit

[5]The specific time periods we are excluding from this comparison are 2009Q1-2015Q4 and 2020Q2-2020Q4. We do not exclude 2021, as it is particularly contentious whether federal funds rate should have been at the ZLB during this period.

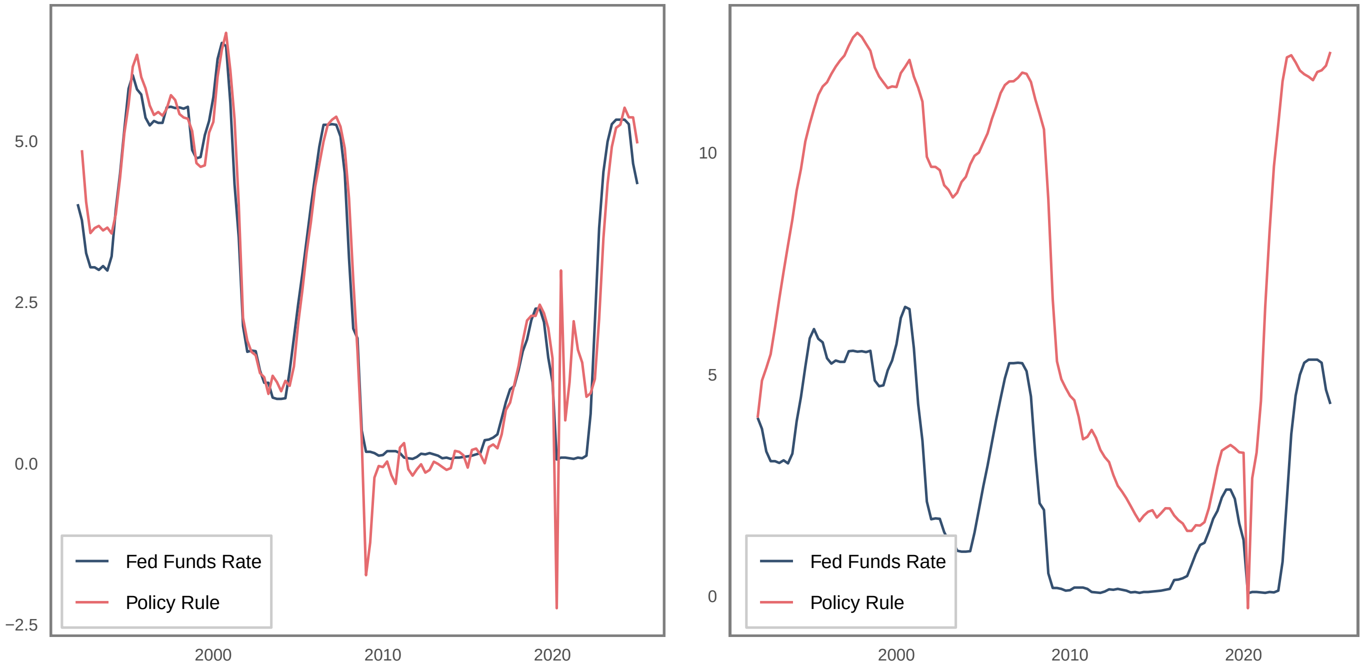

Figure 8: First Difference Policy Rule

Note: This figure plots the level of interest rates for the first difference rule $\Delta i = 0.5(\Delta y_t^n - \Delta y_t^{n*})$ where Δy_t^n is the median 3-quarter ahead forecast of nominal GDP growth from the Survey of Professional Forecasters and $\Delta y_t^{n*} = \pi^* + g_t^*$ with $\pi^* = 2\%$ and g_t^* is the median 10-year forecast for real GDP from the Survey of Professional Forecasters. The left panel uses the true lagged value of the federal funds rate for each period (i.e., gives a one-period prediction). The right panel cumulates the prescriptive changes in the nominal interest rate. The sample period is 1992Q1 to 2025Q1.

is smaller (about 30bp).

Orphanides (2003) proposed a variant of the Taylor rule formulated in first differences as opposed to levels. An advantage of this type of rule is that it avoids the need to estimate the output gap. A simple version of Orphanides' rule is $\Delta i_t = 0.5(E_t \Delta ny_{t+1} - E_t \Delta ny^*_{t+1})$, where $E_t \Delta ny_{t+1}$ is the expected growth rate of nominal GDP and $E_t \Delta ny^*_{t+1}$ is expected desired growth of nominal GDP. Figure 8 plots the implications of this rule with $E_t \Delta ny_{t+1}$ set equal to the median 3-quarter ahead forecast of nominal GDP from the Survey of Professional Forecasters and $E_t \Delta ny^*_{t+1} = \pi^* + g^*_{t+1}$ with $\pi^* = 2\%$ and g_t^* set equal to the median 10-year forecast for the growth of real GDP from the Survey of Professional Forecasters. We present two versions the fit of this rule. In the left panel, we set the lagged interest rate equal to its actual value for each period. Given the high persistence of interest rates, this anchors the prescriptions of the rule to a value close to the truth. In the right panel, in contrast, we cumulate the changes prescribed by the rule. In this case, errors cumulate rapidly. Figure B.3 plots the actual and prescribed changes in interest rates for this rule.

The substantial deviations from the Taylor rule and variants of the Taylor rule that we have documented can arise either because of policy mistakes or because these rules are not always reliable guides to good policy. Taylor (2012, 2023) argues that the deviations during 2003-2006 and 2021-2023 were policy mistakes. Others disagree. Strict adherence to the Taylor rule would have resulted in substantially tighter policy over the period 2012-2019. The dominant thrust of criticism of the Fed during this period, however, was that policy was too tight resulting in a slow recovery from the Great Recession and inflation that was persistently below the Fed's 2% inflation target.

2.3 G7 Monetary Policy and the Taylor Rule

Figure 9 plots the fit of the original Taylor rule to the policy rate in G7 countries and the Euro Area from 1962 to 2024. We use the 12-month core CPI inflation rate and estimate the output gap using data on industrial production and the filtering methodology of Hamilton (2018). The fit varies from country to country. The fit is (generally) good for the UK from 1980 to 2008 with the exception of a large deviation in the early 1990s. The fit for Germany is also reasonably good from the mid-1980s to 1998. The fit for other countries is less good. There are some sporadic episodes when the fit is good (France in the 1980s and Canada in the early 2000). But generally the fit is not good. The fit is particularly poor for Japan.

Figure 9 also plots an estimated Taylor rule for these countries and the Euro Area. We estimate $i_t = \alpha + \beta\pi_t + \gamma y_t + \varepsilon_t$ for the period 1979:Q1-2008:Q4 and plot the fit of this estimated rule over the entire sample. (For Germany, France, and Italy, we end the estimation sample in 1998:Q4. For the Euro Area, the estimation sample is 1999:Q1-2008:Q4.) The estimated rule yields a less volatile path for interest rates in most countries than the original Taylor rule reflecting the fact that these countries have systematically varied interest rates less than the Taylor rule prescribes. Table B.1 reports the estimated coefficients. They are smaller than the coefficients in the original Taylor rule in all cases. For the Euro Area, France, Italy, and the U.K., the estimated coefficient on inflation is smaller than one. Despite this fact, these countries have not seen inflation spiral out of control.

A prominent strand of the literature has considered a variant of the Taylor rule that involves partial adjustment of the interest rate towards a Taylor-rule-type target. Clarida, Galí, and Gertler (1998, 2000) are prominent papers that adopt this approach. We have also estimated this type of policy rule for the G7. Specifically, we estimate a rule with a lagged interest rate term: $i_t = \alpha + \rho i_{t-1} + \beta\pi_t + \gamma(y_t - y_t^*) + \epsilon_t$. The results are reported in Table B.2 and Figure B.1.

In this case, our estimated rules imply very small short-run responses to inflation and the out-

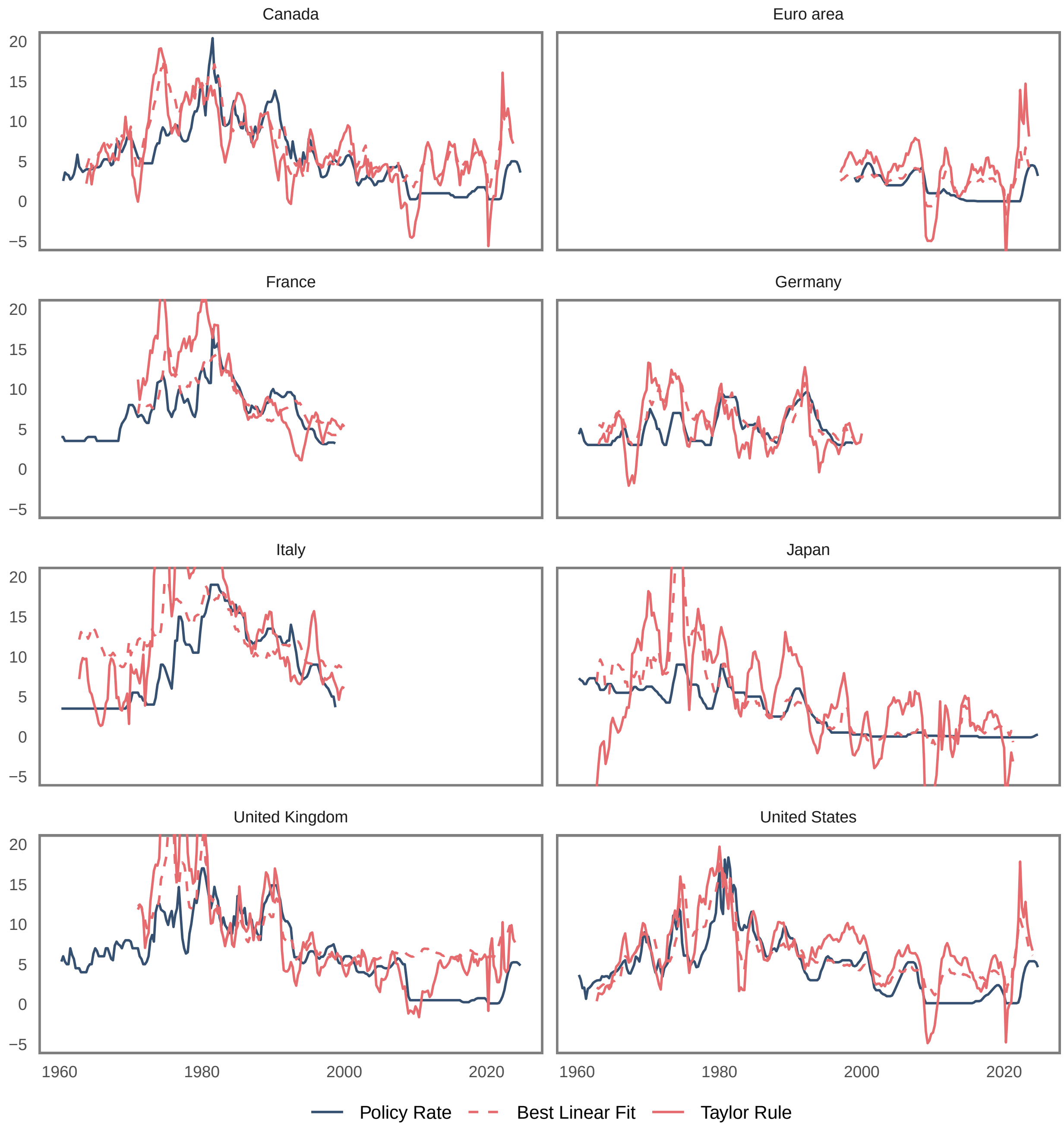

Figure 9: Taylor Rules for G7 Countries

Note: The figure plots the policy rate for G7 countries and for the Euro Area in dark blue. It plots the original Taylor rule in light red. It also plots an estimated Taylor rule in broken light red. We estimate $i_t = \alpha + \beta\pi_t + \gamma y_t + \varepsilon_t$ on the sample period of 1979:Q1-2008:Q4. For Germany, France, and Italy, the estimation sample ends in 1998Q4. For the Euro Area, the estimation sample is 1999:Q1-2008:Q4. We use the 12-month core CPI inflation rate and an output gap measure constructed by applying Hamilton's (2018) filter to data on industrial production.

put gap. However, the responsiveness of the long-run target to which the interest rate is (slowly) converging is much larger. This is calculated by multiplying the short-run coefficients by a factor of $1/(1-\rho)$. We estimate values of ρ around 0.85, implying that $1/(1-\rho)$ is roughly seven. The coefficients we estimate imply a long-run response of the nominal interest rate to inflation that is larger than one. With this type of rule, equilibrium determinacy depends on this long-run response. These estimated rules therefore satisfy the "Taylor Principle."

However, the large long-run response is achieved through very gradual adjustment over a long period. (With $\rho = 0.85$, half of the adjustment occurs over one year.) In other words, if this type of rule is correctly specified, it involves a huge amount of forward guidance. Over modest sample periods, the public would largely need to take this on faith since the adjustment towards the target interest rate is so slow that it is hard to verify and the target itself is rarely achieved. (Figure B.1 plots the target rate implied by the estimated rule.) The same logic implies that models with very gradual adjustment (a large estimated ρ) can fit very well even if the model for the target rate is very far from correctly specified.[6]

Our analysis for the G7 is cruder than our earlier analysis for the US. We do not have real-time data for the G7. We also do not have estimates of the output gap of comparable quality to those available for the US. It is possible that simple policy rules would fit better with real-time data and measures of the output gap that better reflected the views of the local central banks. It is also important to keep in mind that some of these countries operated a fixed exchange rate regime for parts of our sample period.

2.4 Post-Covid Policy and Inflation

As inflationary pressure developed in the wake of Covid, central banks around the world diverged in their reactions. Some central banks promptly began raising interest rates and raised rates rapidly over the course of 2021. Others waited much longer and raised rates less. Figure 10 illustrates this heterogeneity with data from eight central banks. The central banks of Brazil, Chile, Hungary, and Poland raised rates early, while the central banks of the United States, Mexico, the Euro Area, and Japan raised rates later and by less.

Figure 11 presents data for a much larger set of countries.[7] We break countries into "early

[6]The predictive fit of partial adjustment models arises mostly from the lagged interest rate term and not the accuracy of the model for the target.

[7]Here we use the Central Bank Policy Rate dataset from the Bank of International Settlements (BIS). The set of countries/regions is Australia, Brazil, Canada, Chile, Colombia, Croatia, Czechia, Denmark, Euro area, Hong Kong SAR, Hungary, Iceland, India, Indonesia, Israel, Japan, Korea, Malaysia, Mexico, Morocco, New Zealand, North Macedo-

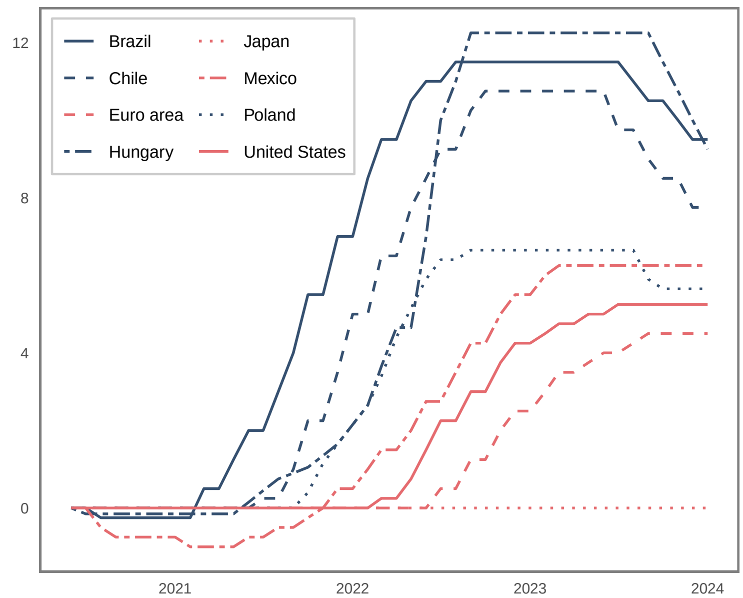

Figure 10: Cross-Country Heterogeneity in Post-Covid Monetary Policy

Note: The figure plots the policy rate relative to its value in July 2020 for the period July 2020 to January 2024.

risers" that raised their policy rate more between January 2021 and July 2022 than between July 2022 and January 2024 and "late risers" that raised rates more in the latter of these two periods. The top two panels plot the evolution of policy rates, with the early risers on the left and the late risers on the right. The early risers raised rates earlier (by definition) but also, on average, raised rates substantially more than the late risers. The average increase in the policy rate among the early risers was 8.5 points, while it was only 4.2 points for the late risers. The bottom two panels plot the evolution of inflation for these two sets of countries. Despite raising rates more promptly and by substantially more, the early risers experienced a larger increase in inflation over this period. Inflation rose by 10.8 points on average for the early risers, but only by 5.9 points on average for the late risers.

Why would inflation rise more in the set of countries that raised rates faster and by larger amounts? One potential explanation is that the monetary authorities in the early riser countries have less credibility than the monetary authorities in the late riser countries. A central bank with low credibility will see inflation expectations rise more in response to an inflationary shock. This effectively makes inflation more sensitive to the inflationary shock in the country with a low credibility central bank, holding monetary policy fixed. The central bank with low credibility, therefore,

nia, Norway, Peru, Philippines, Poland, Romania, Saudi Arabia, South Africa, Sweden, Switzerland, Thailand, United Kingdom, United States. We exclude Argentina, China, Russia, Serbia, and Türkiye. For inflation, we use BIS data on consumer prices.

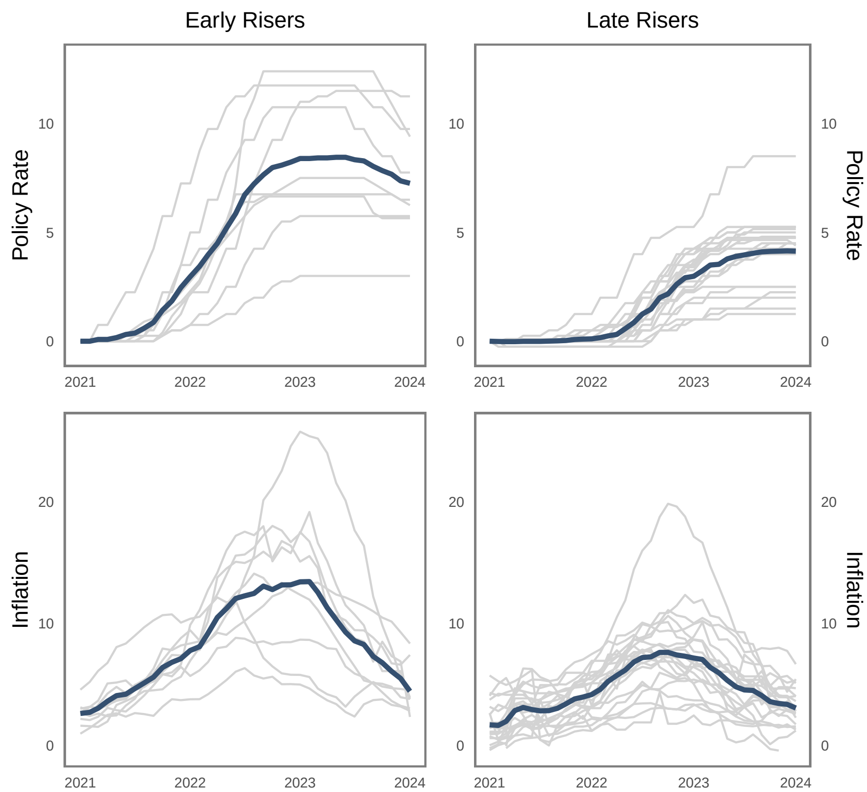

Figure 11: Policy Rate and Inflation for Early and Late Risers

Note: The top panels plot the change in the policy rate relative to its value in January 2021. The bottom panels plot the inflation rate. Each narrow line corresponds to a country. The bold line is the average across countries in that panel. The left panels shows the "early risers," defined as countries that increased their policy rate more between January 2021 and July 2022 than between July 2022 and January 2024. The right panels shows the "late risers," defined conversely.

needs to respond more to achieve the same degree of success as a central bank with high credibility. It must fight both the underlying shock and also the increase in inflation expectations. The high credibility central bank, in contrast, benefits from inflation expectations being more firmly anchored.

Figure 12 presents evidence supportive of this hypothesis. We plot the change in the policy rate in a country between January 2021 and July 2022 against the average inflation rate in that country between 1990 and 2019. The relationship between these variables is very strong. The coefficient in an OLS regression through these points is 1.36 (with standard error of 0.17) and the R^2 is 0.67. Countries with a worse inflation history over the preceding 30 years raised their policy rate more than countries with a better inflation history.[8] We interpret this as evidence that countries with more credible monetary authorities were able to look through the post-Covid supply shocks to a

[8] Jacome et al. (2025) present related evidence.

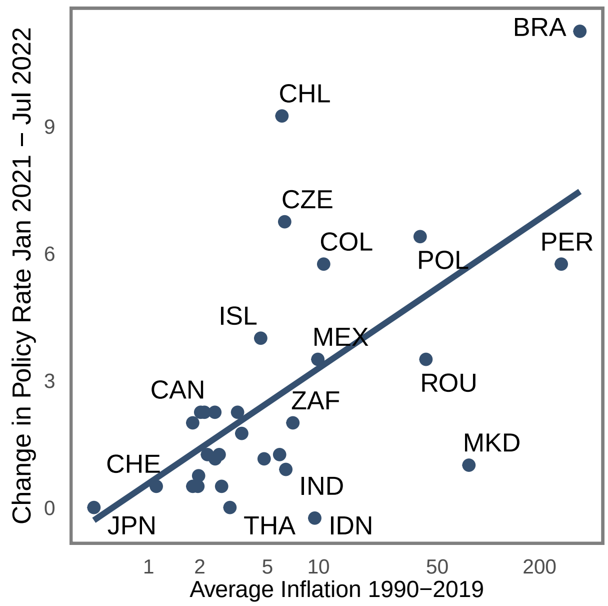

Figure 12: Early Rate Hikes and Historical Inflation

Note: The figure plots the change in the policy rate between January 2021 and July 2022 against the average inflation rate between 1990 and 2019. Each point is a country. The line is an OLS regression line through these points.

greater extent and still achieve better inflation outcomes.[9]

Bocola et al. (2025) present a model that captures this logic. In their model, the private sector is imperfectly informed about the central bank's objective function. This gives rise to imperfect credibility and learning by the private sector about the central bank's commitment to price stability. A central bank with low credibility raises (real) rates more in response to an inflationary supply shock because this reduces the extent to which inflation expectations increase. But despite tightening policy more, the low credibility central bank faces more inflation in equilibrium. Bocola et al. present evidence of substantial heterogeneity in the elasticity of long-run inflation expectations to surprise monetary policy actions (a sufficient statistic for credibility in their model). In advanced economies such as the U.S. and Euro Area, inflation expectations are much better anchored according to this metric than in emerging market economies such as Brazil and Turkey.[10]

[9]We have run analogous regressions with the total magnitude of policy rate increases between January 2021 and January 2024 and the speed of policy rate increases as the dependent variable with similar results.

[10]Several other papers have developed related ideas including Erceg and Levin (2003), King and Lu (2022), Carvalho et al. (2023), and Beaudry, Carter, and Lahiri (2023)

3 Liberating Monetary Policy from Determinacy Concerns (But Not Inflation Spirals)

As we saw in section 2, central banks frequently deviate from the Taylor rule. Some of these deviations involve the central bank responding much less aggressively to inflationary shocks than the Taylor rule prescribes. The post-Covid period is an example. Central bankers often argue that they should look through certain supply shocks and sectoral shocks and vary the interest rate less than one-for-one with inflation in response to such shocks.

A prominent concern with such a policy is that it may open the door to self-fulfilling economic fluctuations—equilibrium indeterminacy. In this section, we present two arguments for why this concern is overstated in the literature. First, in the canonical New Keynesian model with fully rational expectations, self-fulfilling economic fluctuations can be ruled out in a more targeted manner than is typically done in the literature, leaving policy free to respond in a shock-contingent manner to demand and supply shocks without risking indeterminacy of the equilibrium. Second, local indeterminacy is extremely fragile to even very modest and reasonable deviations from full rational expectations.

We also discuss the more traditional concern that passive interest rate policy will result in inflation spiraling out of control. This is an important concern that hinges crucially on the degree to which long-run inflation expectations are anchored.

3.1 The Canonical New Keynesian Model

We begin by considering the canonical New Keynesian model. The behavior of the private sector in this model is described by an intertemporal IS curve and a Phillips curve:

$$y_t = \mathbb{E}_t y_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1}) + \epsilon_t, \tag{3}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa(y_t - y_t^*) + \eta_t, \tag{4}$$

where y_t denotes output, π_t denotes inflation, $\mathbb{E}_t$ denotes model-consistent expectations conditional on information known at time t, σ is the intertemporal elasticity of substitution, β is agents' subjective discount factor, and κ is a composite parameter representing the "slope" of the Phillips curve. Woodford (2003) and Galí (2015) provide detailed discussions of the derivation of these equations from primitive assumptions on preferences and technology.

Notice that we have chosen to write the model in terms of three exogenous variables: a demand shock ϵ_t, the efficient level of output y_t^*, and a cost-push shock, η_t. The efficient level of output is the level of output that the central bank must target to minimize the welfare loss of economic fluctuations. In some cases, the efficient level of output is equal to the level of output that would prevail with flexible prices—which we denote by y_t^f—but in other cases, these diverge.

Supply shocks can then be divided into two categories. The first category consists of supply shocks that do not drive a wedge between the efficient level of output and the flexible-price level of output. In the canonical New Keynesian model, productivity shocks are an example of such shocks. Cost push shocks η_t are a second category of supply shocks that do drive a wedge between the efficient level of output and the natural level of output. Cost push shocks are proportional to the difference between the efficient and flexible-price levels of output, $\eta_t = \kappa(y_t^* - y_t^f)$. They create a trade-off between inflation stabilization and output stabilization. We discuss in section 4.3 how a wide variety of shocks (including sectoral productivity shocks) yield cost push shocks in extensions of the New Keynesian model.

We assume that the central bank's objective is to minimize the following quadratic loss function

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left[\pi_{t+j}^2 + \alpha(y_{t+j} - y_{t+j}^*)^2 \right], \tag{5}$$

where α is the relative weight on output stabilization in the central bank's objective—i.e., the weight on the Fed's maximum employment mandate.[11]

It is convenient to define the output gap as $x_t = y_t - y_t^*$ and rewrite the model as

$$x_t = \mathbb{E}_t x_{t+1} - \sigma(i_t - \mathbb{E}_t \pi_{t+1}) + \epsilon_t - y_t^* + \mathbb{E}_t y_{t+1}^*, \tag{6}$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t + \eta_t. \tag{7}$$

3.2 A Minimalist's Taylor Principle in a Model with Demand Shocks

It is well-known that a "divine coincidence" holds in the canonical New Keynesian model in response to demand shocks, productivity shocks, and other supply shocks that do not drive a wedge between y_t^* and y_t^f (Blanchard and Galí, 2007). With a single instrument, the central bank can achieve a bliss point for *both* objectives: $\pi_t = 0$ and $x_t = 0$. To see this, consider a case with only

[11] This loss function can be derived from micro-foundations (see, e.g, Woodford, 2003). In that case, α is a function of the structural parameters of the model. For typical calibrations of the model, this microfoundation yields a very small value for α. We consider larger values of α in this paper.

shocks to the dynamic IS curve, i.e., suppose $\eta_t = 0$. Equation (7) then implies that for inflation to be zero at all time, the output gap must be zero at all times; and equation (6) implies that for the output gap to be zero at all time, the interest rate must be

$$i_t = \sigma^{-1}(\epsilon_t - y_t^* + E_t y_{t+1}^*) \equiv r_t^*.$$

We refer to $r_t^* \equiv \sigma^{-1}(\epsilon_t - y_t^* + E_t y_{t+1}^*)$ as the natural rate of interest.[12] If the nominal interest rate i_t tracks r_t^*, the bliss point $\pi_t = 0$ and $x_t = 0$ is an equilibrium.

Does this mean that the central bank can simply adopt the policy rule $i_t = r_t^*$? The modern literature on monetary theory has emphasized that the answer to this question is 'no.' The problem is that the policy rule $i_t = r_t^*$ does not guarantee a locally determinate equilibrium. Put differently, there are other bounded paths for inflation and the output gap that satisfy equations (6)-(7) and the policy rule $i_t = r_t^*$. In fact there are infinitely many such paths and many of them involve a great deal of variation in inflation and the output gap.

A conceptually simple solution to this determinacy problem is for the central bank to set policy according to the following policy rule:

$$i_t = r_t^* + \phi_o \pi_t, \tag{8}$$

where $\phi_o > 1$. With this policy rule, the unique bounded equilibrium of the model is $\pi_t = 0$ and $x_t = 0$ (Woodford, 2003; Galí, 2015). The nominal interest rate is very responsive: it tracks the natural rate. In fact, it is so responsive that inflation and the output gap do not vary at all.

Policy rule (8) may at first blush seem similar to the Taylor rule. In fact this rule is fundamentally different from the Taylor rule. The $\phi_o \pi_t$ term in this policy rule is completely inactive on equilibrium. The policy rule (8) yields an equilibrium with $\pi_t = 0$ and $x_t = 0$, which means that $\phi_o \pi_t = 0$. The role of the $\phi_o \pi_t$ term is purely to eliminate other less desirable equilibria associated with *non-fundamental shocks*. (Throughout the paper, we will put a subscript o on ϕ for "off-equilibrium" when that term in the policy rule is inactive on equilibrium.)

In sharp contrast, the analogous term in the Taylor rule guides changes in interest rates on equilibrium in response to normal shocks such as demand and supply shocks. This is a crucial empirical distinction since only on-equilibrium features of the policy rule are observed in the data. We say that a policy rule that responds strongly to inflation associated with non-fundamental

[12]Strictly speaking, this is the efficient level of the real interest rate.

shocks (but not necessarily fundamental shocks) satisfies a minimalist's Taylor principle.

3.3 A Minimalist's Taylor Principle in a Model with Cost-Push Shocks

Policy rules that make use of the minimalist's Taylor principle can also be used in settings where the divine coincidence does not hold and inflation occurs on the equilibrium path. We consider the canonical New Keynesian model with cost push shocks and start with the case of optimal policy with discretion.[13] (We do the commitment case below.) Suppose for simplicity that the cost push shock follows an AR(1) process. Galí (2015) shows that optimal policy under discretion implies that $x_t = -(\kappa/\alpha)\pi_t$ and in equilibrium $\pi_t^d = a_\pi^d \eta_t$ and $x_t^d = -a_x^d \eta_t$, where a_π^d and a_x^d are positive constants and the d superscripts refer to optimal discretion. (See page 130 of Galí (2015) for their exact expressions in terms of the model's primitive parameters). In this equilibrium, the nominal interest rate is $i_t^d = r_t^* + a_i^d \eta_t$, where a_i^d is a positive constant.

How should the central bank bring about this equilibrium? The policy rule (8) with $\phi_o > 1$ will again achieve determinacy. But in this case, $\pi_t \neq 0$ and the $\phi_o \pi_t$ term in policy rule (8) is active on equilibrium. In this case, therefore, policy rule (8) does not yield a minimalist Taylor principle. Moreover, to bring about the optimal response, the value of ϕ_o must be $a_i^d / a_\pi^d = (\alpha\rho_s + \sigma^{-1}\kappa(1-\rho_s))/\alpha$, where ρ_s is the persistence of the cost push shock (Galí, 2015, p. 130-133). With $\alpha = 1$ (equal weight on percentage changes in inflation and the output gap in the central bank's loss function), $\sigma = 1$ (an intertemporal elasticity of substitution equal to one), and the slope of the Phillips curve $\kappa < 1$ (we use 0.024 later in this paper), the optimal ϕ_o is less than one. In this case, policy rule (8) cannot yield both determinacy and the optimal outcome.

There is, however, a different type of policy rule that yields determinacy via the minimalist's Taylor principle and thereby leaves the central bank free to respond optimally to the natural rate of interest and cost push shocks on equilibrium. This is the policy rule

$$i_t = r_t^* + a_i^d \eta_t + \phi_o(\pi_t - \pi_t^d), \tag{9}$$

where $\phi_o > 1$ as before. This policy rule achieves optimal policy with discretion as a unique bounded equilibrium. Just as in the divine coincidence case discussed in the last section, the last term in this policy rule—$\phi_o(\pi_t - \pi_t^d)$—is completely inactive on equilibrium. In response to

[13] Tenreyro (2024) has pointed out that optimal policy under discretion implicitly incorporates a great deal of commitment. For example, if the central bank is assumed to minimize (5), one is already assuming that the central bank is committed not to be subject to the inflation bias emphasized by Kydland and Prescott (1977) and Barro and Gordon (1983).

natural rate shocks, both $\pi_t = 0$ and $\pi_t^d = 0$, implying that $\phi_o(\pi_t - \pi_t^d) = 0$. In response to cost push shocks, $\pi_t = \pi_t^d$, implying that $\phi_o(\pi_t - \pi_t^d) = 0$. The role played by the last term in the policy rule—the minimalist's Taylor rule term—is solely to eliminate indeterminacy. It plays a purely off-equilibrium role, and cannot be estimated by an econometrician in observed time series data.[14]

The minimalist Taylor principle can also be implemented for optimal policy with commitment. Suppose again that the cost push shock follows an AR(1) process. Galí (2015) shows that optimal policy implies $\Delta x_t = -(\kappa/\alpha)\pi_t$.[15] Combining this equation with equations (6) and (7), one can show that equilibrium inflation and output under optimal policy with commitment takes the form $\pi_t^c = b_\pi^c x_{t-1}^c + a_\pi^c \eta_t$ and $x_t^c = b_x^c x_{t-1}^c + a_x^c \eta_t$, where a_π^c, b_π^c, a_x^c, b_x^c are constants which can be determined using the method of undetermined coefficients. In this case, the equilibrium nominal interest rate will be $i_t^c = r_t^* + b_i^c x_{t-1}^c + a_i^c \eta_t$, where again a_i^c and b_i^c are constants.

As in the cases above, one can construct a policy rule that yields a unique bounded equilibrium simply by tagging on a term that responds strongly to deviations of inflation from the optimal path of inflation:

$$i_t = r_t^* + b_i^c x_{t-1}^c + a_i^c \eta_t + \phi_o(\pi_t - \pi_t^c), \tag{10}$$

where $\phi_o > 1$. As before, the last term in this interest rate rule plays only an off-equilibrium role.

An important feature of policy rule (10) is that it frees the central bank to respond very differently to demand versus cost push shocks even if this implies violating the standard Taylor principle on equilibrium. This freedom arises from the complete separation it achieves between the response of the central bank to fundamental and non-fundamental shocks. Determinacy is achieved by responding forcefully to non-fundamental shocks. Responding aggressively to fundamental shocks is not necessary.

We have focused on optimal policy under discretion and commitment. But the argument is more general. The central bank can choose a wide range of policies in response to fundamental shocks and add a term of the form $\phi_o(\pi_t - \pi_t^x)$ to its policy rule, where π_t^x denotes the minimum state variable response of inflation to fundamental shocks given the central bank's policy. This added term will be completely inactive on equilibrium, but it will guarantee determinacy.

[14] Galí (2015, p. 133) discusses this type of policy rule. This idea goes back at least to King (2000), who proposes that the central bank fully stabilize the output gap in response to cost push shocks and tags on a term to the interest rate rule that responds strongly only to inflation movements that deviate from the equilibrium with $x_t = 0$.

[15] The condition for optimal policy is different in the period when the initial commitment is made. We ignore this and instead assume the central bank is setting optimal policy with commitment from a timeless perspective (Woodford, 2003).

It is not uncommon to see researchers let concerns about indeterminacy constrain the ways in which monetary policy responds to fundamental shocks. In particular, to let concerns about determinacy dictate a strong response to cost push shocks when such a response is not optimal. Adopting the minimal Taylor principle relaxes this constraint. Strong responses to non-fundamental shocks (off equilibrium) allow the central bank to "look through" cost push shocks without concern for determinacy.

There are two obvious practical concerns with ensuring determinacy via a minimalist Taylor principle. First, policymakers may not always be able to identify non-fundamental shocks. Second, policymakers may have trouble convincing observers that they will respond forcefully to non-fundamental inflation if this behavior is not observed on the equilibrium path. A conservative approach would therefore be for the central bank to adopt the default of responding strongly to inflation for fear that some component of the observed inflation may be caused by non-fundamental shocks. But to deviate from this when it has substantial confidence that the inflation is caused by cost push shocks for which a smaller response is optimal.

3.4 (In)determinacy in a Less Forward-Looking Model of the Economy

A different approach to liberating optimal monetary policy deliberations from determinacy concerns is to consider models that are less forward-looking than the canonical New Keynesian model. Motivated by the forward guidance puzzle (Del Negro, Giannoni, and Patterson, 2012; McKay, Nakamura, and Steinsson, 2016), a number of researchers have in recent years proposed departures from the cannonical New Keynesian model in which households and firms have less than fully rational expectations (Angeletos and Lian, 2018; Woodford, 2018; Farhi and Werning, 2019; Gabaix, 2020). Here we consider the finite planning horizon model of Woodford (2018) which Gust, Herbst, and López-Salido (2022) show provides a better fit to U.S. business cycles than the canonical New Keynesian model and other variants of behavioral New Keynesian models.

The cyclical components of output, inflation, and the nominal interest rate in Woodford's finite planning horizon model are given by the solution to

$$\tilde{y}_t = \omega \mathbb{E}_t \tilde{y}_{t+1} - \sigma(\tilde{\imath}_t - \omega \mathbb{E}_t \tilde{\pi}_{t+1}) + \epsilon_t, \tag{11}$$

$$\tilde{\pi}_t = \omega\beta \mathbb{E}_t \tilde{\pi}_{t+1} + \kappa(\tilde{y}_t - y_t^*) + \eta_t, \tag{12}$$

and a monetary policy rule, where $\tilde{y}_t$, $\tilde{\pi}_t$, and $\tilde{\imath}_t$ denote the cyclical component of output, inflation, and the nominal interest rate. The difference between this model and the canonical New Keynesian model is the factor $\omega < 1$ that multiplies the expected output and expected inflation terms in the dynamic IS equation and Phillips curve. This factor dampens the degree to which the model is forward looking.[16] The models proposed by Angeletos and Lian (2018) and Gabaix (2020) yield very similar but not identical equations.

Indeterminacy of the equilibrium does not arise in the finite planning horizon model (Woodford, 2018; Dupraz and Marx, 2025). The reason is that Woodford's model assumes that agents' beliefs about their continuation value at the end of their finite planning horizon and the value of the variables that this continuation value depends on (in particular output and inflation) evolve according to a backward-looking rule based on past experience. At any given point in time, these beliefs are given. There is only one path of output and inflation that is consistent with these given beliefs for any sequence of fundamental shocks. All non-fundamental fluctuations involve dynamics relative to this path that die out exponentially over the infinite future. These will not be consistent with agents' beliefs at the end of the finite planning horizon and therefore cannot be sustained as equilibria in the finite planning horizon model.[17]

At a more intuitive level, a non-fundamental disturbance can only be sustained if agents today expect agents tomorrow to also respond to the disturbance, and tomorrow's agents must expect agents the next day to also respond, and so on into the infinite future. When agents have finite planning horizons, this sequence of beliefs about the behavior of future agents gets cut off at the end of the finite planning horizon and therefore cannot be sustained as an equilibrium. This shows that the local indeterminacy problem is extremely fragile to the standard (but extreme) rational expectations assumption of infinite planning horizons.

But suppose we ignore the fact that beliefs about the economy beyond the finite planning horizon are given at any point in time in Woodford's model and simply consider equations (11) and (12) as a full description of the behavior of the private sector.[18] Even in this case, indeterminacy turns out to be highly fragile to modest deviations from fully rational expectations (i.e., modest deviations from $\omega = 1$). In appendix C, we show that equations (11) and (12) augmented with a

[16] Woodford's (2018) model also involves time-varying trend components to output, inflation, and the nominal interest rate. However, the model is block-recursive with the trends depending on the cyclical components but not vice versa. We start by focusing on the cyclical part of the model.

[17] In fact, as Dupraz and Marx (2025) emphasize, the finite planning horizon model also rids the model of self-fulfilling hyperinflations for the same reason. I.e., it yields a globally unique solution.

[18] Recall that other variants of less forward-looking New Keynesian models—e.g., Angeletos and Lian (2018); Gabaix (2020)—give rise to very similar equations.

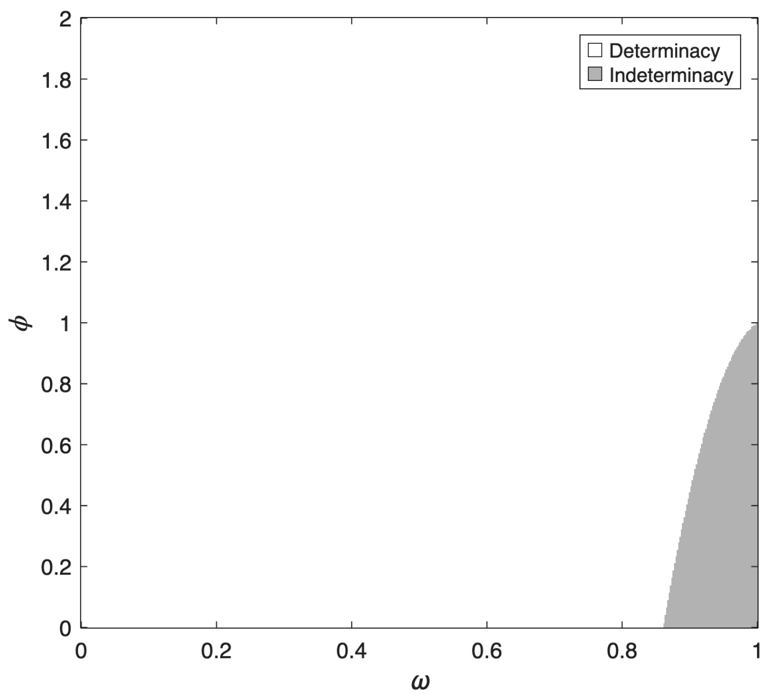

Figure 13: Determinacy in a Less Forward-Looking Model

Note: The figure depicts the set of values of parameters ϕ and ω for which the condition $\beta\omega(1-\omega) < (1-\omega) + \kappa\sigma(\phi-\omega)$ guaranteeing determinacy is satisfied when $\sigma = 1$, $\beta = 0.99$, and $\kappa = 0.024$.

monetary policy rule given by $\tilde{\imath}_t = \phi\tilde{\pi}_t$ yields a unique bounded solution if

$$\beta\omega(1-\omega) < (1-\omega) + \kappa\sigma(\phi-\omega). \tag{13}$$

Figure 13 shows that the value of ϕ required for determinacy is very sensitive to ω. While $\phi > 1$ is required when $\omega = 1$ (the canonical New Keynesian model), only $\phi > 0.45$ is needed for $\omega = 0.9$, and any positive value of ϕ guarantees determinacy if $\omega < 0.86$.[19] For reference, Gust, Herbst, and López-Salido (2022) estimate a value of 0.5 for ω for U.S. business cycle fluctuations and Gabaix (2020) estimates a value of 0.75 for a closely related parameter in his behavioral New Keynesian model. Clearly, even very modest deviations from fully rational expectations eliminate concerns about equilibrium determinacy in the New Keynesian model.

Another stark illustration of how fragile indeterminacy in the New Keynesian model is to deviations from full rationality is developed by Angeletos and Lian (2023). They show that equilibria that load on non-fundamental shocks rely on complete recall of past non-fundamental shocks into

[19]Gust, Herbst, and López-Salido (2022) argue that $\phi > \omega$ is needed to guarantee determinacy in this case. Their derivation of this result contains an error. Equation (13) is (we believe) the correct condition for determinacy.

the infinite past. Even infinitesimally small amounts of imperfect recall of past non-fundamental shocks eliminate all local indeterminacy.[20]

3.5 Avoiding Inflationary Spirals

The traditional concern regarding the central bank setting policy using interest rates and not being sufficiently responsive to inflation was not indeterminacy but rather that inflation would spiral out of control (Wicksell, 1898; Friedman, 1968). Suppose inflation rises and is expected to remain high. If the central bank raises interest rates less than one-for-one, the real interest rate falls. This increases demand, and therefore raises inflation further. If inflation expectations respond sufficiently, this type of feedback loop can lead inflation to spiral out of control.

Perhaps surprisingly, this type of inflation spiral does not arise in the canonical full-information New Keynesian model. Consider the simple case in which monetary policy is given by the policy rule $i_t = \phi\pi_t$. The "fundamental" equilibrium of the model then returns to steady state after an inflationary cost push shock even if the nominal interest rate is completely unresponsive ($\phi = 0$). Inflation dies out as the underlying shock dies out. This is the case because long-run inflation expectations are completely anchored with this policy rule irrespective of the value of ϕ.[21]

The assumption of completely anchored long-run inflation expectations is extreme and unrealistic. Carvalho et al. (2023) propose a model with imperfectly anchored inflation expectations and show that it helps explain the joint low-frequency dynamics of inflation and inflation expectations in the United States in the post-WWII era. Woodford (2018) assumes that agents' beliefs about inflation at the end of their planning horizon—which act like long-run inflation expectations—are imperfectly anchored in his finite planning horizon model. In Dupraz and Marx's (2025) somewhat simplified version of this model, agents' terminal beliefs about inflation evolve according to the following constant-gain learning rule:

$$\bar{\pi}_t = (1-\gamma)\bar{\pi}_{t-1} + \gamma\pi_t \tag{14}$$

[20] Angeletos and Lian (2023) show this result in a linear approximation of their model. Models with incomplete markets that yield a discounted Euler equation also yield a determinate equilibrium (Acharya and Dogra, 2020; Bilbiie, 2024).

[21] In theory, inflation spirals can also arise from purely speculative hyperinflations (a different form of indeterminacy from the local indeterminacy problem discussed earlier in this section). We are not aware of any historical hyperinflation that was speculative (i.e. occurred without huge growth in the money supply). The classic theoretical solution to speculative hyperinflations involves a state-contingent fiscal backstop in extreme circumstances as discussed in Obstfeld and Rogoff (1983, 1986, 2021).

where $\bar{\pi}_t$ represents terminal beliefs about inflation and γ is the "gain parameter" that governs the speed of updating of these beliefs. When inflation increases, this increases agents' terminal beliefs about inflation. If monetary policy is insufficiently responsive, inflation and terminal beliefs about inflation keep rising. This may give rise to an inflation spiral.

This logic suggests that the degree to which long-run inflation expectations are anchored is a crucial determinant of the extent to which central banks can look through inflationary supply shocks. If inflation expectations are anchored, the central bank can look through a supply shock and rely on the shock itself dissipating for inflation to come down. If, however, inflation expectations are imperfectly anchored, looking through a supply shock risks destabilizing inflation expectations which then sparks the beginnings of an inflation spiral that will eventually require very high interest rates to tame. Anchored inflation expectations allow for less responsive policy: if inflation expectations do not rise, the nominal interest rate doesn't need to rise as much.

3.6 Summing Up

The analysis in this section demonstrates two general ideas. First, the Taylor principle does not need to hold on the equilibrium path for local determinacy. This helps explain why countries with well-anchored inflation expectation have been able to avoid high and unstable inflation over long periods of time without a strong and synchronous response of interest rates to inflation on the equilibrium path.

Determinacy does, however, require a credible commitment that the central bank will respond aggressively to signs that inflation is being caused by non-fundamental shocks or inflation spirals (e.g., our minimalist Taylor principle). For this, long-term inflation expectations are a key harbinger. If long-run inflation expectations become unanchored, the central bank will no longer be able to look through adverse supply shocks without risking an inflation spiral.[22]

The Fed benefited from a historic degree of anchoring of long-run inflation expectations during the post-Covid inflation spike. Figure 1 shows that long-run inflation expectations hardly budged during this episode. The small uptick in long-run inflation expectations in 2022 was swiftly followed by aggressive monetary policy tightening. This contrast sharply with the early 1980s, when long-run inflation expectations varied nearly one-for-one with realized inflation.

[22] Kiley (2025) discusses monetary policy rules that respond directly to long-run inflation expectations.

4 When Is It Optimal to Respond Less Than One-for-One to Inflation?

We now turn to optimal monetary policy. We present three reasons why it is optimal for a central bank with firmly anchored long-run inflation expectations to vary the nominal interest rate less than one-for-one with inflation in certain circumstances: 1) forward guidance, 2) correlated shocks, and 3) long and variable lags. We begin with a warm-up on optimal simple rules when the economy is hit by cost push shocks to help build intuition.

4.1 Warm Up: Optimal Simple Rules with Cost Push Shocks

Consider the following class of simple policy rules

$$i_t = \phi\pi_t + \phi_o(\pi_t - \pi_t^x). \tag{15}$$

The first term in this policy rule $\phi\pi_t$ is the on-equilibrium response of the nominal interest rate to inflation. The second term $\phi_o(\pi_t - \pi_t^x)$ implements our minimalist Taylor principle: it is an off-equilibrium response to non-fundamental variation in inflation. We assume that $\phi_o > 1$. We define π_t^x to be the fundamental response of inflation—i.e., the response of inflation in the "minimum state variable" equilibrium (McCallum, 1983) of the model with policy rule (15). The term $(\pi_t - \pi_t^x)$ is then zero unless inflation is affected by non-fundamental shocks. As in our analysis in section 3, the term $\phi_o(\pi_t - \pi_t^x)$ is included in the central bank's policy rule to eliminate local indeterminacy. Given the presence of the $\phi_o(\pi_t - \pi_t^x)$ term, we can consider policy rules with $\phi < 1$.

Consider the case where the economy is hit by cost push shocks η_t. We show in Appendix C, that the optimal value of ϕ in this case is

$$\phi = \rho_s + \frac{\kappa}{\alpha\sigma}\frac{(1-\rho_s)}{(1-\beta\rho_s)}, \tag{16}$$

where ρ_s is the persistence of the cost push shocks.

Interestingly, the optimal value of ϕ may be less than one—i.e., the nominal interest rate may *optimally* respond less than one-for-one with inflation. To understand why, notice that $\phi \to \rho_s$ when $\kappa \to 0$ or $\alpha \to \infty$. The $\kappa \to 0$ limit occurs when the Phillips curve is completely flat. The $\alpha \to \infty$ limit occurs when the weight on the output gap in the central bank's objective function becomes arbitrarily large. In these cases, inflation stabilization becomes arbitrarily costly—either because of the magnitude of output variation needed is large (when κ is small) or because the welfare loss from output variation is large (α is large).

Since the cost of inflation stabilization is high when $\kappa \to 0$ or $\alpha \to \infty$, the central bank chooses to stabilize the output gap. It does this by setting $\phi = \rho_s$. We can see this by plugging the policy rule (15) into the Euler equation (6). This yields

$$x_t = \mathbb{E}_t x_{t+1} - \sigma(\phi\pi_t - \mathbb{E}_t\pi_{t+1}). \tag{17}$$

To stabilize the output gap, the central bank must stabilize the real interest rate. Given the policy rule, this requires,

$$\phi\pi_t - \mathbb{E}_t\pi_{t+1} = 0. \tag{18}$$

If the persistence of the cost push shock is ρ_s, we have $\mathbb{E}_t\pi_{t+1} = \rho_s\pi_t$. Plugging this expression into the equation above yields $\phi\pi_t = \rho_s\pi_t$ or $\phi = \rho_s$.[23] Away from the $\kappa \to 0$ or $\alpha \to \infty$ limits, optimal policy raises the real interest rate (even if the coefficient is smaller than one). This means that the central bank leans against the inflation caused by the cost push shock (but does not fully eliminate it).

Clarida, Galí, and Gertler (1999) consider instead a policy rule of the form $i_t = \phi E_t\pi_{t+1}$. For this class of policy rules, the optimal value of ϕ is the same as equation (16) except that the first term is 1 rather than ρ_s. Just as in the case discussed above, it is optimal to respond one-for-one to expected inflation in the $\kappa \to 0$ or $\alpha \to \infty$ limits. Since inflation is partly transitory, this can imply responding less than one-for-one to realized inflation.

One way to interpret these results is that central banks should look through the part of inflation that is not expected to persist. When inflation expectations are unanchored—as they were in the 1980s—inflation expectations tend to move strongly with actual inflation. In this case, the distinction between realized and expected inflation makes little difference. However, when inflation expectations are firmly anchored, even short-term inflation expectations can deviate strongly from realized inflation.

The post-Covid inflation spike was a dramatic example of this phenomenon. Figure 14 plots core PCE inflation and 1-year inflation expectations for the GDP deflator from the Survey of Pro-

[23] In the continuous time limit of our model, the ρ_s in equation (16) becomes one and $\phi = 1$ is optimal in the $\kappa \to 0$ or $\alpha \to \infty$ limits. In this case, the interest rate moves one-for-one with inflation. It is not clear to us that the continuous time limit of the model is a better approximation to reality. It seems quite plausible that households, firms, and the central bank respond to macro developments only periodically rather than continuously, in which case the discrete time version is more realistic. The FOMC schedules eight regular meetings per year. Also, the standard formulation of the Taylor rule uses 12-month inflation as a measure of inflationary pressures.

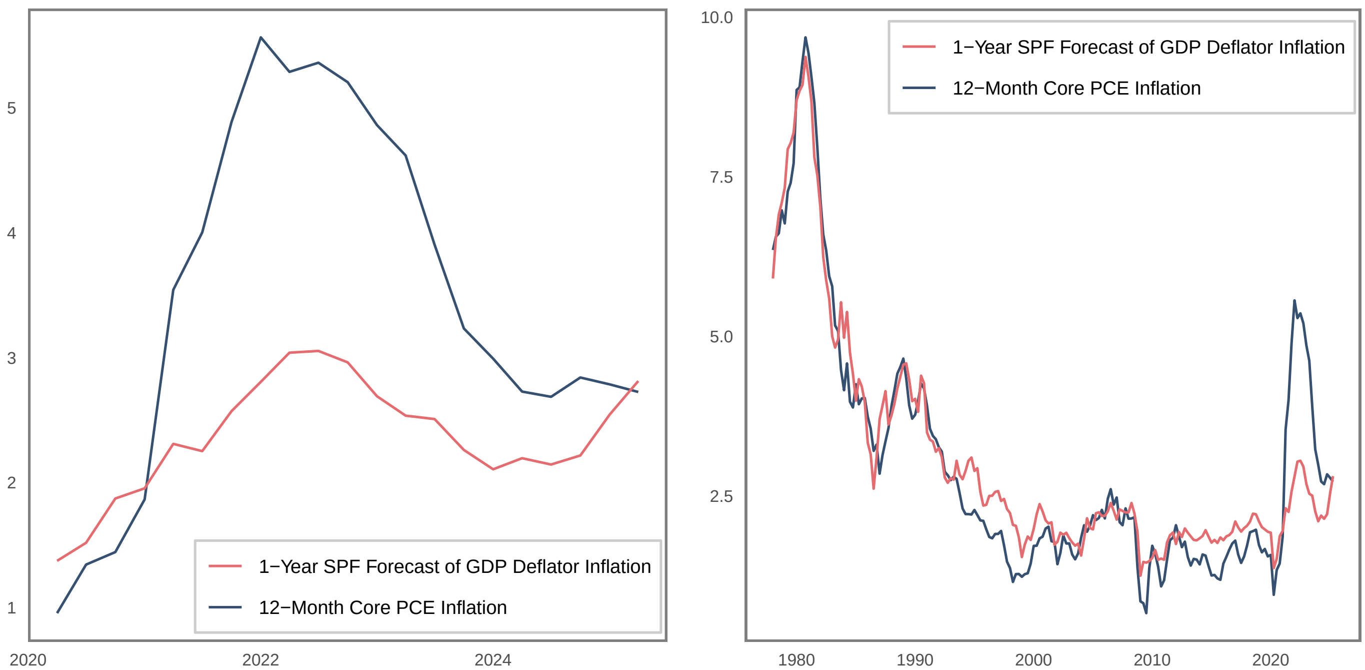

Figure 14: Core Inflation and One-Year Expected Inflation

Note: The figure plots core PCE inflation and one-year expected inflation for the GDP deflator from the Survey of Professional Forecasters. The sample period in the left can is 2020Q3 to 2025Q2. The sample period in the right panel is 1978Q1 to 2025Q2.

fessional Forecasters. In the left panel, we see that core PCE inflation rose from 2% to almost 6% in 2021 and 2022, while 1-year inflation expectations only rose to 3%. The right panel plots these same two variables back to the late 1970s. The magnitude of the difference between them that emerged post-Covid was unprecedented since the late 1970s. During the turbulent 1970s and 1980s, there was very little daylight between inflation and 1-year inflation expectations.[24]

It is optimal for the central bank to respond even less strongly to cost push shocks in Woodford's (2018) finite planning horizon model. Consider, for simplicity, the case where long-run beliefs are well anchored in that model (the gain parameter in equation (14) is small). We show in Appendix C that the optimal ϕ when the central bank is responding to cost push shocks is

$$\phi = \omega\rho_s + \frac{\kappa}{\alpha\sigma}\frac{(1-\omega\rho_s)}{(1-\beta\omega\rho_s)}. \tag{19}$$

In this case, $\phi \to \omega\rho_s \leq \rho_s$ when $\kappa \to 0$ or $\alpha \to \infty$. Recall that ω is the factor by which expectations terms are discounted in Woodford's model due to the fact that agents' planning horizons are finite. If ω is substantially below one—as the estimates of Gust, Herbst, and López-Salido (2022)

[24]Figure B.2 in the Appendix is an analogous figure for 1-quarter inflation expectations.

suggest—the optimal ϕ can be quite small.

The optimal response to demand (as opposed to cost-push) shocks is, in contrast, unambiguously aggressive. In the canonical New Keynesian model, any variation in inflation induced by demand shocks is suboptimal (since the divine coincidence holds). To minimize equilibrium variation in inflation, monetary policy should respond very strongly (infinitely strongly) to demand-driven inflation. In other words, the optimal value of ϕ is infinite in this case and actual inflation doesn't move at all.[25]

4.2 Optimal Policy with Commitment in Response to Cost-Push Shocks

Next consider optimal policy with commitment. In this case, we simulate data from the canonical New Keynesian model with only cost push shocks and with monetary policy set optimally with commentment. (Recall that optimal monetary policy with commitment implies that $\Delta x_t = -(\kappa/\alpha)\pi_t$.) We then run a Taylor rule regression:

$$i_t = \bar{r} + \phi_\pi \pi_t + \phi_y x_t + \varepsilon_t \tag{20}$$

on this simulated data. For this exercise we calibrate the model at a quarterly frequency as follows. We set $\beta = 0.99$ and $\sigma = 1$. We set the slope of the Phillips curve to $\kappa = 0.024$ as estimated by Rotemberg and Woodford (1997). We assume that the cost push shocks follow an AR(1) process with an autoregressive coefficient of 0.85. We multiply inflation and the nominal interest rate by four so as to measure these variables in annualized form. We simulate the economy for 10,000 periods (with a 100 period burn-in).

Table 1 reports the results from this analysis for a wide range of different weights on the output gap in the central bank's loss function α. For concreteness, consider the results for $\alpha = 1$. In this case, the coefficient on inflation in the estimated Taylor rule is 0.81 and the coefficient on the output gap is 0.47. Both values are smaller than those Taylor chose for the original Taylor rule. The coefficient on inflation is substantially smaller. In particular, it is smaller than one.

We also report the quantity $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$. This is the quantity that traditional analyses of local determinacy focus on (e.g., Woodford, 2003; Galí, 2015). If monetary policy is governed by a

[25] If the economy is hit by both demand shocks and cost push shocks and the central bank sets policy according to a rule $i_t = \phi_\pi \pi_t + \phi_x x_t$, the relative value of ϕ_π and ϕ_x are set to respond optimally to the cost push shock and it is optimal to drive both of these coefficients to very large (infinite) values to eliminate economic fluctuations associated with the demand shock. However, this conclusion is highly sensitive to measurement error in the data and exact knowledge of the structure of the economy (Boehm and House, 2019).

Table 1: Estimated Taylor Rules under Optimal Policy with Commitment

Weight on Output Gap (α)	Inflation	Output Gap	$\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$
10.00	0.84	1.02	0.95
5.00	0.84	0.85	0.93
2.00	0.83	0.62	0.89
1.00	0.81	0.47	0.86
0.50	0.79	0.34	0.82
0.20	0.71	0.21	0.73
0.10	0.60	0.13	0.62
0.05	0.40	0.06	0.41
0.02	-0.14	-0.02	-0.15
0.01	-0.94	-0.07	-0.95

Note: The table reports the regression coefficients ϕ_π and ϕ_y from a Taylor rule regression $i_t = \bar{r} + \phi_\pi \pi_t + \phi_y x_t + \varepsilon_t$ on simulated data from the canonical New Keynesian model when policy is optimal with commitment. We annualize the model-generated data on inflation and the nominal interest rate by multiplying by it four. We also report $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$, the quantity that is used to evaluate the Taylor principle in traditional analyses. We show results for different values of α the coefficient on the output gap in the central bank's loss function (5). We use our baseline calibration with a slope of the Phillips curve of $\kappa = 0.024$ and persistence of the cost push shocks of $\rho_s = 0.85$.

simple Taylor rule, this quantity must be larger than one to guarantee determinacy, in which case the Taylor principle is said to hold. The results in Table 1 show that the Taylor principle does not hold for a Taylor rule estimated on simulated data from the model with monetary policy set optimally with commitment.[26]

Intuitively, the reason why optimal policy yields relatively moderate contemporaneous co-movement of the nominal interest rate with inflation and the output gap is that the central bank optimally uses a combination of current and future tight policy to respond to the inflationary cost push shock. In other words, optimal policy involves a substantial amount of forward guidance. When α is small, this effect is sufficiently strong that the contemporaneous comovement of the nominal interest rate and inflation can switch sign.[27]

This kind of forward guidance is an important component of the Federal Reserve's policy in

[26] In Appendix D, we present two variants on this analysis. We present results for a case where we assume a flatter Phillips curve slope of $\kappa = 0.0069$ based on the analysis of Hazell et al. (2022). See more detail on how this slope is calculated in the appendix. We also present results for a Taylor rule specification with 12-month inflation. In both cases, the results are qualitatively similar.

[27] This effect is stronger when α is small because the central bank is more willing to vary the real interest rate and therefore the output gap when α is small. When α is large, the central bank limits variation in the real interest rate to achieve a near-zero output gap. When α is small, the central bank varies the real interest rate more to achieve a better outcome for inflation. This involves substantial deflation in the periods after an inflationary shock. During these periods, nominal rates are high while inflation is low.

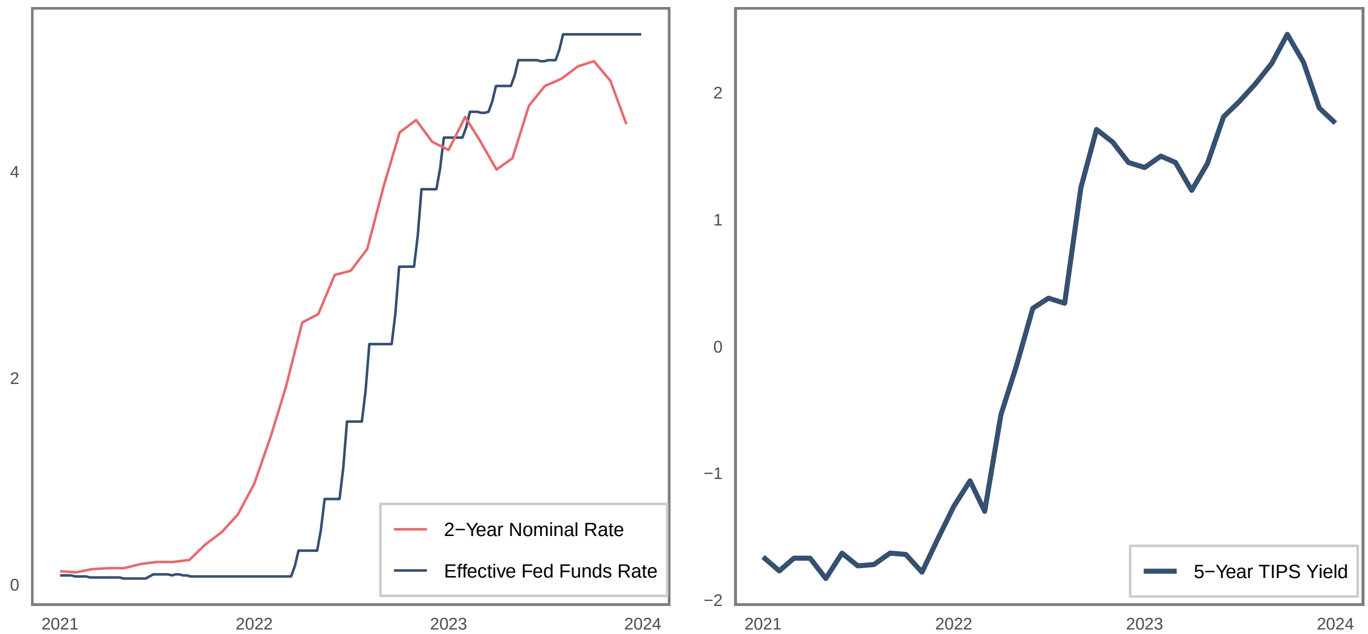

Figure 15: Forward Guidance During Post-Covid Tightening

Note: The left panel plots the federal funds rate at a weekly frequency and the 2-year nominal Treasury rate at a monthly frequency. The right panel plots the 5-year constant maturity inflation indexed yield calculated from U.S. TIPS securities by the Board of Governors of the Federal Reserve System. The sample period is January 2021 to January 2024.

practice. When inflation was rising after Covid, the Fed did not raise the federal funds rate until March 2022. However, members of the FOMC began to "pivot" in November 2021 in speeches and other communications, which led longer-term interest rates to start rising much earlier than the federal funds rate. The left panel of Figure 15 plots the federal funds rate along with the 2-year nominal Treasury rate from January 2021 to January 2024. The 2-year rate began rising even before the pivot began and had risen to roughly 2% by the time of the Fed's first federal funds rate hike. The 2-year rate continued to rise ahead of the federal funds rate throughout 2022, with the federal funds rate only catching up at the end of 2022. The fact that the 2-year yield led the federal funds rate over this period by a substantial amount reflects forward guidance by the Fed and the bond market's understanding of the Fed's reaction function.

Dupraz and Marx (2025) argue provocatively that the Fed's delayed response to inflationary shocks in 2021 and 2022 may have been close to optimal. They come to this conclusion using Woodford's finite horizon planning model, in which they show that delayed interest rate tightening is optimal in response to cost push shocks. While short term real interest rates fell in 2021 and early 2022, longer-term real interest rates rose dramatically. The right panel of Figure 15 plots the 5-year real interest rate implied by TIPS between January 2021 and January 2024. From late 2021 to late 2022, it rose by a whopping 3.5 percentage points.

While the optimal response to cost push shocks with commitment is muted and delayed, the optimal response to demand shocks is forceful and immediate (the nominal rate should track the natural rate period-by-period). An important practical challenge facing central banks is to assess what shocks are hitting the economy at any given point in time. This will inevitably give rise to debates about the optimal course of policy. In many cases, however, observable variables will give clues as to which types of shocks are hitting the economy and therefore what optimal policy would dictate. Oil shocks are perhaps the most obvious example, but variation in fiscal policy, military spending, house price, and shocks such as 9/11 are other salient examples.

Recent research finds support for the view that the Federal Reserve acts in a shock-contingent manner along the lines discussed above. Hofmann, Manea, and Mojon (2024) estimate a "targeted" Taylor rule where they distinguish between demand-driven inflation and supply-driven inflation using the decomposition of Shapiro (2024). Over the sample period 1979Q3-2007Q4, they find that the coefficient on demand-driven inflation is almost four times larger than the coefficient on supply-driven inflation (3.75 versus 1.02).

4.3 Correlated Shocks

A second reason why it may be optimal for the central bank to respond less than one-for-one to a change in inflation is the presence of correlated shocks. In theoretical models of monetary policy, demand and supply shocks are usually assumed to be uncorrelated and analyzed separately. Actual inflationary episodes, however, typically arise from a combination of different shocks. Correlated shocks may also arise because a particular fundamental disturbance (e.g., a productivity shock) yields a shock to both the Phillips curve and the dynamic IS equation. In the canonical New Keynesian model, most standard shocks map into either a shock to the Phillips curve or a shock to the dynamic IS equation (not both). However, the stylized nature of the canonical New Keynesian model implies that it abstracts from great number of complexities in real economies. These complexities imply that there are other variables that should show up in the equations of the model to accurately represent the world. The error terms of the model equations absorb all of these extra variables. To the extent that these extra variables (in the error terms) are driven by the same primitive shocks, the error terms in the different equations will be correlated. For this reason, it is natural to think of shocks to the Phillips curve and dynamic IS equation as being correlated.

Consider a model with both wage and price rigidity. Such a model yields a price Phillips curve with a real wage gap term, i.e., the deviation of the real wage from the flexible price real wage (Erceg, Henderson, and Levin, 2000). This term is a part of the error term in the Phillips curve in the 3-equation New Keynesian model. In effect it shows up as a cost push shock. But the real wage gap is a function of productivity, which also determines the natural rate of interest. This means that productivity shocks show up both as cost push shocks (shocks to the Phillips curve) and natural rate shocks (shocks to the dynamics IS curve) in the canonical New Keynesian model if the true economy features wage and price rigidity. As a consequence, one should expect cost push shocks and natural rate shocks to be correlated (negatively correlated).[28]

Correlated shocks similarly arise from models featuring multiple sectors with heterogeneous price rigidity (or other heterogeneity and frictions). In such models, sectoral relative price gaps appear in the Phillips curve (unless the price index is defined in a very particular manner) and break the divine coincidence (Benigno, 2004; Woodford, 2003; Rubbo, 2023; Afrouzi, Bhattarai, and Wu, 2024). An important example of such relative prices are energy prices. Another example is the real exchange rate in an open economy setting (Corsetti, Dedola, and Leduc, 2011). Such relative price gaps are in the error term of the canonical New Keynesian Phillips curve (except in knife-edge cases). Since they depend on productivity shocks, they again lead to correlations between shocks to the Phillips curve and shocks to the dynamics IS curve.

Table 2 presents results analogous to those presented in Table 1 except that we simulate the model with both cost push and natural rate shocks and assume that these shocks are either perfectly negatively correlated or perfectly positively correlated. We see that in the case of negatively correlated shocks—i.e., an inflationary cost push shock paired with a negative shock to the natural rate—the estimated Taylor rule coefficient on inflation (as well as $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$) is even smaller than in the case presented in Table 1.[29] With $\alpha = 1$, the coefficient on inflation is only 0.64. The low comovement of inflation and the nominal interest rate arises because the natural rate of interest falls when the economy is hit by an inflationary cost push shock.

The results in Table 2 are for a case where the variance of the cost push shock and the natural

[28]An important wrinkle to this interpretation is that the real wage gap is affected by monetary policy. This implies that the error term in the Phillips curve is not exogenous. A full analysis would to take this into account. This contrasts the fully exogenous if somewhat artificial cost push shocks typically assumed in the literature, e.g., tax shocks and markup shocks (Steinsson, 2003). This same wrinkle applies to the relative price gaps discussed in the next paragraph.

[29]The presence of natural rate shocks that are uncorrelated with the cost push shocks has no effect on the regression coefficients. Since the divine coincidence holds with respect to natural rate shocks, the central bank optimally offsets them perfectly, leading to variation in the nominal interest rate that is uncorrelated with output and inflation, i.e., random noise in the dependent variable, which leaves the coefficients in the regression unchanged.

Table 2: Estimated Taylor Rule with Optimal Policy under Commitment and Correlated Shocks

	Perfect Negative Correlation			Perfect Positive Correlation		
α	Inflation	Output Gap	$\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$	Inflation	Output Gap	$\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$
10.00	0.68	2.13	0.90	1.01	-0.09	1.00
5.00	0.68	1.79	0.86	1.00	-0.09	0.99
2.00	0.66	1.35	0.80	1.00	-0.10	0.99
1.00	0.64	1.05	0.75	0.99	-0.10	0.98
0.50	0.60	0.80	0.69	0.97	-0.11	0.96
0.20	0.51	0.54	0.57	0.91	-0.12	0.90
0.10	0.39	0.40	0.43	0.82	-0.14	0.80
0.05	0.16	0.28	0.19	0.64	-0.15	0.62
0.02	-0.43	0.16	-0.41	0.14	-0.19	0.12
0.01	-1.28	0.07	-1.27	-0.61	-0.22	-0.63

Note: The table reports the regression coefficients ϕ_π and ϕ_y from a Taylor rule regression $i_t = \bar{r} + \phi_\pi \pi_t + \phi_y x_t + \varepsilon_t$ on simulated data from the canonical New Keynesian model when policy is optimal with commitment. We annualize the model-generated data on inflation and the nominal interest rate by multiplying by it four. We also report $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$, the quantity that must be greater than one to guarantee determinacy if the central bank does not respond strongly specifically to non-fundamental variation in inflation. We report cases where the cost push shocks and natural rate shocks are perfectly negatively correlated and a case where they are perfectly positively correlated. In both cases, the two shocks have equal variance. We show results for a wide range of different values of α, the coefficient on the output gap, in the central bank's loss function (5). We use our baseline calibration with a slope of the Phillips curve of $\kappa = 0.024$ and persistence of the shocks of $\rho_s = \rho_{r^*} = 0.85$.

rate shock are the same. Figure 16 varies the relative variance of these shocks. Here, we report only the composite coefficient $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$ which has traditionally been emphasized in discussions of local determinacy. We see that when the economy is hit mostly by natural rate shocks, this composite coefficient becomes very small (even negative in extreme cases).

The early phases of Covid likely saw a combination of a positive cost push shock a negative shock to the natural rate. Covid shifted demand away from contact-intensive service sectors and towards goods producing sectors (Stock and Watson, 2025). Guerrieri et al. (2021) show that this type of shock manifests as an inflationary cost push shock in an economy with downward nominal rigidity. Furthermore, Covid resulted in heightened uncertainty and fear that likely lowered the natural rate of interest. Pushing in the other direction was the large amount of fiscal stimulus passed by Congress in several rounds in 2020 and 2021.

4.4 Long and Variable Lags

A third reason why central banks might want to vary the nominal interest rate less than one-for-one with inflation is if the shock causing the inflation is transitory and monetary policy only

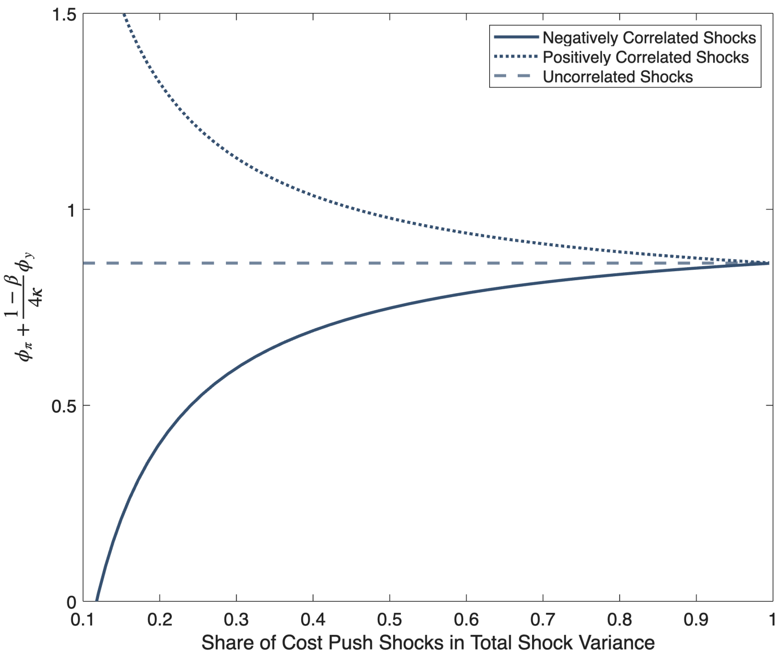

Figure 16: Taylor Principle with Increasing Relative Variance of Cost-Push Shocks

Note: The figure plots $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$ for estimated Taylor rules based on simulated data from the canonical New Keynesian model when policy is optimal with commitment. We do this for different relative variances of the cost push shocks to total shock variance. In other words, the x-axis of the figure is $\text{var}(\eta_t)/(\text{var}(\eta_t) + \text{var}(r_t^*))$. We report results for the case of uncorrelated shocks, perfectly negatively correlated shocks, and perfectly positively correlated shocks. We use our baseline calibration with a slope of the Phillips curve of $\kappa = 0.024$, the weight on output in the central bank's loss function of $\alpha = 1$, and persistence of the shocks of $\rho_s = \rho_{r^*} = 0.85$.

affects the economy with a lag. If monetary policy only affects the economy with a 6-12 month lag and the shock that is resulting in elevated inflation will have largely died out by that time, there is little point in the central bank responding to the shock. Bygones are bygones. The framework developed by Barnichon and Mesters (2023) formalizes these ideas and shows how to incorporate empirical evidence to quantify them.

Barnichon and Mesters (2023) show that the optimal response of policy to a shock is given by the weighted product of: 1) the effect of the shock on the policy objectives (e.g., inflation and the output gap), and 2) the effect of a change in the policy instrument on the policy objectives. Both of these effects should be thought of as impulse responses over the relevant horizon. In the case of a transitory shock, the effect of the shock on the policy objectives may be largely complete within (say) a year. If the policy instrument affects the policy objectives with a lag of close to a year, the effect of the policy instrument on the policy objectives will be close to orthogonal to the effect of the shock on the policy objectives. If this is the case, the product of the two impulse responses will be close to zero and it is optimal not to respond strongly to the shock.

Interestingly, we are not aware of existing structural models that provide micro-foundations for the delayed response of the economy to interest rates that we describe above. Simple New Keynesian models feature very front-loaded responses of output and inflation to monetary policy. While the academic literature has developed more complex models with predetermined decisions about expenditures and price setting (Rotemberg and Woodford, 1997) or habits and investment adjustment costs (Christiano, Eichenbaum, and Evans, 2005), models of this type typically imply that *lagged* expectations of *current* interest rates affect output and inflation. This is not the same as if the lagged interest rates themselves affecting output and inflation.[30]

The arguments in this section again depends on long-run inflation expectations being firmly anchored. If long-run inflation expectations are not firmly anchored, even a transitory shock has longer-term effects on the policy objectives. In this case, even monetary policy that affects the economy with a lag is useful in bringing policy objectives back to target. Also, a less credible central bank may find it important to respond aggressively to inflation to bolster its reputation as an inflation-fighter (both on and off the equilibrium path).[31]

5 Conclusion

When John Taylor introduced his famous interest rate rule over 30 years ago, he showed that it provided a surprisingly simple—but accurate—description of monetary policy for the six year period from 1987 to 1992. Over the subsequent decades, the Taylor rule has achieved near-mythical status. Hundreds of researchers have estimated similar rules for the US and other countries and researchers routinely assume that policy follows such a rule in theoretical papers on monetary policy and business cycles. We show, however, that deviations from the rule have occurred frequently, particularly over the past 20 years. In many cases, interest rates vary less than one-for-one with inflation for sustained periods.

Do these deviations from the Taylor rule constitute prima facie evidence of suboptimal monetary policy? We argue they do not. We articulate several reasons why optimal monetary policy does not always dictate a more than one-for-one response of interest rates to inflation even in benchmark theoretical models: forward guidance, correlated shocks, and "long and variable lags."

[30] Consider a transitory shock. If demand is affected by lagged interest rates, reacting to the shock has no benefit but has a cost of creating future fluctuations. If, however, demand is affected by lagged expectations of current interest rates, reacting to the shock has neither a benefit nor a cost. Reacting is therefore harmless in the second case, but harmful in the first case.

[31] Olivi, Sterk, and Xhani (2024) and Caratelli and Halperin (2025) provide additional rationales for muted responses to inflationary shocks.

The academic literature has emphasized the role of the “Taylor principle” in avoiding self-fulfilling fluctuations (equilibrium indeterminacy). We emphasize that determinacy can be achieved without constraining the central bank’s ability to respond optimally to fundamental shocks. Moreover, indeterminacy is fragile to even very modest deviations from fully rational expectations. This helps explain the empirical observation that less than one-for-one responses of interest rates to inflation have not obviously engendered self-fulfilling inflation in countries with strongly anchored inflation expectations.

The most recent episode of muted interest rate responses to inflationary pressure occurred in the aftermath of the Covid crisis. Central banks with strong inflation-fighting track records were able to partly “look through” the inflation with little apparent cost: central banks with weaker track records raised rates more aggressively, but nevertheless experienced larger bouts of inflation. A natural explanation is that only the former set of central banks could rely on long-run inflation expectations being firmly anchored.

The Fed’s inflation-fighting credibility—built over the preceding forty years—allowed for a wider array of policy actions in this episode—and therefore better outcomes—than were possible when the Taylor rule was originally proposed. During the post-Covid inflation episode, the market was confident that the Fed would act aggressively if inflation persisted or de-anchoring of expectations started to occur. This high degree of credibility is partly due to the Fed’s strong track record, but also partly due to institutions such as central bank independence. These are valuable assets that can be destroyed much faster than they were built up.

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A Data

We detail figures by figures the data sources used in the paper.

Figure 1: Inflation and Long-Run Inflation Expectations

Long-run inflation expectations is the forecast of annual average inflation over the next 10 years. Before 1991, we use the data from Blue Chip. From 1991 onward, we use the Survey of Professional Forecasters. We download these series from the Philadelphia FED research data (link). Core CPI inflation is the research series constructed by the BLS. It uses the current methodology to estimate a consistent series since 1978. We download it from the BLS (link).

Figure 2: Fit of Original Taylor Rule, 1987-1992

To replicate Taylor (1993), we download the 1993:Q2 vintage of the GDP deflator and the real GDP directly from the FRED website. We then follow Taylor (1993) and compute the output gap as the deviation from real GDP from its linear trend over the period 1984:Q1 - 1992:Q3. We compute inflation as the 12-month growth rate of the GDP deflator.

Figure 3: Original Taylor Rule with Real-Time Data

We obtain the real-time measure of the GDP deflator from the Philadelphia FED real-time research data (link). For each vintage, we compute the 4-quarter inflation rate. Then, for each date we take the inflation rate from the corresponding vintage date.

Our main series for the real-time Greenbook's measure of the output gap comes from Edge and Rudd (2016), and goes until 2008:Q3. We complete this series until 2019:Q4 using the Philadelphia FED real-time research data (link). After 2019:Q4, the Greenbook's measure is not available, so we use the real-time CBO's measure of the output gap. We obtain it directly from the FRED, by downloading the CBO estimates of potential output for each vintage date.

Figure 4: Original Taylor Rule with Retrospective Data

We download the last vintage of the GDP deflator directly from the FRED. For the Greenbook's measure of the output gap, we use the last vintage available from the Philadelphia FED real-time research data. This series goes back until 1975:Q1. To extend it until 1965:Q4, we use the last vintage available in Edge and Rudd (2016) data, which is the 2008:Q3 vintage. This implicitly assumes that no major revisions about the period 1965:Q4 - 1975:Q1 happened after 2008:Q3. After 2019:Q4, the Greenbook's measure is not available, so we use the last vintage of the CBO's measure of the output gap, that we download directly from the FRED website.

Figure 5: Estimates of the Output Gap in the U.S.

This figure shows the measures of output gap used in figures 3 and 4.

Figure 6: Clarida, Galí, Gertler Policy Rule with Real-Time Data

This figure uses the same series for the real-time measure of the output gap as figure 3. We lead the series by one quarter to proxy for the one quarter ahead output gap expectations.

We obtain the real-time Greenbooks' measure of inflation expectations from the Philadelphia FED real-time research data (link). We use the one quarter ahead expectations about the 12-month inflation rate. After 2019:Q4, the Greenbook's measure is not available, so we use the real-time data from the Survey of Professional Forecasters (link). We combine the median forecast data for levels with the GDP deflator to recover the one quarter ahead expectations about the 12-month inflation rate.

Figure 7: Balanced-Approach Rule with Core-PCE Inflation, and Time-Varying R^*

We obtain the real-time data on core PCE inflation from the Philadelphia FED real-time research data (link). The data are available only until 1996:Q1. Before that, we use the current vintage to complete the series.

For the real-time Greenbook measure of the output gap, we use the same series as in figure 3.

For the natural rate of interest r_t^*, we use the median value of the long-run estimate of the nominal interest rate from the FOMC Summary of Economic Projections, minus the inflation target of 2%. We obtain the series directly from FRED. Before 2012, this series is not available, we set $r_t^* = 2.0$.

Figure 8: First Difference Policy Rule

We obtain the data from the Philadelphia FED real-time reasearch data for the median 3-quarter ahead forecast (link) and for the median 10-year forecast of real GDP growth (link). We interpolate over the missing quarters for the 10-year forecast.

Figure 9: Simple Rules for G7 Countries

We obtain the policy rate for each country from the BIS (link), and the core CPI inflation from the OECD (link). We construct the output gap by applying Hamilton (2018)'s filter to industrial production data, that we obtain from the OECD, retrieved from FRED.

Figures 10-12

For this set of figures, we use the BIS data on policy rate (link) and on CPI inflation (link). The full sample of countries covered is Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Croatia, Czechia, Denmark, Euro area, Hong Kong SAR, Hungary, Iceland, India, Indonesia, Israel, Japan, Korea, Malaysia, Mexico, Morocco, New Zealand, North Macedonia, Norway, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Serbia, South Africa, Sweden, Switzerland, Thailand, Türkiye, United Kingdom, United States.

We exclude Argentina, China, Russia, and Türkiye from the analysis, as they are outliers in their post-Covid policy response. We also exclude Serbia, which is an outlier in its inflation rate in the early 1990s.

Figure 14: Core Inflation and One-Year Expected Inflation

We download the core PCE inflation series directly from FRED, and the 1-year ahead forecast for the GDP deflator inflation from the Philadelphia FED real-time research data (link).

Figure 15: Forward Guidance During Post-Covid Tightening

We download the all series directly from FRED.

B Additional Empirical Results

Table B.1: Estimated Taylor Rules for G7

Country	**Constant** α	**Core CPI** β	**Gap Coeff** γ
CAN	2.19	1.37	0.14
DEU	2.08	1.30	0.13
EUR	1.58	0.57	0.19
FRA	5.38	0.61	-0.21
GBR	4.81	0.79	0.01
ITA	8.41	0.49	-0.17
JPN	0.67	1.29	0.01
USA	0.86	1.34	0.10

Note: This table reports the estimated coefficients of the regression $i_t = \alpha + \beta\pi_t + \gamma y_t + \varepsilon_t$, on the sample 1979Q1 to 2008Q4. For Germany, France and Italy, the sample ends in 1998Q4. For the Euro area, it starts in 1997Q1. We measure inflation using the 12-month core CPI inflation rate, and the output gap using an Hamilton (2018) filter on industrial production data.

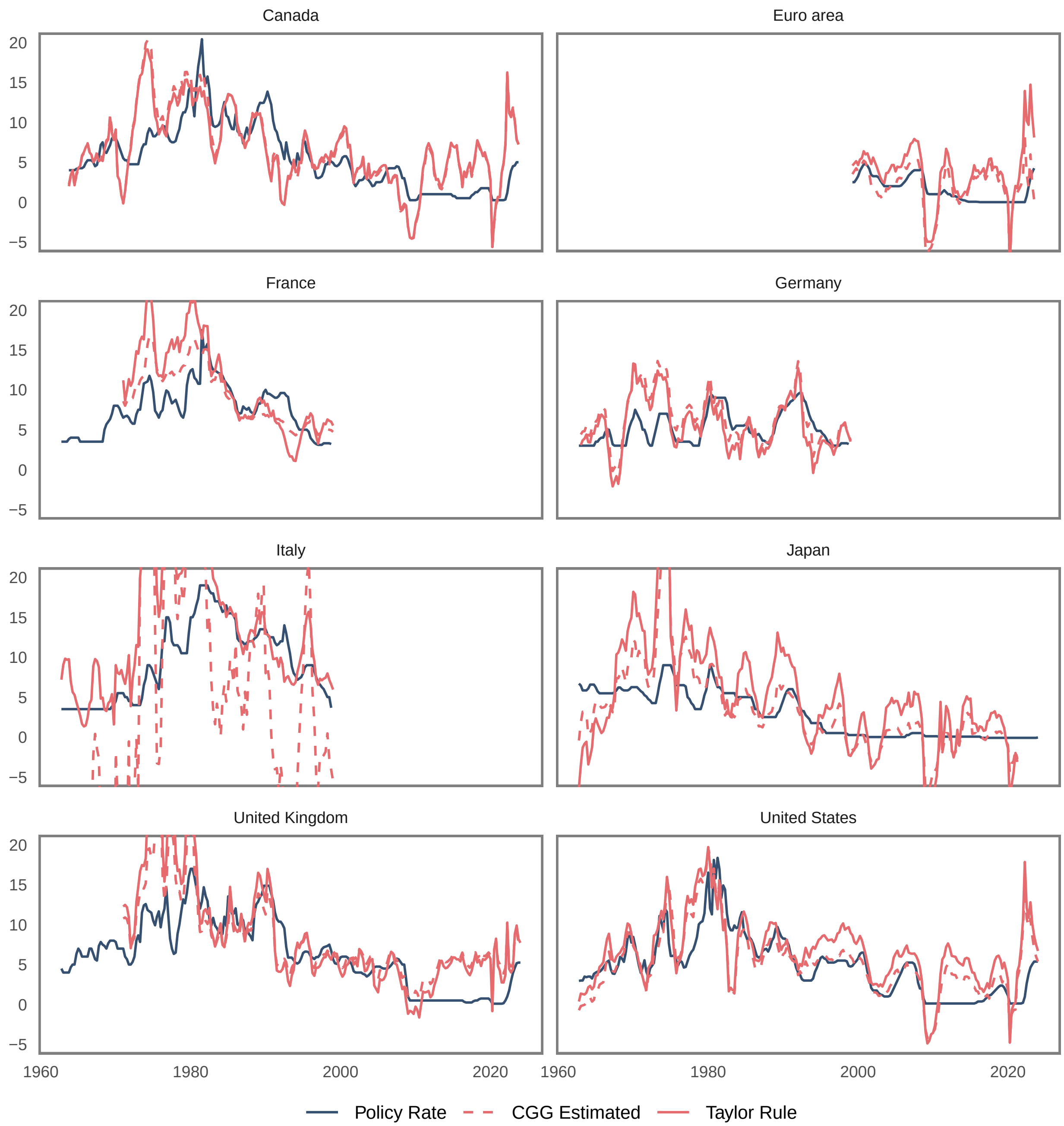

Figure B.1: More Simple Rules for G7 Countries

Note: The figure plots the policy rate for G7 countries and for the Euro Area in dark blue. It plots the original Taylor rule in light red. It also plots an estimated policy rule in broken light red. We estimate $i_t = \alpha + \rho i_{t-1} + \beta\pi_t + \gamma\hat{y}_t + \epsilon_t$ for each country on the sample period of 1979:Q1-2008:Q4. For Germany, France, and Italy, the estimation sample ends in 1998Q4. For the Euro Area, the estimation sample is 1999:Q1-2008:Q4. We plot the target rate $i^* = \frac{\alpha}{1-\rho} + \frac{\beta}{1-\rho}\pi_t + \frac{\gamma}{1-\rho}\hat{y}_t$. We use the 12-month core CPI inflation rate and an output gap measure constructed by applying Hamilton's (2018) filter to data on industrial production.

Table B.2: Estimated Coefficients for Policy Rules for G7

Country	Constant α	Core CPI β	Gap Coeff γ	Persistence ρ
CAN	0.06	0.23	0.07	0.86
DEU	0.24	0.30	0.07	0.82
EUR	0.32	-0.04	0.08	0.84
FRA	0.50	0.15	0.02	0.84
GBR	0.44	0.17	0.06	0.84
ITA	-0.52	0.07	0.06	0.97
JPN	-0.02	0.12	0.02	0.91
USA	-0.20	0.33	0.07	0.80

Note: This table reports the estimated coefficients of the regression $i_t = \alpha + \rho i_{t-1} + \beta \pi_t + \gamma y_t + \varepsilon_t$, on the sample 1979Q1 to 2008Q4. For Germany, France and Italy, the sample ends in 1998Q4. For the Euro area, it starts in 1997Q1. We measure inflation using the 12-month core CPI inflation rate, and the output gap using an Hamilton (2018) filter on industrial production data.

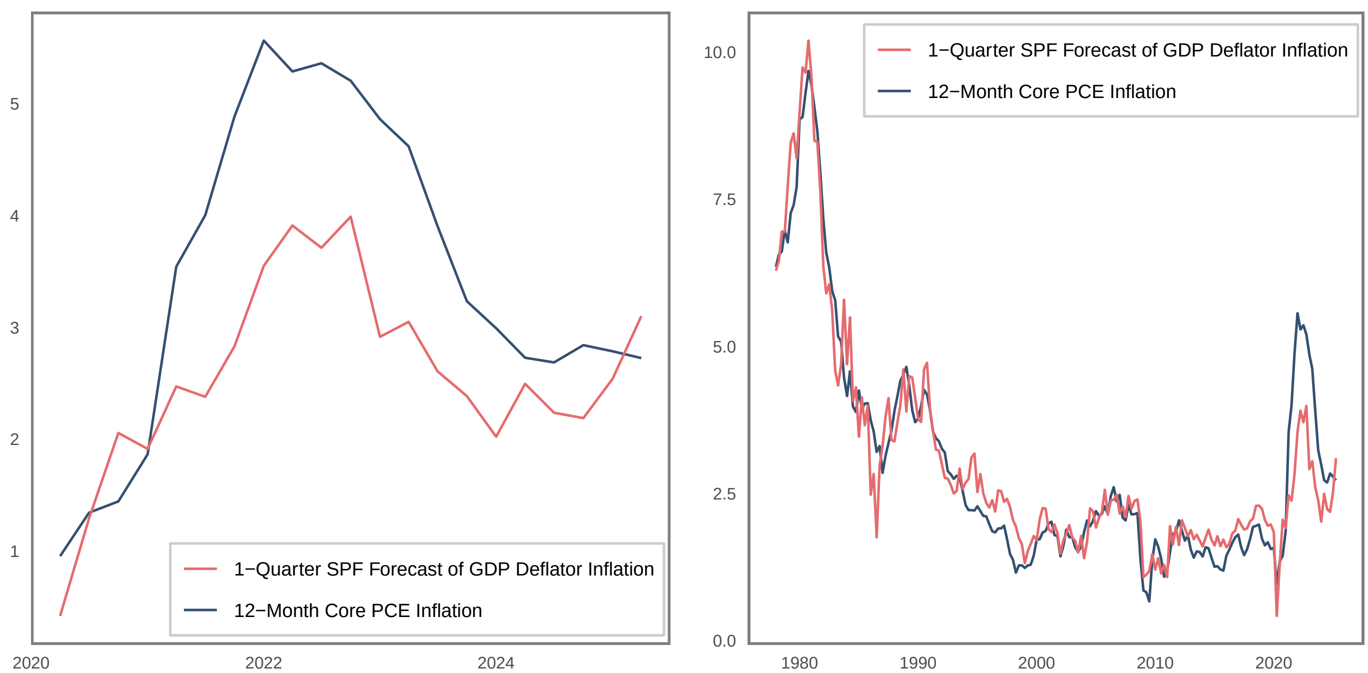

Figure B.2: Core Inflation and One-Quarter Expected Inflation

Note: The figure plots core PCE inflation and one-quarter expected inflation for the GDP deflator from the Survey of Professional Forecasters. The sample period in the left can is 2020Q3 to 2025Q2. The sample period in the right panel is 1978Q1 to 2025Q2.

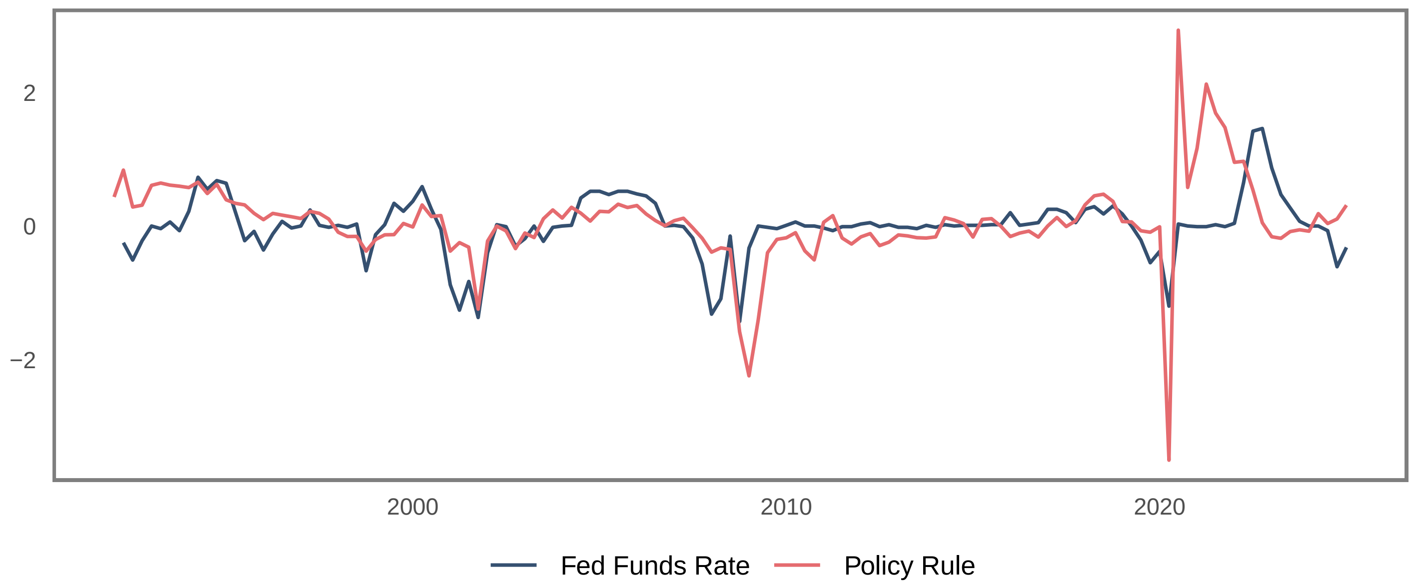

Figure B.3: First Difference Policy Rule: Actual and Prescribed Change in Interest Rates

Note: This figure plots the change in interest rates for the first difference rule $\Delta i = 0.5(\Delta y_t^n - \Delta y_t^{n*})$ where Δy_t^n is the median 3-quarter ahead forecast of nominal GDP growth from the Survey of Professional Forecasters and $\Delta y_t^{n*} = \pi^* + g_t^*$ with $\pi^* = 2\%$ and g_t^* is the median 10-year forecast for real GDP from the Survey of Professional Forecasters. The left panel uses the true lagged value of the federal funds rate for each period (i.e., gives a one-period prediction). The right panel cumulates the predicted changes in the nominal interest rate. The sample period is 1992Q1 to 2025Q1.

C Derivations

C.1 Derivation of Equation (13)

The equations for the cyclical component of output and inflation in Woodford's finite planning horizon model when monetary policy is given by $\tilde{\imath}_t = \phi\tilde{\pi}_t$ can be written as

$$E_t z_{t+1} = Az_t + Be_t$$

where $z_t = [\tilde{y}_t, \tilde{\pi}_t]'$, e_t is a vector of shocks, and

$$A = \frac{1}{\beta\omega}\begin{pmatrix} \sigma\kappa + \beta & -\sigma(1-\beta\phi) \\ -\kappa & 1 \end{pmatrix}. \tag{21}$$

Proposition C.1 in Woodford (2003) shows that the model has a determinate equilibrium if

$$\text{det}A - \text{tr}A > -1 \tag{22}$$

$$\text{det}A + \text{tr}A > -1. \tag{23}$$

In our case

$$\text{det}(A) = \frac{1+\sigma\kappa\phi}{\beta\omega^2} \qquad \text{and} \qquad \text{tr}(A) = \frac{(1+\beta)+\sigma\kappa}{\beta\omega}.$$

Both of these are positive. So, condition (23) is satisfied. That leaves condition (22), which is satisfied if equation (13) holds.

C.2 Derivation of Equation (16)

The minimum variable solution to the canonical New Keynesian model with monetary policy given by policy rule (15) is

$$\pi_t = \frac{\kappa}{\Delta^d} r_t^* + \frac{1-\rho_s}{\Delta^s}\eta_t \tag{24}$$

$$y_t = \frac{1-\beta\rho_d}{\Delta^d} r_t^* - \frac{\sigma(\phi-\rho_s)}{\Delta^s}\eta_t \tag{25}$$

where $\Delta^z = (1-\rho_z)(1-\beta\rho_z) + \kappa\sigma(\phi-\rho_z)$ for $z = \{r^*, \eta\}$.

Focusing on the case were $r_t^* = 0$, we can plug this solution into the loss function (5). This yields

$$\operatorname{var}(\eta_t)\left[\left(\frac{1-\rho_s}{\Delta^s}\right)^2+\alpha\left(\frac{\sigma(\phi-\rho_s)}{\Delta^s}\right)^2\right] \tag{26}$$

Differentiating with respect to ϕ, and setting the result equal to zero yields equation (16).

C.3 Derivation of Equation (19)

The minimum variable solution to Woodford's finite horizon model with constant trends and with monetary policy given by$\tilde{\imath}_t = \phi\tilde{\pi}_t$ is

$$\tilde{\pi}_t = \frac{\kappa}{\Delta^d} r_t^* + \frac{1-\omega\rho_s}{\Delta^s}\eta_t \tag{27}$$

$$\tilde{y}_t = \frac{1-\beta\omega\rho_d}{\Delta^d} r_t^* - \frac{\sigma(\phi-\omega\rho_s)}{\Delta^s}\eta_t \tag{28}$$

where $\Delta^z = (1-\omega\rho_z)(1-\beta\omega\rho_z)+\kappa\sigma(\phi-\omega\rho_z)$ for $z=\{r^*,\eta\}$.

Focusing on the case were $r_t^* = 0$, we can plug this solution into the loss function (5). This yields

$$\operatorname{var}(\eta_t)\left[\left(\frac{1-\omega\rho_s}{\Delta^s}\right)^2+\alpha\left(\frac{\sigma(\phi-\omega\rho_s)}{\Delta^s}\right)^2\right] \tag{29}$$

Differentiating with respect to ϕ, and setting the result equal to zero yields equation (19).

D Additional Theoretical Results

Table D.3: Taylor Rules under Optimal Policy with Commitment with Flatter Phillips Curve

α	Inflation	Output Gap	$\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$
10.00	0.85	0.40	0.99
5.00	0.85	0.38	0.99
2.00	0.85	0.34	0.97
1.00	0.84	0.30	0.95
0.50	0.83	0.26	0.93
0.20	0.81	0.19	0.88
0.10	0.78	0.14	0.83
0.05	0.71	0.10	0.75
0.02	0.53	0.05	0.55
0.01	0.25	0.02	0.25

Note: The table reports the regression coefficients ϕ_π and ϕ_y from a Taylor rule regression $i_t = \bar{r} + \phi_\pi \pi_t + \phi_y \frac{x_t}{4} + \varepsilon_t$ on simulated data from the canonical New Keynesian model when policy is optimal with commitment. We also report $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$, the quantity that must be greater than one to guarantee determinacy if the central bank does not respond strongly specifically to non-fundamental variation in inflation. We show results for different values of α the coefficient on the output gap in the loss function (5). We assume a slope of the Phillips curve of $\kappa = 0.0069$ based on estimates from Hazell et al. (2022). Hazell et al. (2022) estimate a slope of the Phillips curve for the non-housing component of the CPI of 0.0062. They also present an estimate of the slope of the Phillips curve for the housing component of the CPI of 0.0243. A weighted average of these two estimates is $0.58 \times 0.0062 + 0.42 \times 0.0243 = 0.0138$. The Phillips curve slope estimates in Hazell et al. (2022) are for a Phillips curve with the unemployment rate as the activity variables. A simple way to convert this into a Phillips curve slope for a Phillips curve with the output gap as the activity variable is to appeal to Okun's law with a coefficient of two. This yields $0.0138/2 = 0.0069$. We assume a persistence of the cost push shocks of $\rho_s = 0.85$.

Table D.4: Taylor Rules under Optimal Policy with Commitment using 12-month Inflation

α	Inflation	Output Gap	$\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$
10.00	0.81	2.04	1.03
5.00	0.81	1.74	0.99
2.00	0.80	1.24	0.93
1.00	0.78	0.92	0.88
0.50	0.76	0.66	0.83
0.20	0.69	0.40	0.73
0.10	0.58	0.24	0.61
0.05	0.39	0.11	0.40
0.02	-0.14	-0.03	-0.14
0.01	-0.91	-0.11	-0.92

Note: The table reports the regression coefficients ϕ_π and ϕ_y from a Taylor rule regression $i_t = \bar{r} + \phi_\pi \pi_t^{12m} + \phi_y \frac{x_t}{4} + \varepsilon_t$ on simulated data from the canonical New Keynesian model when policy is optimal with commitment. Here π_t^{12m} is 12-month inflation computed as $(\prod_{s=0}^{3}(1+\pi_{t-s}))^{1/4} - 1$. We also report $\phi_\pi + \phi_y \frac{1-\beta}{4\kappa}$, the quantity that must be greater than one to guarantee determinacy if the central bank does not respond strongly specifically to non-fundamental variation in inflation. We show results for different values of α the coefficient on the output gap in the loss function (5). We use our baseline calibration with a slope of the Phillips curve of $\kappa = 0.024$ and persistence of the cost push shocks of $\rho_s = 0.85$.