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A new look at historical monetary policy (and the great inflation) through the lens of a persistence-dependent policy rule

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Abstract

The origins of the Great Inflation, a central 20th-century U.S. macroeconomic event, remain contested. Prominent explanations are poor inflation forecasts or inaccurate output gap measurement. An alternative view is that the Federal Open Market Committee (FOMC) was unwilling to fight inflation, perhaps due to political pressures. Here, we sort this out via a novel econometric approach, disaggregating the real-time unemployment and inflation time series entering the FOMC historical policy reaction-function into persistence components, using one-sided Fourier filtering; this implicitly estimates the unemployment gap in actual use. We find compelling evidence for (economically interpretable) persistence-dependence in both variables. Furthermore, our results support the "unwilling to fight" view: the FOMC's unemployment gap responses were essentially unchanged pre- and post-Volcker, while its inflation responses sharpened markedly starting with Volcker.

JEL classifications: E52, C22, C32.

1. Introduction

The Great Inflation of the 1970s is widely regarded as one of the central events in U.S. macroeconomic history over the past 100 years. As such, it has been subject to intense scrutiny, including a prominent NBER conference (Bordo and Orphanides, 2013). Most of these studies of historical FOMC behavior have used variants of a simple monetary policy rule. These were articulated in 1992 by Taylor (1993), who proposed a rule of the form shown in Equation (1)

$$i_t = \alpha + \beta \hat{u}_{t-1} + \varphi \pi_{t-1} + e_t \tag{1}$$

where i_t is the federal funds rate, π_{t-1} is the annualized inflation rate from period t –2 to period $t-1$, $\hat{u}_{t-1}$ is an estimate of (trendless) real activity (output gap, unemployment rate, or unemployment rate gap) in period $t-1$, and e_t is a stationary exogenous monetary shock. There are many variants of Equation (1), such as the use of forward-looking rules or the addition of other variables. (For more details, see Knotek *et al.*, 2016, and its appendix; Ashley *et al.*, 2019.)

Many of these studies find that the central bank's policy changed markedly starting with Volcker.[1] The question is, why? One prominent explanation of the pre-Volcker behavior is the "ideas" hypothesis—the notion that FOMC errors in the 1970s were due to erroneous beliefs about the structure of the economy, or to erroneous gap measurements, such as an unrealistically low estimate of the natural rate of unemployment. Other studies point to biased forecasts. Finally, some studies conclude that the FOMC was unwilling to fight inflation, either owing to political pressures, or to beliefs about the effectiveness of monetary policy. We review several of these studies.

Our approach to why the central bank's policy changed markedly is novel. Estimating Equation (1) requires an estimate of $\hat{u}_{t-1} \equiv (u_{t-1} - u^*_{t-1})$; that is, an estimate of u^*_t, the time-varying natural rate of unemployment (or an estimate of potential output). Most empirical work studying historical FOMC behavior takes for granted that the FOMC used a particular unemployment rate or output gap, imposed in a specification such as Equation (1) *a priori*. But, as we discuss immediately below, there are both econometric and conceptual problems with this approach. One contribution of the present paper is that we have developed novel econometric tools that allow us to ask simultaneously whether the FOMC even used a gap, and whether it can reconstruct an econometrically valid estimate of the gap that was actually used. As an additional benefit, our new tools (discussed in Section 2 and in the online Technical Appendix) also allow us to undertake the flexible quantification of the degree to which, historically, the FOMC has paid more attention to transient versus relatively persistent fluctuations in unemployment and/or inflation.

What are the possible econometric problems to which we have alluded? The use of many of the most commonly used estimates of u^*_t itself compromises inference. For instance, if one's estimate of u^*_t derives from a two-sided filter—such as an HP filter, or a symmetric moving average filter—this will distort the coefficient estimate φ in Equation (1) (see Ashley and Verbrugge, 2008).[2] Further, most estimates of u^*_t are inherently problematic in that they are imprecise, are subject to large revisions, and typically hinge on untested (and perhaps untestable) auxiliary assumptions about the natural rate data-generating process (such as an explicit formulation of its persistence). Any or all of these assumptions may well be substantially incorrect. As may be expected, then, u^*_t estimates vary widely across concepts and methods (see Tasci and Verbrugge, 2014). (Use of an output gap instead of an unemployment gap in Equation (1), also common, does not improve matters.)[3] Thus, any particular u^*_t series assumption can easily threaten the validity of the resulting inference, and may render conclusions about such things as the origins of the Great Inflation suspect. In contrast (as discussed below), our approach uses only one-sided filtering, assumes little about u^*_t, and allows the data to speak about the nature of the u^*_t estimates actually used.

1 See Judd and Rudebusch (1998) or Clarida *et al.* (2000), and related work cited at this point in Ashley *et al.* (2019).

2 Of course, not all studies use two-sided gap estimates; for instance, authors using Greenbook data are using one-sided estimates.

3 Output gap estimates are often two-sided, and notoriously sensitive to model assumptions; see footnote 3 in Ashley *et al.* (2019).

This relates to the conceptual problem. Imposing a particular u_t^* measure amounts to an assumption that FOMC members were in broad agreement about that particular measure. This seems unlikely, especially during the 1970s. Subsequent to the seminal work of Friedman (1968) and Phelps (1968), a few papers emerged providing estimates of a natural rate of unemployment (typically constant), but there is no evidence that these were taken on board by FOMC members.[4] Examining FOMC *Memoranda of Discussion*, Kozicki and Tinsley (2006) note that the most prominent published estimates, those of the Council of Economic Advisers, were almost never cited in the 1970s. Hetzel (2017), an author who writes extensively about the historical evolution of central banking, asserts that during the 1970s there was a "general belief that 4% unemployment represented full employment" (p. 13), despite a number of studies suggesting higher estimates (see references in Nikolsko-Rzhevskyy and Papell, 2012) . Other textual analyses of FOMC minutes and transcripts, such as Chappell *et al.* (2004) or Weise (2012), indicate that the 1970s FOMC was concerned about high and rising unemployment, and was grappling with the notion of what level was sustainable, but there was nothing like a settled concept or estimate guiding the FOMC's deliberations during this period.

Given this history, in the present study we let the data themselves speak as to whether and how the FOMC was actually responding to movements in the unemployment rate, so as to address such questions as whether the FOMC historically acted in a manner that (implicitly or explicitly) responded to an unemployment gap of some sort? Putting this differently, is an unemployment rate gap useful (or necessary) in order to provide a good description of the FOMC's historical behavior?[5] Additionally, did the FOMC respond to persistent movements in the unemployment rate in a way that was systematically different from its response to business cycle fluctuations (or to even less persistent fluctuations) in that variable?[6] Did this aspect of the FOMC's behavior change with the chairmanship of Volcker? If so, do our results suggest an explanation?

The work described below uses the lens of estimated simple policy rules to address these questions empirically and to provide credible answers. It also illustrates the application of a relatively novel econometric approach that is simple, transparent, and well-suited to the real-time data (in both u_t and π_t), which is appropriate to the FOMC context. The method allows for possible feedback in the relationship (in contrast to frequency-domain alternative methods), does not require ancillary assumptions about the data-generating processes, and is sufficiently flexible as to not presuppose the answers. It is discussed at length in Section 2.

Our findings are striking, but intuitively appealing upon reflection. First, activity-gap estimation errors do not seem to explain the Great Inflation. Our estimates indicate that FOMC federal funds rate responses to unemployment rate fluctuations were *essentially the same* during the Martin-Burns-Miller (MBM) period as during the Volcker-Greenspan-Bernanke (VGB) period. In particular, irrespective of any belief the FOMC may have had about the natural rate of unemployment, we find that the FOMC ignored the most persistent unemployment rate fluctuations over both periods. Thus, during the *entire* period of

4 For discussion of this, see footnote 4 in Ashley *et al.* (2019).

5 We agree with Kozicki and Tinsley (2006) that it is "more plausible that the 1970s FOMC gauged real resource slack by aggregate unemployment" than by using estimated output gaps. For further discussion, see footnote 6 in Ashley *et al.* (2019).

6 Belief in a fixed natural rate need not preclude persistence-dependent FOMC actions.

our study, our results suggest that the FOMC implicitly formed an unemployment gap in much the same manner, with the most persistent (i.e., lowest frequency) fluctuations serving the role of an intermediate target.[7] These results cast serious doubt on one part (or subset) of the "ideas" hypothesis—that the Great Inflation in the 1970s was due to an unrealistically low estimate of the natural rate of unemployment (e.g., Orphanides, 2002; Romer and Romer, 2002; Romer, 2005). Further, these results also suggest that previous work, which has largely relied on particular gap estimates imposed *a priori*, may have come to erroneous conclusions about FOMC behavior in the 1970s.

Second, our findings also appear to indicate that previous empirical work using Equation (1) has been mis-specified with respect to inflation as well. Historically, the FOMC also responded in a persistence-dependent manner to real-time fluctuations in the inflation rate. We find that this behavior became much more pronounced after Volcker; and the post-Volcker FOMC was also much more aggressive in its response to inflation. This persistence-dependent behavior accords well with intuition. Measured inflation is often subject to large transitory influences, which can affect an aggregate price index for long periods. This is one reason that policymakers have argued—e.g., Mishkin (2007)—that the central bank should not respond to transitory fluctuations in inflation.[8]

Third, we provide evidence against the conjecture that FOMC behavior in the 1970s chiefly resulted from inaccurate inflation forecasts (see, e.g., Orphanides, 2002; Levin and Taylor, 2013; or Fuhrer and Olivei, 2017). While this mechanism could certainly operate in conjunction with policy preferences—Greenbook inflation forecasts for portions of the 1970s were downward-biased—our evidence suggests that the actual behavior of the FOMC in the 1970s is more consistent with its using real-time CPI inflation data, and simple (but reasonably accurate) inflation forecasts.

Finally, our results suggest that policy preferences—possibly driven by political pressures—constitute a far more likely explanation of the Great Inflation; we discuss this below. This finding is timely. Some have recently argued that the rise of populism worldwide could undermine support for central bank independence.[9]

2. Methodology

In this paper, we allow the data to speak as to how the FOMC has historically responded to fluctuations with various persistence levels in the unemployment rate and in the inflation rate. Our approach is simple and transparent, but delivers new insights into historical FOMC behavior. Following Clarida *et al.* (2000), we primarily consider two sub-sample periods. The first of these is January 1965 to August 1979, which roughly corresponds to the MBM period. The second sub-sample runs from September 1979 to August 2008. It covers the tenures of Volcker and Greenspan, and part of Bernanke's tenure, ending as the "zero lower bound" episode began.

7 Jeffrey Fuhrer suggested the term "intermediate target" during the 2017 Boston Federal Reserve central banking conference. This notion is distinct from an earlier use of this term to describe other measures; for example, monetary aggregates, to which the FOMC could also pay attention.

8 Footnote 9 in Ashley *et al.* (2019) clarifies that using "core" inflation measures does not adequately address this issue, and provides a cogent example.

9 See, for example, Buiter (2016), Binder (2018), and several other studies noted in Ashley *et al.* (2019).

We estimate the central bank's assumed monetary policy rule using a new method proposed by Ashley and Verbrugge (2008).[10] This method allows us to avoid imposing a particular u_t^* estimate but, instead, to test whether (and quantify how) the FOMC distinguished between fluctuations with differing persistence levels. Essentially, we use a one-sided filtering technique to partition the real-time unemployment rate and inflation rate into components with differing levels of persistence. Using standard regression techniques and tests, it is then straightforward to determine whether the FOMC responded (in real time) to the persistent part in the same manner that it responded to the less persistent part, or to the high-frequency part. Thus, the relevant u_t^* is discoverable here simply by partitioning unemployment fluctuations by persistence levels. We note that our approach does not impose an assumption that the policy reaction coefficients differ across persistence levels; it merely allows for the possibility, leaving the usefulness and importance of this distinction as an empirical issue on which the data can speak. A brief description of our method follows; for more details, see the online Technical Appendix, or refer to Ashley and Verbrugge (2008).

We use moving windows to filter the real-time data at each time t, partitioning the time t observation into various persistence (or frequency) components. One-sided filtering is essential: first, two-sided filtering cannot be conducted in real time; and second, two-sided filtering results in distorted coefficient estimates and destroys the ability to make causal statements (except in limited cases).[11] The precision of the partitioning is substantially enhanced by extending the data in each window with forecasts or "projections"; (see also Stock and Watson, 1999, or Clark and Kozicki, 2005). Thus, for example, to partition the unemployment rate at time t, we apply the Ashley-Verbrugge filter to a rolling window of 96 observations ending in t, augmented with a set of 1- through 24-month forecasts, starting at time $t+1$. The Ashley-Verbrugge filter is then applied to this 120-month window, and the time-t decomposition is saved. (The inflation rate is partitioned in the same manner except, in that case, a 42-month window is augmented by 18 months of forecasts. We argue below why distinct window lengths for the two variables are appropriate.) Figures 1 and 2 display the resulting components of each of these two variables, in each case partitioning the data by persistence level into three persistence components.

Is this method subject to our previous critique, the imposition of concepts from the future? No. We are not arguing that the FOMC made use of techniques from the future in order to guide their decision-making.[12] Instead, what we are asking is whether the FOMC, using the tools it had on hand at various points in time (such as forecasts, judgment, various trend estimates, or detailed studies of particular unemployment rate or inflation movements), has historically acted as if it were making this type of persistence distinction in its

10 The online Technical Appendix describes the latest version of this method.

11 Two-sided filters (such as the HP filter) applied to both the explanatory and dependent variables—as in classical RBC studies, or in recent New Keynesian DSGE modeling—distort relationships among variables that are contemporaneously cross-correlated or in a feedback relationship. This is due to two-sided filtering inherently mixing up future and past values of the time series; see Ashley and Verbrugge (2008). For the same reason, and because such calculations are incompatible with the use of real-time data, two-sided cross-spectral estimates or filtering with wavelets should similarly be eschewed for this kind of analysis.

12 In Ashley *et al.* (2019), we argue that spectral tools were not likely to have been used, even in the VGB period.

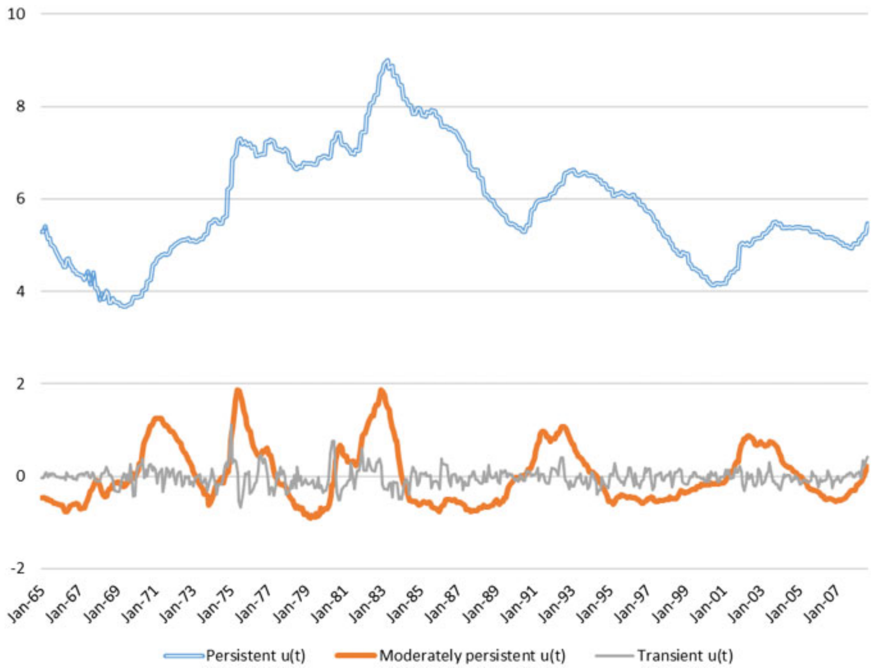

Fig. 1. Components of unemployment rate by persistence.

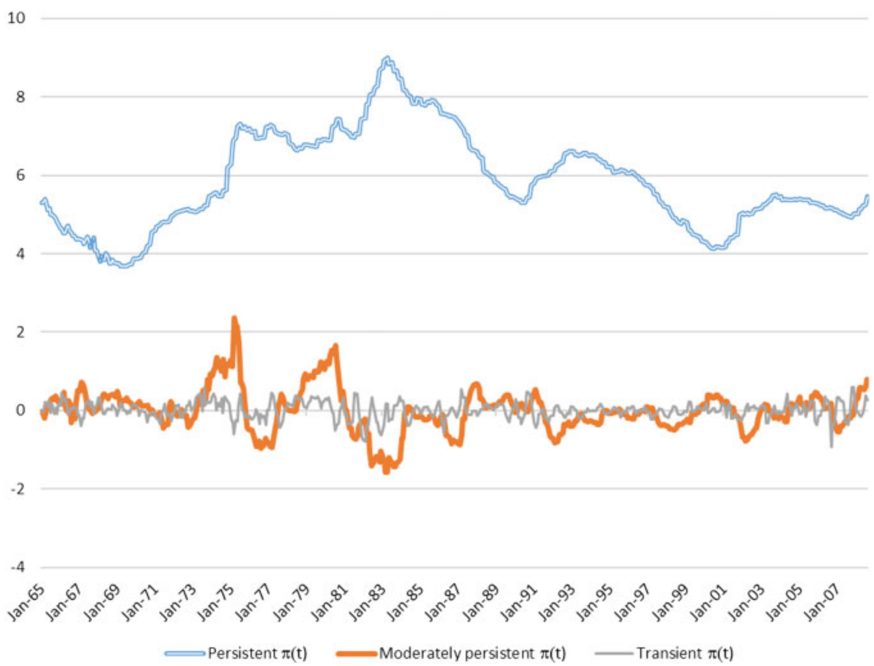

Fig. 2. Components of inflation rate by persistence.

decision-making. Indeed, one may note that our method uses real-time information to assist in identifying persistent versus transient movements, in roughly the same manner that an informed observer may do using judgment.[13] In particular, we are using new tools to better understand and describe the historical behavior of the central bank, allowing the data to inform us as to the manner in which the central bank actually responded to fluctuations in these macroeconomic variables.

While the original Taylor-type monetary policy response function is attractive in its simplicity, our extension of it broadens its generality and descriptive power, yielding novel results. By allowing the data a chance to tell us whether the FOMC treated apparently persistent fluctuations differently than fluctuations that appeared to be more transient, without imposing a particular gap estimate, we obtain a clearer picture of how the FOMC actually behaved, and how its behavior evolved between the MBM and VGB periods.

3. Empirical results

3.1 Data description and discussion of partitioning

We use real-time data on the civilian unemployment rate (u_t) and the 12-month growth rate in the (real-time) CPI inflation rate (π_t),[14] taken from the St. Louis Federal Reserve Bank's ALFRED data set. (In our investigation of the experience of the 1970s, for comparison purposes we also make use of real-time quarterly GNP deflator data, and inflation forecasts deriving from FOMC Greenbooks, both available from the Real-Time Data Research Center at the Federal Reserve Bank of Philadelphia.) For our projections of the unemployment rate, a case where univariate models can be slow to detect turning points in the data, we also make use of the Survey of Professional Forecasters projections of this variable, also available from the Federal Reserve Bank of Philadelphia. (We linearly interpolate these quarterly forecasts in order to obtain monthly forecasts.)

As the backward-looking filtering employed here uses up a good deal of sample data as a "start-up" period, our regressions begin in January 1965. Our sample period ends in August 2008, just prior to the period of zero lower bound. The data we are analyzing correspond closely to those that were available to the FOMC at the time it set the federal funds rate (i_t).[15]

Our treatment of the federal funds rate, and the information available to the FOMC during its meeting each month, warrants some discussion. Over most of our sample, the federal funds rate experienced notable day-to-day changes, and was also subject to end-of-month effects as banks addressed regulatory constraints. Our goal is to estimate the FOMC reaction function, which models the FOMC federal funds rate decision in its meeting, in reaction to or based upon the information that the FOMC had available when it made the decision. However, FOMC meeting dates—and conference phone conversations at which

13 See Meyer *et al.* (2013), for one example.

14 Specifically, we use the inflation rate defined as the 12-month growth rate in percentage terms—that is, $100ln(CPI_t/CPI_{t-12})$—where CPI_t is the non-seasonally adjusted CPI for urban wage earners and clerical workers until February 1978 and the non-seasonally adjusted CPI for all urban consumers thereafter. The value for CPI_{t-12} in π_t is that which was available when CPI_t was released.

15 *Source*: http://research.stlouisfed.org/fred2/.

decisions could also be taken—did not occur on the same day each month.[16] Hence, for each month we estimate the monthly federal funds rate by taking a trimmed-mean estimate of the federal funds rate over the six business days following an FOMC meeting, trimming the highest and lowest daily rates of that period, and taking the average over the remaining four observations. If there was no meeting that month, we implicitly assume an FOMC meeting on the 20th day of the month at which the rate was left unchanged.[17] For the monthly unemployment rate and inflation rate series, we then utilized the information that was actually available immediately prior to the FOMC deliberations that month. Most commonly, the FOMC had available the unemployment rate from the previous month, and the CPI inflation rate from two months prior. However, for meetings that occurred late in the month, CPI inflation data from the previous month were often available. (We describe below a robustness exercise that used GNP deflator information aligned with the same meeting dates.)

As noted, following Clarida *et al.* (2000), we primarily consider two sub-sample periods: January 1965–August 1979, the MBM period; and September 1979–August 2008, the VGB period. The Great Inflation occurred during the MBM period. Most of the VGB period is also referred to as the Great Moderation (see, e.g., Kim and Nelson, 2006) as it is characterized by low variance in most macroeconomic variables.

Each monthly observation on u_t and π_t is here decomposed into frequency (persistence) components (as noted above and described in the online Technical Appendix), using moving windows. In specifying the length of the moving windows used in decomposing the real-time unemployment rate, we note that the natural rate of unemployment is usually thought to be quite slow in varying. For instance, Boivin (2006) uses a five-year moving average of the unemployment rate as a proxy for the natural rate. A shorter window—say, 36 months—would risk including business cycle effects within the lowest-frequency unemployment rate component, and likely not properly distinguish very persistent supply-side pressures on the unemployment rate from less persistent business-cycle related influences on the unemployment rate. Put differently, this choice of short window length would impose the restriction that the central bank responds in much the same way to an unemployment rate fluctuation with a reversion period of 36 months as it does to a fluctuation with substantially larger reversion periods (e.g., 5 years, or even 10 years). Hence, we conjectured that a 10-year window would likely result in a satisfactory decomposition for the unemployment rate.[18] As will be evident below, the outcome of the empirical analysis presented here will inform us as to whether a shorter window would have been adequate. In specifying the length of the moving windows used in decomposing the real-time inflation rate, in contrast, we considered that a central bank may very well react differently to a

16 In fact, occasionally, there were two or more meetings in a single month. In those cases, we selected one of the meetings, preferentially the meeting or conference call at which a rate change took place. Earlier in the sample, when Greenbook forecast information was more variable, we also gave consideration to meetings at which richer forecast information was included in the Greenbook.

17 A referee suggested that we alternatively use the intended federal funds rate from Romer and Romer (2004). Results are nearly unchanged, as these series are nearly identical.

18 An exercise—not reported here—that estimated the width of a moving average of the unemployment rate that best matched prominent estimates of the NAIRU resulted in a moving average of nine years.

fluctuation in the real-time inflation rate that has persisted for just 12 months—as compared to one that has persisted for, say, 36 or 48 months—but that it seems unlikely *a priori* that it would attend to a fluctuation of 60 months substantially differently than to one that has persisted substantially longer than this.[19] We thus judged that a moving 60-month window would suffice for the inflation rate.[20]

We isolate the most persistent fluctuations that are resolvable given the length of the filtering window; thus, the most persistent fluctuations in the unemployment rate consist of all fluctuations that take longer than 120 months to complete, while the most persistent fluctuations in the inflation rate consist of all fluctuations that take longer than 60 months to complete. We will denote these here as the "very persistent" fluctuations.[21] Next, we split out the "transient" fluctuations of each variable, where these consist of all fluctuations that take 12 months or less to complete. We will be able to investigate whether the FOMC effectively ignored these fluctuations, or treated them in the same manner as other fluctuations. Below, we refer to the remaining component of u_t or π_t as the "moderately persistent" fluctuations.

Time plots of "persistent" components, "moderately persistent" components, and "transient" components are displayed in Fig. 1 for the u_t components and in Fig. 2 for the π_t components.

A few words of explanation may be in order. The very persistent component is not as smooth as, from the nomenclature, one would expect; and there appears to be a modest correlation between the very persistent and the moderately persistent components. The first issue comes about because both the real-time data and the projections used in each window can, and do, shift each period, leading to fluctuations that are not particularly smooth in what otherwise would have been a very smooth "very persistent" component. The windowing procedure implies that the extremely persistent component will incorporate a nonlinear adaptive trend, including all zero-frequency components as well as all components whose period exceeds the width of the window. (See the online Technical Appendix, for a figure demonstrating how the lower frequency movements of the data are estimated by our procedure.) The second issue arises for similar reasons. Had the entire data sample been subsumed into one long window, these components would be precisely uncorrelated. But, in real time, there is always a time-t innovation that represents a departure from the time $t-1$ forecast of the variable at time t. The movement at time t must be decomposed into various persistence components and, without observations of the variable at times $t+1, t+2$, and so on, it is impossible to parse the time-t change into its persistence components without error. A given innovation in real-time u_t or π_t will unavoidably be somewhat misattributed across the components, yielding both a modest level of correlation between the components.[22]

19 A (centered) 36-month moving average is often used as an estimate of trend inflation; see, for example, Cecchetti (1997) or Brischetto and Richards (2007), and footnote 21 in Ashley *et al.* (2019).

20 Our empirical results are not particularly sensitive to specifying somewhat shorter (or longer) moving windows for use in decomposing u_t and π_t, or alternative partitions (see Ashley *et al.*, 2019; footnote 22 therein discusses some technical details that are omitted here for brevity and discusses available code implementing our decompositions).

21 The very persistent component will include all fluctuations corresponding to reversion periods longer than the filtering window. For more details, see the online Technical Appendix.

22 Most of the resulting inter-component correlations we observe in Figs 1 and 2 are actually quite small, typically around 0.1. The most persistent part of each series has a correlation with the moderately persistent part in the order of 0.2 (u_t) to 0.35 (π_t), however.

3.2 Specification and results

Our empirical specification was guided by prior work and by theoretical considerations, in conjunction with a desire to allow the data to speak as clearly as possible.

First, the federal funds rate is highly persistent. As discussed in more detail in Ashley *et al.* (2019), empirical estimates of central bank policy functions generally indicate substantial inertia, and such inertia may be deliberate (see, e.g., Humpage and Mukherjee, 2015). In the U.S.A. at least, there is evidence for "double inertia" (see Carlstrom and Fuerst, 2014): in both periods, two lags of the federal funds rate are necessary to yield serially uncorrelated fitting errors.[23] From an econometric standpoint, ignoring such persistence is likely to lead to severe parameter estimate distortions (see Ashley and Verbrugge, 2009); these distortions are avoided here by the inclusion of lags in i_t.

Second, as discussed in the introduction, it is common to see an estimate of a "natural rate of unemployment" and/or an inflation target in a central bank policy reaction function specification. Such inclusions are inherently awkward because these quantities are time-varying (albeit slowly so), but their time variation cannot be identified without making strong (and untestable) assumptions about their time-evolution. Such variables are not included in our base model specification, presented in Equation (2), because the estimation methodology we use in our immediately subsequent model specification, presented in Equation (3), will allow for the coefficients on u_t and π_t to differ for slowly varying ("highly persistent") fluctuations in these variables. In this manner, we elegantly allow for, but do not impose, a gap specification.

Given the "double inertia" and timing discussion above, our base model specification is as given in Equation (2):

$$i_t = \delta_1 i_{t-1} + \delta_2 i_{t-2} + (1 - \delta_1 - \delta_2)(\alpha + \beta u_{t-1} + \varphi \pi_{t-2}) + e_t. \tag{2}$$

To investigate whether the FOMC reaction function differentiated between highly persistent, moderately persistent, and higher-frequency movements of each variable, we respecify Equation (2) to allow for the possibility that the coefficients on π_t and u_t depend on the persistence levels of the fluctuations in these variates. This yields the model given in Equation (3):

$$i_t = \delta_1 i_{t-1} + \delta_2 i_{t-2} + (1 - \delta_1 - \delta_2)\left(\alpha + \sum_{k=1}^{3} \beta_k u_{t-1}^k + \sum_{j=1}^{3} \varphi_j \pi_{t-2}^j\right) + \epsilon_t. \tag{3}$$

In Equation (3), the superscripts on u_t and π_t distinguish the components of these variables, as partitioned into three persistence levels. In particular, u_t^1 is the "highly persistent" component of u_t; u_t^2 is the "moderately persistent" component of u_t; and u_t^3 is the "transient" component of u_t, as described in Section 3.1. This model specification allows us to estimate distinct policy-response coefficients (β_1, β_2, and β_3) for these components of unemployment rate fluctuations, as these may have been perceived by the FOMC based upon the real-time data available to it at the time a decision was made. The variables ($\pi_t^1, \pi_t^2,$ and π_t^3) and coefficients (φ_1, φ_2, and φ_3) are analogously defined, corresponding to the "highly persistent", "moderately persistent", and "transient" components of inflation rate data.

23 Evidence for double inertia is admittedly weaker in the VGB period, unless we use the Romer and Romer (2004) federal funds rate series. Our results are robust to using a single lag of i_t in the VGB period.

Table 1. Estimation results, Equations (2) and (3)

	Equation (2)				Equation (3)		F-test: $\gamma^{MBM} = \gamma^{VGB}$ $\gamma = \{\delta_i, \beta_i, \varphi_i\}$
	MBM period	VGB period		Persistence (in months)	MBM period	VGB period	
$\delta_{1(i_{t-1})}$	+1.43 (0.08)	+1.08 (0.19)	δ_1 (i_{t-1})		+1.29 (0.07)	+0.94 (0.19)	0.08
$\delta_{2(i_{t-2})}$	−0.51 (0.08)	−0.14 (0.19)	δ_2 (i_{t-2})		−0.38 (0.08)	−0.06 (0.19)	0.20
			β_1 (u_t^1)	>120	−0.45 (0.38)	+0.20 (0.35)	0.07
$\beta_{(u_t)}$	−0.84 (0.28)	+0.04 (0.46)	β_2 (u_t^2)	12–120	−1.60 (0.55)	−2.93 (0.55)	0.92
			β_3 (u_t^3)	≤ 12	−6.44 (2.55)	−8.36 (2.57)	0.39
			φ_1 (π_t^1)	>60	+0.61 (0.21)	+1.59 (0.37)	0.04
$\varphi_{(\pi_t)}$	+0.63 (0.19)	+1.50 (0.72)	φ_2 (π_t^2)	12–60	+0.06 (0.64)	−1.00 (1.05)	0.79
			φ_3 (π_t^3)	≤ 12	+1.11 (1.87)	−6.65 (2.04)	0.17
			F-tests:				
			$\beta_i = 0\ \forall i$		0.002	0.000	
			$\beta_i = \beta_j\ \forall i,j$		0.049	0.000	
			$\beta_2 = \beta_3$		0.051	0.041	
			$\varphi_i = 0\ \forall i$		0.014	0.000	
			$\varphi_i = \varphi_j\ \forall i,j$		0.67	0.000	
			$\varphi_2 = \varphi_3$		0.58	0.008	

Source: Authors' calculations. The coefficients δ_1 and δ_2 are on lagged i_t; the 'β' coefficients are on lagged unemployment, whereas the 'ϕ' coefficients are on lagged inflation. Eicker-White standard error estimates appear in parentheses.

The first two columns of Table 1 separately display NLS estimates of δ_1, δ_2, β, and φ over the MBM and VGB sub-periods, corresponding to Equation (2). The inclusion of two lags in i_t in this model suffices to yield serially uncorrelated model fitting errors. Eicker-White standard errors are quoted for all coefficient estimates, which account, at least asymptotically, for any heteroskedasticity in ϵ_t.[24] The coefficients δ_1 and δ_2 quantify the "double inertia" discussed above. These coefficient estimates are fairly stable across the two periods, and the null hypothesis that both of these coefficients are zero can always be rejected with $P < 0.0005$.[25]

24 Possible parameter estimation distortion due to three outlying observations in the fitting errors—for July 1973, May 1980, and February 1981—was addressed using dummy variables to shift the intercept. The estimated coefficients on these dummy variables were always highly significant—and (negative, negative, positive) in signs, respectively—but their exclusion did not substantively affect the inference results reported below. Consequently, the listing of these coefficient estimates—and the model intercept term (α)—is, for simplicity, suppressed in Table 1.

25 Federal Reserve funds rate dynamics were significantly more volatile prior to 1983 than afterwards. We discuss the regime shifts explanation in Ashley *et al.* (2019).

The base model specification in Equation (2) imposes the assumption that the FOMC did not distinguish the most persistent movements in u_t and π_t from other fluctuations. As one may have expected, during the VGB period this is a profound mis-specification. While β and φ enter with conventional signs and statistical significance during the MBM period, during the VGB period the estimates would appear to indicate that the FOMC ignored fluctuations in u_t in this period, since $H_0 : \beta = 0$ cannot be rejected at conventional levels of significance. Taking these coefficient estimates at face value also indicates that the FOMC's response to inflation rate fluctuations was notably smaller in the MBM period than in the VGB period: on average, the FOMC increased the federal funds rate by only 0.63% for every 1% increase in the inflation rate in the MGM period whereas, in the VGB period, the estimated response is 1.50%. The FOMC's short-run response to a 1% increase in the unemployment rate is only economically meaningful during the MBM period and, even then, its economic significance is somewhat modest (−0.84%).[26]

But these base model results are artifactual; during this period, the implicit u_t target of the FOMC was varying substantially. Allowing for (but not imposing an assumption that) the possibility that the FOMC could distinguish the most persistent movements in u_t and π_t from other fluctuations—see Equation (3)—yields interestingly different results, which we now describe.

We begin by discussing an anomalous coefficient estimate: φ_3 is estimated to be significantly negative during the VGB period, ostensibly indicating high-frequency accommodation of inflation rate fluctuations. However, this result is actually an artifact, because this coefficient was unstable during the VGB period. Between October 1979 and October 1982, rather than targeting the federal funds rate, the FOMC was targeting non-borrowed reserves (as a means to control monetary aggregates and, hence, inflation). During this period, the federal funds rate was highly variable, with reversals that roughly line up with high-frequency inflation shifts. This is consistent with the view that high-frequency shifts in inflation occurred along with (and perhaps caused) high-frequency shifts in money demand that, in turn, induced high-frequency shifts in the federal funds rate. To test this, we allowed for a break in φ_3 after 1982. In that case, φ_3 is statistically different from zero only during the pre-1983 period, while other inferences are unaffected.

With respect to the persistence-decomposed u_t fluctuations, we note that the null hypothesis $\beta_1 = \beta_2 = \beta_3$ can be rejected in both periods—very strongly in the VGB period. The source of that rejection is clear: β_1, the coefficient on the very persistent component of u_t, is statistically insignificant in both periods. Thus, our results suggest that during the MBM period, *just as in the VGB period*, the FOMC did not respond to (i.e., was ignoring) the most persistent unemployment rate fluctuations. (Equivalently, the FOMC was implicitly forming a "gap" term or intermediate target consisting of u_t^1, and only responding to $\{u_t - u_t^1\}$.)[27] Now turn to the β_2 estimates; that is, the coefficients on the "moderately persistent" components of u_t for the two periods. The point estimates in Table 1 suggest

26 If one re-estimates Equation (2) using a conventional unemployment rate gap, one finds—in keeping with most of the literature—evidence for a response to unemployment rate fluctuations in the VGB period. Evidently, the apparent non-response to unemployment rate fluctuations in the VGB period indicated in Table 1 for Equation (2) arises from the fact that the FOMC does not respond to extremely persistent movements in the unemployment rate, and these comprise a large part of the variance.

27 To see this, note that $i_t = \beta(u_{t-1} - u_{t-1}^1) = \beta\Big((u_{t-1}^1 + u_{t-1}^2 + u_{t-1}^3) - u_{t-1}^1\Big) = \beta(u_{t-1}^2 + u_{t-1}^3)$.

that, during the VGB period, even more so than in the MBM period, the FOMC responded aggressively to those unemployment rate fluctuations that are, perhaps, the most responsive to policy changes; however, the hypothesis that $\beta_2^{MBM} = \beta_2^{VGB}$ cannot be rejected at the 10% level of significance. So, there is no real evidence here that this response is different across the two periods. Thus, we find that the FOMC *in both periods* ignored very persistent movements in u_t, and focused significantly on responding to less persistent fluctuations. We note that our methodology has allowed us to determine this without making use of any ancillary assumptions.

This continuity of behavior that we find regarding fluctuations in the unemployment rate is evidence against one part of the "views" explanation of the Great Inflation. Our results suggest that conceptual or measurement struggles related to the activity gap do *not* explain FOMC behavior in the 1970s, as some analysts have asserted. Instead, over the time span in our study the FOMC *always* ignored very persistent fluctuations in the unemployment rate, sharply contrasting to its strong (and stable) response to *moderately* persistent fluctuations in the unemployment rate. The implicit gap, $(u_t - u_t^1)$, comprises a new activity gap estimate that is quite different from its predecessors. Notice that u_t^1, the most persistent part of u_t, *includes* movements of very low frequency in the unemployment rate—of the sort comprising conventional (and slowly moving) natural rate estimates, such as the CBO's—but it is not *limited to* those movements. Our insignificant estimate for β_1—that is, our finding that the FOMC ignored u_t^1, the most persistent component of u_t—is consistent with its viewing such movements as being natural rate fluctuations or, alternatively, as treating u_t^1 as an intermediate target. Our results thus suggest that much previous work (which has often focused on particular estimates of an output gap, rather than on an unemployment gap) may have come to erroneous conclusions with respect to historical FOMC behavior.[28]

With respect to inflation rate (π_t) fluctuations, we find that—in contrast to its continuity of response to the unemployment rate over both periods—the FOMC's response to inflation movements changed in not just one way, but *two* ways between the MBM and the VGB periods. First, comparing the φ_1, φ_2, and φ_3 estimates for the two periods, the VGB FOMC became notably more aggressive in its response to inflation—something other authors have noted (e.g., Clarida *et al.*, 2000, or Conrad and Eife, 2012). Indeed, in contrast to many studies,[29] we can reject the hypothesis $\varphi_1^{MBM} = \varphi_1^{VGB}$ at the 5% level of significance. And, second, in the VGB period the FOMC also became much more focused on fighting the *persistent* fluctuations in inflation, and ignoring more transient movements. While the φ_k coefficient estimates themselves are consistent with a differential-inflation-persistence-response interpretation in the MBM period, the formal statistical test of coefficient equality fails to reject the null hypothesis that the FOMC responded to all inflation fluctuations in the same way during this period; the rejection p-value for this null hypothesis is 0.67. We interpret this as indicating that, during the VGB period, the FOMC became either more focused on, or more accurate at, identifying persistent inflation fluctuations.

We provide robustness checks in Section 3.3, following Ashley *et al.* (2019). Our results are robust to estimating standard errors using bootstrapping and to the inclusion of a time-

28 In Ashley and Verbrugge (2020), we also find that coefficient instability ("weakening") in the Phillips curve relationship is entirely due to an erroneous unemployment gap specification, and that this inflation relationship also features economically interpretable persistence-dependence.

29 See, for example, Coibion and Gorodnichenko (2012) and the discussion therein.

varying r_t^*. Our results are strengthened if we impose that $\beta_2 = \beta_3$ and $\phi_2 = \phi_3$. In-sample tests and out-of-sample forecasts indicate that our u_t^* estimate better describes historical FOMC behavior than does the CBO estimate of u_t^*, as is also the case with a conventional output gap estimate.[30]

3.3 The Great Inflation

3.3.1 "Ideas" versus a change in policy preferences As noted above, our results shed some light on the origins of the Great Inflation. They imply that one version of the "ideas" hypothesis—the "bad gap" version, that FOMC errors in the 1970s were due to erroneous beliefs about the structure of the economy, in particular an unrealistically low estimate of the natural rate of unemployment (e.g., Orphanides, 2002; Romer and Romer, 2002; Romer, 2005)—cannot fully explain FOMC policy during that time period. Our findings point in this direction because we show that FOMC behavior with respect to the federal funds rate response to the unemployment rate remained rather stable between the MBM and VGB periods: during both periods, it ignored the most persistent fluctuations in u_t, implicitly forming the gap in the same manner. Putting this differently, FOMC behavior in the 1970s does *not* seem related to mismeasurement of u_t^*. So, what can explain the high inflation of that period?

As noted above, during the VGB period, the FOMC became more aggressive in its response to inflation, and more focused on fighting the *persistent* fluctuations in inflation. What accounts for this distinct change in behavior? There are two possibilities, between which our analysis cannot distinguish. The first amounts to a variant of the ideas hypothesis, "policy ineffectiveness or pessimism". There is some evidence to suggest that some Federal Reserve officials—notably Arthur Burns and G. William Miller—held the belief that inflation was driven by wage-cost pressures, and that monetary policy would be ineffective in combatting inflation, or that the cost of reducing inflation would be vast.

The second possibility is a change in policy preferences, possibly driven by changing political pressures; see, for example, Chappell *et al.* (1993), Lakdawala (2016), and other work discussed in Ashley *et al.* (2019). For instance, Abrams (2006) relates Nixon administration pressure on Burns, and argues that it is difficult to explain the expansionary policy leading up to the 1972 election without invoking political pressure. In 1979, after leaving the FOMC, Burns (1979) himself indicated that "at any time within that period, [the FOMC] could have. . .terminate[d] inflation with little delay" and that it did not do so for political reasons.

3.3.2 Whither the "poor forecasts" explanation Some conjecture that the behavior of the FOMC in the1970s resulted from inaccurate inflation forecasts (see, e.g., Orphanides, 2002; Levin and Taylor, 2013; or Fuhrer and Olivei, 2017). To investigate this hypothesis, in parallel to our treatment of the real-time monthly CPI inflation rate, we constructed monthly estimates of the highly persistent part of the quarterly GNP deflator. For this exercise, one-sided filtering was conducted for each month using a five-year window of quarterly data based upon 15 quarters of real-time data, augmented with the monthly real-time nowcasts and 4 quarterly forecasts in the Greenbook of that month.[31] We find that, as one

30 We are indebted to a referee for suggesting the latter test.

31 Early in the sample, in order to obtain a sufficient number of forecasts, we had to augment Greenbook forecasts. We did this using SPF forecasts when available, or using simple univariate

may have expected based upon previous research, the implied (Greenbook-based) estimate of $\pi_t^{persistent}$ is systematically lower than our baseline CPI-based estimate during a large portion of the 1970s.

High collinearity of the components of the GDP deflator with those of the CPI led to inconclusive in-sample tests. We conducted a second out-of-sample forecast comparison test to determine which model—our baseline CPI-based model, or the alternative GNP deflator with Greenbook forecasts—better predicted or described actual FOMC behavior. As before, we used the Diebold–Mariano forecast comparison test to compare two linear models over the MBM period, estimated over rolling 10-year windows. Both models treat u_t identically, with this variable entering in gap form as in $(u_t - u_t^{persistent})$; in both models, this term was lagged one month. Regarding the treatment of π_t, the GNP deflator model uses the *current* real-time estimate of $\pi_t^{persistent}$, while our model uses our real-time estimate of $\pi_t^{persistent}$, lagged two months. Then, each model included a constant and one lag of the federal funds rate. Despite our model's informational disadvantage—the GNP deflator model always uses all available inflation information, including CPI inflation and other inflation-relevant data, while our baseline model ignores other inflation relevant data and is sometimes one month out of date relative to the GNP deflator data—our baseline model significantly outperformed the GNP deflator model: the p-value of the Diebold–Mariano test statistic was 0.037. This indicates that the actual behavior of the FOMC in the 1970s is more consistent with its having used real-time CPI inflation data (where identification of the persistent part of inflation fluctuations uses information from simple but reliable inflation forecasts). Our results thus suggest that poor inflation forecasts are not the chief explanation of the FOMC behavior in the 1970s.[32]

4. Conclusions

Using the lens of simple monetary policy reaction functions, we apply recently developed econometric tools to deepen our understanding of FOMC behavior, and how it changed between the MBM and VGB periods. Standard simple monetary policy rules such as Equation (2) properly allow for persistence in the federal funds rate, but impose an assumption regarding an activity gap, as well as an assumption of persistence-independence regarding the inflation rate reaction. In this paper, we relax these restrictions and test them. Our results are surprising along some dimensions, but accord well with intuition and certain other accounts. Our study reaches the following conclusions.

First, we note that estimates of Equation (2)—which imposes a constant natural rate of unemployment and persistence-independence in the FOMC reaction function regarding the unemployment rate—lead to the conclusion that the FOMC was largely unresponsive to unemployment rate fluctuations in the VGB period. While we agree that Equation (2) is rarely estimated in this form, we note that this fundamentally misleading result underscores the necessity, in this instance, of allowing for a distinction between the response to persistent movement in the unemployment rate versus the response to a less persistent fluctuation.

forecasts that treated available Greenbook forecasts (or Greenbook + SPF forecasts) as additional data.

32 While we are encouraged by the post-sample forecasting effectiveness of our model, the present study is about inference rather than forecasting. We lay no claim here to having developed a new forecasting approach. For a study along those lines, see, for example, Carlstrom and Zaman (2014).

By extension, we would argue that there are likely many other macroeconomic relationships in which the relationship between two variables differs by persistence level. In such cases, restricting this relationship to be the same will quite likely miss out on uncovering some interesting features in the data, and may well lead to over-simplified and distorted inferences. And, given the tools now at our disposal, such restrictions are not necessary.

Second, in the VGB period, the FOMC's response to inflation movements changed in two ways, rather than just one. First, our results suggest that the VGB FOMC became more aggressive in its response to inflation—something other authors have noted (e.g., Clarida *et al.*, 2000). But second, it also apparently became much more focused on fighting the *persistent* fluctuations in inflation, and began ignoring more transient movements.[33]

Third, by allowing the data themselves to inform us about FOMC responses to persistent fluctuations versus higher-frequency fluctuations, we notably find that (i) the FOMC during the MBM period did respond to an unemployment gap, and that (ii) mismeasurement of u_t^* (or the output gap) is *not* an entirely convincing explanation for FOMC behavior in the 1970s, as some analysts have argued. Instead, whether or not such an equilibrium concept was understood formally, or simply incorporated into judgment (consciously or unconsciously), the FOMC in *both* periods ignored extremely persistent fluctuations in the unemployment rate, although it arguably became better at this in the VGB period. We follow Fuhrer, and identify this persistent component of the unemployment rate "the FOMC's 'intermediate unemployment rate target'". This lack of response to highly persistent fluctuations contrasts sharply with the FOMC's strong response to *moderately* persistent unemployment fluctuations, those fluctuations presumably most responsive to policy.

The continuity of FOMC behavior between the MBM and VGB periods sheds some light on the origins of the Great Inflation and suggests that much previous work, imposing *a priori* gaps on the data, may have come to erroneous conclusions about FOMC behavior in the 1970s. In particular, our results suggest that the "ideas" hypothesis—that FOMC errors in the 1970s were due to erroneous beliefs about the structure of the economy, particularly conceptual or measurement errors regarding the activity gap (e.g., Orphanides, 2002, or Romer, 2005)—cannot fully explain FOMC policy during that time period. Our forecasting results further suggest that the "poor inflation forecasts" hypothesis also fails to explain FOMC behavior. Hence, taken together, our results suggest that policy preferences—possibly driven by political pressures—are far more likely to be the central explanation of the Great Inflation.

Economic theory often suggests that decision-makers distinguish between fluctuations with different degrees of persistence. The straightforward technique used here illustrates how one can easily test this hypothesis—even in settings where (as here) feedback is likely, so that ordinary spectral analysis is inappropriate. Using this technique can lead to sharp new insights about the process generating such data, whereas ordinary time-series

33 While the coefficient estimates themselves are consistent with a differential-inflation-persistence-response interpretation in the MBM period, formal statistical tests fail to reject the null hypothesis that the FOMC responded to all inflation fluctuations in the same way during this period. We interpret this as indicating that the FOMC during the VGB period became either more focused on, or more accurate at identifying, persistent inflation fluctuations. Broadly speaking, this accords with the analysis of Goodfriend and King (2013); in discussing that paper, Svensson (2013) states that "a major explanation for the Great Inflation could be a small weight on inflation stabilization and a drifting inflation target does not seem so far-fetched" (p. 213).

techniques (in either the time domain, or the frequency domain) would both fail to uncover features of this nature in the data-generating process reliably, and yield distorted inference results for having glossed over them. Any empirical finding of persistence-dependence deriving from the new econometric methodology used here is very clearly interpretable in intuitive economic terms. This methodology is therefore particularly well-suited to guiding the construction of deeper and richer structural model specifications for the economic processes underlying the data-generating mechanism the properties of which have thus been unveiled.

In keeping with this, we conclude with a discussion of the implications of our work for DSGE modeling. Most of the DSGE models used for studying optimal monetary policy are essentially linearized approximations to richer models, and are typically driven by exogenous AR(1) driving processes; thus, they yield linear empirical specifications. Ultimately, this is why policy rules resembling Equation (1) are often found to be optimal (or nearly so) in such DSGE models. Above, we have discussed some episodes—corresponding to different Federal Reserve chairmanships—during which we find that empirical estimations of the policy rules that appear to have been used by the FOMC are persistence-dependent to a statistically significant degree. Apparently, the FOMC in its historical behavior did routinely distinguish between unemployment and inflation rate fluctuations with differing perceived persistence levels, and differently so across the two chairmanship episodes we consider.

Our persistence-dependence results are the natural reflection of a neglected nonlinearity in the empirical policy rule specification. As has been noted many times (e.g., Fernández-Villaverde, 2011), linearization eliminates many phenomena of interest, such as asymmetries and threshold effects. Persistence-dependence is another such phenomenon. Our persistence-dependence results—and analogous results on inflation dynamics that we obtain in Ashley and Verbrugge (2020), or on consumption behavior in Blundell *et al.* (2013), or on the money-interest rate link in Cochrane (1989)—suggest that DSGE modeling may benefit from specifying a richer dynamic structure that endogenously generates persistence-dependent optimal policies.

Supplementary material

Supplementary material is available on the OUP website. These are the data and replication files and the online Appendix.

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