THE PHILLIPS CURVE IS ALIVE AND WELL:
INFLATION AND THE NAIRU DURING THE SLOW RECOVERY

Robert J. Gordon

The Phillips Curve is Alive and Well: Inflation and the NAIRU During the Slow Recovery
Robert J. Gordon
NBER Working Paper No. 19390
August 2013
JEL No. E00,E31,E52,J60,J64

ABSTRACT

The Phillips Curve (hereafter PC) is widely viewed as dead, destined to the mortuary scrapyard of discarded economic ideas. The coroner's evidence consists of the small standard deviation of the core inflation rate in the past two decades despite substantial volatility of the unemployment rate, and in particular the common tendency of PC inflation equations to predict ever greater amounts of negative inflation (i.e., deflation) over the years of labor-market slack since 2008, sometimes called "the case of the missing deflation". The apparent failure of the PC deprives the Fed of a means of estimating the natural rate of unemployment (or NAIRU), and thus the Fed is steering the economy in a fog with no navigational device to determine the size of the unemployment gap, one of the two primary goals of its "dual mandate." The results of this paper contain important new information for Fed policymakers, for Fed-watchers, and almost everyone else in the community of policy-makers and practitioners of applied macro.

The greatest failure in the history of the PC occurred not within the past five years but rather in the mid-1970s, when the predicted negative relation between inflation and unemployment turned out to be utterly wrong. Instead inflation exhibited a strong positive correlation with unemployment. Failure bred success, as a revolution in thinking rebuilt macroeconomics to be not just about demand, but also about supply. By 1980 diagrams of shifting demand and supply curves had appeared in most macroeconomics textbooks. An econometric model of the inflation rate developed in 1982, soon dubbed the "triangle model", incorporated explicit variables for supply shifts and has successfully tracked inflation behavior since then.

The triangle model shows that the puzzle of missing deflation is in fact no puzzle. It can estimate coefficients up to 1996 and then in a 16-year-long dynamic simulation, with no information on the actual values of lagged inflation, predict the 2013:Q1 value of inflation to within 0.50 of a percentage point. The slope of the PC relationship between inflation and unemployment does not decline by half or more, as in the recent literature, but instead is stable. The model's simulation success is furthered here by recognizing the greater impact on inflation of short-run unemployment (spells of 26 weeks or less) than of long-run unemployment. The implied NAIRU for the total unemployment rate has risen since 2007 from 4.8 to 6.5 percent, raising new challenges for the Fed's ability to carry out its dual mandate.

Robert J. Gordon
Department of Economics
Northwestern University
Evanston, IL 60208-2600
and NBER
rjg@northwestern.edu

TABLE OF CONTENTS

1. Introduction

It is widely believed that the Phillips Curve is dead. The U. S. economy during the past five years has experienced stable inflation in the face of prolonged slack in the labor market. According to the standard expectational Phillips Curve (hereafter PC), inflation depends on the expected rate of inflation and the gap between actual and equilibrium unemployment, otherwise known as the natural rate of unemployment or the NAIRU ("Non-Accelerating Inflation Rate of Unemployment"). In this version of the PC with backward-looking (adaptive) expectations, a prolonged period of a positive unemployment gap, as has existed over the five years since mid-2008, mechanically predicts that the inflation rate in each quarter will be lower than in the previous quarter. Several research papers have shown that this model predicts that the inflation rate by now should have declined well into deflationary territory, with an annualized negative inflation rate of as much as minus 4 percent.

1.1 The Case of the Missing Deflation

With no barrier to prevent the inflation rate from turning from positive to negative, the standard Phillips curve has predicted an accelerating deflation after 2008. Because the actual inflation rate has not turned negative but rather has been relatively stable in the range of one to two percent, except when temporarily perturbed by movements in oil prices, the standard Phillips Curve has been discredited. As a result efforts to estimate the time-varying NAIRU (TV-NAIRU) seem to have ceased. The Federal Reserve hence lacks the basic information it needs to carry out its dual mandate, because it cannot estimate the size of the output or unemployment gaps without a viable PC specification needed to estimate the TV-NAIRU. Any attempt to apply the Taylor Rule to monetary policy is missing one of its key ingredients: the size of the output or unemployment gap. The "missing deflation puzzle" was summarized three years ago by John Williams, now President of the San Francisco Fed, when he said:

> The surprise [about inflation] is that it's fallen so little, given the depth and duration of the recent downturn. Based on the experience of past severe recessions, I would have expected inflation to fall by twice as much as it has (Williams 2010, p. 8).

Numerous papers have attempted to solve this puzzle with an ad hoc patchwork of explanations. The most comprehensive exploration of alternative solutions is that of Laurence Ball and Sandeep Mazumder (2011), hereafter identified as B-M. These authors, writing in early 2011, recreate the puzzle by showing that the standard PC model predicts a decline in headline inflation from +4 to -3 percent, a deceleration of 7 percentage points, in the 10 quarters between mid-2008 and the end of 2010. The many suggested B-M solutions include allowing the slope of the PC to fall by half since the mid-1980s, and independently switching from the standard core

inflation index to median inflation across inflation sub-indexes as the dependent variable.[1]

James Stock and Mark Watson (2010) have attempted to solve the missing deflation puzzle by converting the relationship between the inflation rate and the level of the unemployment rate to an alternative between the inflation rate and the *change* in the unemployment rate. Their specific method, to enter the explanatory variable as the unemployment gap minus a 12-quarter moving average of the gap, largely solves the missing-deflation puzzle because the gap term becomes zero soon after the unemployment rate hits its cyclical peak and thus is no longer positive. While the Stock-Watson suggestion solves the missing deflation puzzle, it introduces a new puzzle – why did the PC shift from a level effect to a rate-of-change effect after 2007? There is a substantial earlier literature on the rate-of-change effect as describing the Great Depression years but not the postwar years, and the reasons why that shift occurred, which have been largely forgotten by contemporary researchers (see Romer 1999 and Gordon 1982b).

If correct, the Stock-Watson result would be revolutionary, because it would imply that there is no NAIRU that divides regimes of accelerating from decelerating inflation, and the concept of an output or unemployment gap would become vacuous. Once the unemployment rate stops rising or stops falling, the NAIRU is equal to the actual rate of unemployment. Thus, Stock and Watson would interpret the late 1960s with a stable unemployment rate below 4 percent as a steady-inflation equilibrium, and likewise the economy of 2010-11 with a relatively stable unemployment between 8 and 9 percent as another steady-inflation equilibrium.

Their approach is reminiscent of the "hysteresis hypothesis" that was applied to Europe in the late 1980s, when there was a sharp and permanent increase in the unemployment rate from 2 percent before 1972 to more than 8 percent after 1985. Yet the inflation rate was stable. Key contributions to understanding the hysteresis effect and the implied rise in structural unemployment appear in the edited volume by Rod Cross (1988), and also in a paper by Olivier Blanchard and Lawrence Summers (1986). The extra European unemployment was treated as structural, and analysts since 1985 have called attention to the much higher incidence of long-run unemployment in western Europe than in the U. S. The unprecedented extent and duration of long-run unemployment in the U.S. during 2009-2013 raises the question that is partly answered in this paper, "Has the U. S. labor market finally started acting European?"

The PC literature has been dominated over the past 15 years by an approach called the New-Keynesian Phillips Curve (NKPC). Because of its importance in macroeconomic literature, we examine below the theoretical justification of the NKPC model. The B-M paper shows, as did Gordon (2007, 2011) that the NKPC has failed in practice; its predictions of

---

1. In a subsequent paper in progress, Astrayuda, Ball, and Mazumder (2013) find that the B-M 2011 model is prone to predicting deflation in 2012 and 2013.

accelerating deflation are just as incorrect as those of the simple expectational PC described above, because the reduced form of the NKPC turns out to be a simple regression of inflation on short lags of past inflation and the current unemployment rate or unemployment gap.[2] We affirm the B-M results over dynamic simulations not just of the post-2006 interval but also of the entire 16-year period stretching from 1997 to 2013. In fact, we show that the NKPC model amounts to nothing more than predicting current inflation by short lags on recent inflation, with no separate contribution from the model at all, and the lag of predicted inflation behind actual inflation is clearly visible in charts presented below. For the NKPC model, "today's inflation is yesterday's inflation" – end of story.

1.2 The Triangle Model Provides A Solution

The central result of this paper is that there is no need for patchwork solutions, and no need to resort to hysteresis-like explanations, because the missing deflation puzzle is not a puzzle. The triangle model of the inflation process, developed more than three decades ago, is capable of predicting inflation accurately in post-sample dynamic simulations long after the end of the sample period used to estimate the regression coefficients.

Two tests demonstrate the stability of the model. First, it can track actual inflation in dynamic simulations through 2013:Q1, not just in sample periods that end in 2006 but also those ending in 1996. Using coefficients estimated through 1996:Q4, together with actual data on the explanatory variables – other than the lagged values of inflation, which are replaced by endogenously generated lagged inflation values – the model can forecast inflation in early 2013 with a mean error of less than half of a percentage point. Second, the estimated unemployment coefficient is remarkably stable over alternative sample periods ending in 1996, 2006, or 2013. The conclusion of B-M and much other empirical PC research, that the coefficient on unemployment in the inflation equation has fallen by half or more, represents a classic example of econometric specification bias.

Over the years, the triangle model has provided an explanation for what seemed at the time to be big surprises – (1) the model explained *in advance* in 1982 why the inflation rate fell so rapidly during 1981-86 with a "sacrifice ratio" that was only one-third of forecasts made prior to the disinflation,[3] (2) the model explained why inflation was so low in the late 1990s despite the

---

2. In some versions of the NKPC model, a frequently examined alternative version of the NKPC makes the explanatory variable not the output or unemployment gap but rather labor's marginal cost. As pointed out by many critics, including B-M, the empirical proxy for marginal cost is changes in the income share of labor, and changes in the share behave nothing like the inflation rate and have no predictive power. Further, changes in labor's share consist of three endogenous variables – wage change, price change, and productivity change – that are not recognized as endogenous by the NKPC practitioners.

3. The Gordon-King (1982) paper created a VAR model that combined the triangle inflation model with separate equations to endogenize the exchange rate and import prices. It predicted in advance that disinflation would occur

rapid growth of demand and the decline of the unemployment rate well below anyone's estimate of the NAIRU, and (3) in this paper the same model can explain why deflation did not occur during 2008-13. Section 2.2 below reviews the background of the triangle model and provides details on aspects of the specification that have been altered since 1982.

The late-1980s "hysteresis" literature and subsequent developments have led to a distinction between short-run and long-run unemployment. In the U.S. data, it is conventional to divide these two subgroups of the unemployed at the duration of 26 weeks, or 6 months. An old idea dating back to the Europe-oriented literature of the 1980s on hysteresis is that the long-run unemployed do not place downward pressure on wages and prices because they have become disconnected from the labor market. Countless articles in the American media, especially the business press, over the past few years have pointed to discrimination against the long-run unemployed in the job application process. Resumes received from applicants showing long gaps of time without employment are routinely trashed, on the assumption that the long-run unemployed have lost their skills, become obsolete, or are flawed in some unobservable way for which long-run unemployment serves as a signaling device. Numerous papers, including Mary Daly *et al.* (2011) show shifts in the Beveridge curve for vacancies vs. total unemployment, but these shifts no longer occur when vacancies are plotted against short-run unemployment.

While the triangle model performs better than any other recently published model at tracking inflation in dynamic simulations when the total unemployment rate is used as the demand-side variable, an even better performance in dynamic simulations is achieved when the same model is estimated with the short-run unemployment rate replacing the total unemployment rate. The post-2009 labor-market recovery has been unique for the persistence of long-run employment. The main reason the unemployment rate has stayed so high and for so long is that long-run unemployment (27 weeks or longer) has risen to a level that has not previously been observed in the history of the postwar data. In contrast, short-run unemployment in early 2013 was actually lower than in the 1982-1990 recovery at the same stage.

Results of the 1982 triangle model, with short-run unemployment replacing the total unemployment rate, perform marginally better in goodness of fit tests in sample periods that extend beyond 2007 to 2013 but substantially better by the criteria of the mean error and root-mean-square-error (RMSE) of dynamic simulations. The versions using short-run unemployment also exhibit a smaller downward shift in the PC coefficient after 2007. The basic results of the paper show that once short-run unemployment is substituted for total unemployment, the triangle model, estimated with data through 1996, can track the inflation

---

much faster than the standard models of the time, and its sacrifice ratios, estimated in early 1982, turn out in retrospect accurately to describe the entire 1981-86 experience of the "Volcker disinflation."

rate in 2013:Q1 to within one-quarter of a percent in 16-year dynamic simulations, with no access to any data on the actual behavior of inflation between 1997 and 2013.

Policymakers until now have operated in a statistical fog regarding the current value of the NAIRU and the implied sizes of the unemployment and output gaps. Estimates of the NAIRU are not credible in models that cannot track the actual behavior of inflation in dynamic simulations, and that predict accelerating deflation in the post-2008 half-decade. But, since this paper presents accurate dynamic simulations of inflation behavior, its inflation model can be used to back out the implied time-varying NAIRU that applies to the post-2007 period. The implied short-run unemployment NAIRU is highly stable, staying in the range of 3.9 to 4.4 percent between 1996 and 2013. However, the rise in the extent and duration of long-run employment causes the NAIRU for the total unemployment rate (short-run plus long-run) to increase from 4.8 percent in 2006 to 6.5 percent in 2013:Q1. As a result, this paper supports the recent research that argues that there has been an increase in structural unemployment taking the form of long-run unemployed.

1.3 Has the Phillips Curve Flattened?

Has the slope of the American Phillips Curve (PC) become flatter in the past two decades? Research at the Federal Reserve believes so. The primary published Fed study by John Roberts (2006) attributes to monetary policy both the change in slope and the related marked reduction in U. S. business cycle volatility through 2006. The channel of monetary policy influence comes from an increased Fed responsiveness to output and inflation, so that any pressure for higher inflation or any movement of the output gap away from zero are "nipped in the bud". A flatter PC directly contributes to the interplay between monetary policy and output stabilization, as movements of the output gap above zero generate less inflation than formerly, requiring less monetary tightening and thus a smaller subsequent downward adjustment in output.[4]

However, these conclusions are controversial. The verdict that the PC slope has flattened is highly sensitive to specification choices, and a primary purpose of this paper is to examine the interplay between model specification and conclusions about the stability of PC parameters. In the results presented below, we use the technique of "rolling regressions" to examine changes in the main parameters over time. We show that the response of inflation to the unemployment gap is much smaller in the NKPC variant used by Roberts at the Fed than in the triangle model. The decline in the coefficient on the unemployment gap is even more marked in the time-varying NAIRU version of the NKPC examined in Appendix A. Further doubt about the Fed's 2006-2007 complacency arises from the idea that "any movement of the output gap away from zero is nipped in the bud." A very large movement of the output gap

---

4. Also representing the Fed view are Kohn (2005) and Williams (2006).

below zero occurred in 2008-09, and appears to contradict that assertion of confident monetary control.

1.4 Plan of the Paper

The paper begins in Part 2 with a brief section describing the specification of the NKPC and triangle alternative models. The basic results displaying regression coefficients and dynamic simulation errors are presented in Part 3. The policy implications, including the new estimates of the time-varying (TV) NAIRU and associated future forecasts are included in Figure 4. Tests of the stability of coefficients and other aspects of the triangle and NKPC models are presented in Part 5. Part 6 concludes.

Appendix A examines a version of the NKPC model that allows the NAIRU to vary over time, while Appendix B presents tests showing that the empirical version of the NKPC is nested in the triangle model, allowing significance tests on the set of variables and lags omitted from the NKPC model. As we shall see, every variable and extra lag excluded from the NKPC model and included in the triangle model is highly significant.

2. The New-Keynesian and Triangle Specifications of the Phillips Curve

Section 2.1 compares alternative New-Keynesian Phillips Curve (NKPC) specifications. The literature contains two versions of the NKPC, one in which the driving force of inflation is the unemployment (or output) gap, and the other in which the gap is replaced by the change in marginal cost. Then in section 2.2 we provide the background of the triangle model and supply additional details about its specification.

2.1 The New-Keynesian Phillips Curve (NKPC) Model

The NKPC model is an outgrowth of the important and influential paper by Sargent (1982) on the ends of four hyperinflations. Those episodes clearly demonstrate the importance of forward-looking expectations, in that the start and end of the hyperinflations were primarily determined by changes in fiscal regimes that altered the inflation rate almost immediately. In Weimar Germany of 1921-23 there was no inertia of the type that has characterized postwar U. S. inflation. Any model incorporating forward-looking expectations allows the inflation rate to "jump" up or down in response to changed perceptions of current and future monetary and fiscal policy behavior.

The NKPC model has emerged in the past decade as the centerpiece of macro conference

discussions of inflation dynamics and as the "workhorse" in the evaluation of monetary policy.[5] The point of the NKPC is to derive an empirical description of inflation dynamics that is "derived from first principles in an environment of dynamically optimizing agents" (Gunnar Bårdsen *et al.* 2002). Most expositions of the NKPC, e.g., N. Gregory Mankiw (2001), begin with Guillermo Calvo's (1983) model of random price adjustment.

The theoretical background is that firms follow time-contingent price-adjustment rules. The firm's desired price depends on the overall price level and the unemployment gap.[6] Firms change their price only infrequently, but when they do, they set their price equal to the average desired price until the next price adjustment. The actual price level, in turn, is equal to a weighted average of all prices that firms have set in the past. The first-order conditions for optimization imply that expected future market conditions matter for today's pricing decision. The model can be solved to yield the standard NKPC that makes the inflation rate (p_t) depend on expected future inflation $(E_t p_{t+1})$ and the unemployment (or output) gap:

$$p_t = \alpha E_t p_{t+1} + \beta(U_t - U^*_t) + e_t, \tag{1}$$

where U is the unemployment rate. In our notation lower case letters represent first differences of logarithms and upper-case letters represent either levels or log levels. Note in particular that lower-case p in this paper represents the first difference of the log of the price level, not the price level itself. The constant term is suppressed, and so the NKPC has the interpretation that if $\alpha=1$, then U^*_t represents the NAIRU. Subsequently we show the difference made by the decision whether to treat the NAIRU as a constant or as a Hodrick-Prescott (H-P) trend.

A central challenge to the NKPC approach is to find a proxy for the forward-looking expectations term $(E_t p_{t+1})$. The standard approach is to use instrumental variables. The first-stage equation to be included in the two-stage least squares (2SLS) estimation progress is

$$E_t p_{t+1} = \sum_{i=1}^{4} \lambda_i p_{t-i} + \phi(U_t - U^*_t). \tag{2}$$

Substituting the first-stage equation (2) into the second-stage equation (1), we obtain the reduced-form

---

5. See Olivier Blanchard (2009).

6. Most NKPC papers focus on the output gap, but the high negative correlation between the output and unemployment gaps allows them to be used interchangeably, see below. Mankiw's (2001) exposition followed here uses the unemployment gap.

$$p_t = \alpha \sum_{i=1}^{4} \lambda_i \, p_{t-i} + (\alpha \, \phi + \beta)(U_t - U^*_t) + e_t \qquad\qquad \textbf{(3)}$$

Thus in practice the NKPC is simply a regression of the inflation rate on a few lags of inflation and the unemployment gap. As pointed out by Jeffrey Fuhrer (1997), the only sense in which models including future expectations differ from purely backward-looking models is that they place restrictions on the coefficients of the backward-looking variables that are used as proxies for the unobservable future expectations:

> Of course, some restrictions are necessary in order to separately identify the effects of expected future variables. If the model is specified with unconstrained leads and lags, it will be difficult for the data to distinguish between the leads, which solve out as restricted combinations of lag variables, and unrestricted lags. (Fuhrer, 1997, p. 338)

And, as shown in Fuhrer's paper, these restrictions are implicitly rejected by the data in the sense that he finds that the expected inflation terms are "empirically unimportant" when unconstrained lagged terms are entered as well.

Numerous variants of the NKPC approach have been proposed and estimated. Jordi Galí and Mark Gertler (1999) and Galí with David Lopez-Salido (2005) have proposed a "hybrid" NKPC model in which explicit lagged inflation terms are added to equation (1) in addition to the forward-looking expectation term. They report that in regressions replacing the unemployment gap by labor's income share, "forward-looking behavior is dominant." However, as pointed out by Jeremy Rudd and Karl Whelan (2005), these estimates do not actually distinguish between forward-looking and backward-looking behavior due to the nature of the 2SLS exercise. Galí and co-authors enter additional terms in the first-stage (equation 2 above) – e.g., additional lags on inflation as well as explicit supply shock variables like commodity prices – that are not allowed to enter the second stage (equation 3 above). Indeed, anything that is correlated with current inflation but not included in the second stage will serve as a good instrument for future expected inflation and thus falsely convey the impression that forward-looking behavior is dominant.

These omitted variables boost the coefficient on expected future inflation even if expected future inflation has no influence at all on inflation itself, as occurs when Rudd and Whelan estimate a pure backward-looking model that includes some of the additional variables that Galí *et al.* included as instruments in the two-stage procedure. Overall, the NKPC hybrid approach has delivered no evidence that expectations are forward-looking, since the instruments used in the first stage are incompatible with the theory posited in the second stage.

If longer inflation lags and commodity prices matter for inflation, then why are they omitted from the NKPC equations (1) and (3) above?

The Roberts (2006) version of the NKPC, like that of Galí and his collaborators, relies on a reduced form that looks like equation (3) above – it omits long lags on inflation and any specific variables to represent the influence of supply shocks. It is particularly interesting not only because his study was done at the Fed Board of Governors, giving it substantial influence inside the Fed, but his research also deserves attention because of his finding that the slope of the PC has declined by more than half since the mid 1980s. Roberts describes his equation as a "reduced form" NKPC and indeed it is identical to equation (3) above with two differences: the NAIRU is assumed to be constant, and the sum of coefficients on lagged inflation is assumed to be unity. Thus the Roberts (2006, equation 2, p. 199) version of (3) is:

$$p_t = \sum_{i=1}^{4} \alpha_i \, p_{t-i} + \gamma + \beta U_t + e_t \qquad \textbf{(4)}$$

where the implied constant NAIRU is $-\gamma/\beta$. Subsequently in Appendix A his model will be contrasted with an alternative version of equation (3) above in which the NAIRU (the U^* term) is allowed to vary over time.

2.2 The "Triangle" Model and the Role of Demand and Supply Shocks

The widespread failure of PC research to explain the behavior of inflation since 2008 reflects collective amnesia. An even greater apparent failure of the PC occurred during the 1970s, when inflation turned out to be positively rather than negatively correlated with unemployment. That puzzle was solved by recognizing that macroeconomics was symmetric with microeconomics in which simple demand and supply curves demonstrate that the price and quantity of wheat can be positively or negatively correlated, depending on the importance of demand vs. supply shifts. Starting in 1975 a new body of research showed that the same possibility of a positive or negative correlation with demand factors such as the unemployment rate had to be true as well for the macroeconomic inflation rate, because of aggregate supply shifts.

Finally macroeconomics had caught up with microeconomics: inflation could be negatively correlated with unemployment when demand shocks were dominant, as in the Vietnam-war era of low unemployment, but inflation could also be positively correlated with unemployment in eras like 1973-75 when sharp increases in oil prices raised inflation, reduced purchasing power, and caused a recession in output and sharp rise in the unemployment rate. As we shall see, in these supply-driven episodes, changes in the inflation rate led and unemployment lagged, in contrast to the standard demand-driven sequence when inflation is

slow to adjust to demand shocks that immediately change the unemployment rate.

This revolution in macroeconomics occurred between 1975 and 1982. My early theoretical paper on the policy implications of supply shocks (1975) was developed simultaneously with a complementary paper by Edmund Phelps (1978) that reached the same conclusions in a different model. Facing an adverse, supply shock policymakers could no longer achieve their dual mandate and had to accept some combination of higher inflation and higher unemployment. The two models were subsequently simplified and merged in Gordon (1984). Alan Blinder (1979, 1982) made several early contributions dissecting the role of specific supply shocks in the inflation upsurge of the 1970s, and has recently revisited the role of supply shocks in "the great stagflation" of the 1970s.[7] By 1980 the merger of micro and macro was complete in the "triangle model" of econometric inflation research, and as well in macro textbooks.[8]

The empirical triangle model was developed (Gordon, 1977, 1982a) soon after the first 1973-75 oil shock which caused inflation and unemployment to be positively correlated. The term "triangle" model refers to a Phillips Curve that depends on three elements – inertia, demand, and supply – and in which wages are implicitly solved out of the reduced form. The specification has three distinguishing characteristics — (1) the role of inertia (the bottom of the triangle) is broadly interpreted to go beyond any specific formulation of expectations formation to include other sources of inertia, e.g., explicit or implicit wage and price contracts; (2) the driving force from the demand side is the unemployment or output gap; and (3) supply shock variables appear explicitly in the inflation equation rather than being forced into the error term as in the NKPC approach. This general framework can be written as:

$$p_t \ = \ a(L)p_{t-1} + b(L)D_t + c(L)z_t + e_t. \tag{5}$$

As before lower-case letters designate first differences of logarithms, upper-case letters designate logarithms of levels, and L is a polynomial in the lag operator.

---

7. Blinder's work since 1979 has emphasized the importance of supply shocks in the inflation spikes of the 1970s. In his new paper with Rudd (2013), the authors quantify the influence of supply shocks, including the relative prices of food and energy and also the impact of price controls. However, their aim is quite different from that of this paper. Their model is estimated for monthly CPI data only for the period 1961-79. There is no attempt to perform dynamic simulations using the coefficients of this model after the end of the sample period in 1979. The model is used in simulations to estimate what the behavior of the inflation rate would have been without supply shocks, but there is no extension of the model to assess its success on any subset of data applying to the past 30 years.
8. A explicit theoretical model of inflation behavior in the presence of demand and supply shocks was contained in a new generation of intermediate macroeconomic textbooks published in 1978 by Rudiger Dornbusch and Stanley Fischer and by myself. A simplified version of the demand-supply model appeared in economic principles textbooks, starting in 1979 with that of William Baumol and Blinder.

As in the NKPC approach, the dependent variable p_t is the inflation rate. Inertia is conveyed by a series of lags on the inflation rate (p_{t-1}). D_t is an index of excess demand (normalized so that $D_t=0$ indicates the absence of excess demand), z_t is a vector of supply shock variables (normalized so that $z_t=0$ indicates an absence of supply shocks), and e_t is a serially uncorrelated error term. Distinguishing features in the implementation of this model include unusually long lags on the dependent variable, and a set of supply shock variables that are uniformly defined so that a zero value indicates no upward or downward pressure on inflation. Because zero values of the demand and supply variables imply that the inflation rate is constant at the rate inherited from the past, the constant term in the equation is suppressed.

If in the estimation of equation (5) the sum of the coefficients on the lagged inflation values equals unity, then there is a "natural rate" of the demand variable (D^N_t) consistent with a constant rate of inflation.[9] The triangle equations estimated in this paper use current and lagged values of the unemployment gap as a proxy for the excess demand parameter D_t, where the unemployment gap is defined as the difference between the actual rate of unemployment and the natural rate, and the natural rate (or NAIRU) is allowed to vary over time.

The estimation of the time-varying NAIRU combines the above inflation equation, with the unemployment gap serving as the proxy for excess demand, with a second equation that explicitly allows the NAIRU to vary with time:

$$p_t \; = \; a(L)p_{t-1} + b(L)(U_t - U^N_t) + c(L)z_t + e_t, \tag{6}$$

$$U^N_t \; = \; U^N_{t-1} + \eta_t, \; E\eta_t = 0, \; var(\eta_t) = \tau^2 \tag{7}$$

In this formulation, the disturbance term η_t in the second equation is serially uncorrelated and is uncorrelated with e_t. When this standard deviation $\tau_\eta = 0$, then the natural rate is constant, and when τ_η is positive, the model allows the NAIRU to vary by a limited amount each quarter. If no limit were placed on the ability of the NAIRU to vary each time period, then the time-varying NAIRU (hereafter TV-NAIRU) would jump up and down and soak up all the residual variation in the inflation equation (6).

The triangle approach differs from the NKPC approach by including long lags on the dependent variable, additional lags on the unemployment gap, and explicit variables to represent the supply shocks (the z_t variables in (5) and (6) above), namely the effect on inflation of changes in the relative price of food and energy, the change in the relative price of non-food

---

9. While the estimated sum of the coefficients on lagged inflation is usually roughly equal to unity, that sum must be constrained to be *exactly* unity for a meaningful "natural rate" of the demand variable to be calculated.

non-oil imports, the eight-quarter change in the trend rate of productivity growth, and dummy variables for the effect of the 1971-74 Nixon-era price controls.[10] Lag lengths were originally specified in Gordon (1982) and have not been changed since then.

Since 1982 there have been three changes in the empirical implementation of the triangle model. In the original 1982 version the NAIRU was allowed to vary only with a demographically adjusted unemployment rate that took account of the different unemployment rates and wages of demographic groups arrayed by sex and age. This treatment was changed in Gordon (1997) which adopted a technique developed then by Staiger, Stock and Watson (1997) that allowed the NAIRU to vary over time, hence the TV-NAIRU.[11] The second change occurred in the paper with Ian Dew-Becker (2005) in which the treatment of the productivity variable was changed more accurately to capture the inflationary pressure of varying trend productivity growth.[12] The third change introduced here is to allow the coefficient on the food-energy effect, one of the supply shock variables, to change between the first and last halves of the sample period, reflecting the verdict of previous papers (see especially Blanchard and Galí (2010)) that the overall inflation rate is now less responsive to energy prices than was true in the 1970s and 1980s.

As we shall see throughout this paper the slope coefficients on the PC variable, whether the level of the unemployment rate or the value of the unemployment gap, are much lower in the NKPC versions than in the triangle versions, which usually produce negative slope coefficients close to -0.5, the classic value of the slope coefficient originally noticed in the article that christened the PC by Samuelson and Solow (1960).

The time-varying NAIRU is estimated simultaneously with the inflation equation (6) above. For each set of dependent variables and explanatory variables, there is a different TV-NAIRU. For instance, when supply-shock variables are omitted, the TV-NAIRU soars to 8 percent and above in the mid-1970s, since this is the only way the inflation equation can

---

10. The relative import price variable is defined as the rate of change of the non-food non-oil import deflator minus the rate of change of the dependent variable, either the headline or core PCE deflator. The relative food-energy variable is defined as the difference between the rates of change of the overall PCE deflator and the "core" PCE deflator. The Nixon control variables remain the same as originally specified in Gordon (1982a). Lag lengths remain as in 1982 and are shown explicitly in Table 1. The productivity trend is a Hodrick-Prescott filter (using 6400 as the smoothness parameter) minus the value of that trend eight quarters earlier.
11. The two papers appeared in the same issue of the *Journal of Economic Perspectives* and represented a trading of ideas. I adopted their econometric technique for estimating the time-varying NAIRU, and they adopted several elements of the triangle model.
12. In papers between 1977 and 2005, the productivity variable was the difference in the growth rate of actual productivity growth from trend productivity growth. Starting in Dew-Becker and Gordon (2005), the treatment changed to the eight-quarter change in the productivity trend. The idea was that a declining productivity growth trend in a world of rigid wages would put upward pressure on the inflation rate.

"explain" why inflation was so high in the 1970s. However, when the full set of supply shocks is included in the inflation equation, the TV-NAIRU is quite stable, as we shall see in the results presented in Part 4 below. The main part of this paper examines the behavior of the NKPC model using the Roberts (2006) assumption that the NAIRU is constant; subsequently in Appendices A and B we exhibit results when the NKPC NAIRU is allowed to vary over time.

3. The Explanation of Inflation in the NKPC and Triangle Models

3.1 Plots of the Basic Data

The analysis of coefficient stability and dynamic simulation performance starts with results for "headline" inflation, defined as changes in the BEA's headline personal consumption deflator, which includes changes in the prices of food and energy. Subsequently we examine parallel results for core inflation, i.e., the same inflation definition that subtracts changes in the prices of food and energy. The top frame of Figure 1 plots the total unemployment rate against the four-quarter change in the headline PCE deflator for the 51 years between 1962:Q1 and 2013:Q1. The black horizontal line plots the average value of the total unemployment rate between 1962 and 2013 as 5.84 percent. This basic plot, which appears in most macroeconomics textbooks, demonstrates immediately that macroeconomics is about both demand and supply.

Figure 1a. Four Quarter Changes in Headline Inflation Rate vs Total Unemployment Rate, 1962:Q1 to 2013:Q1
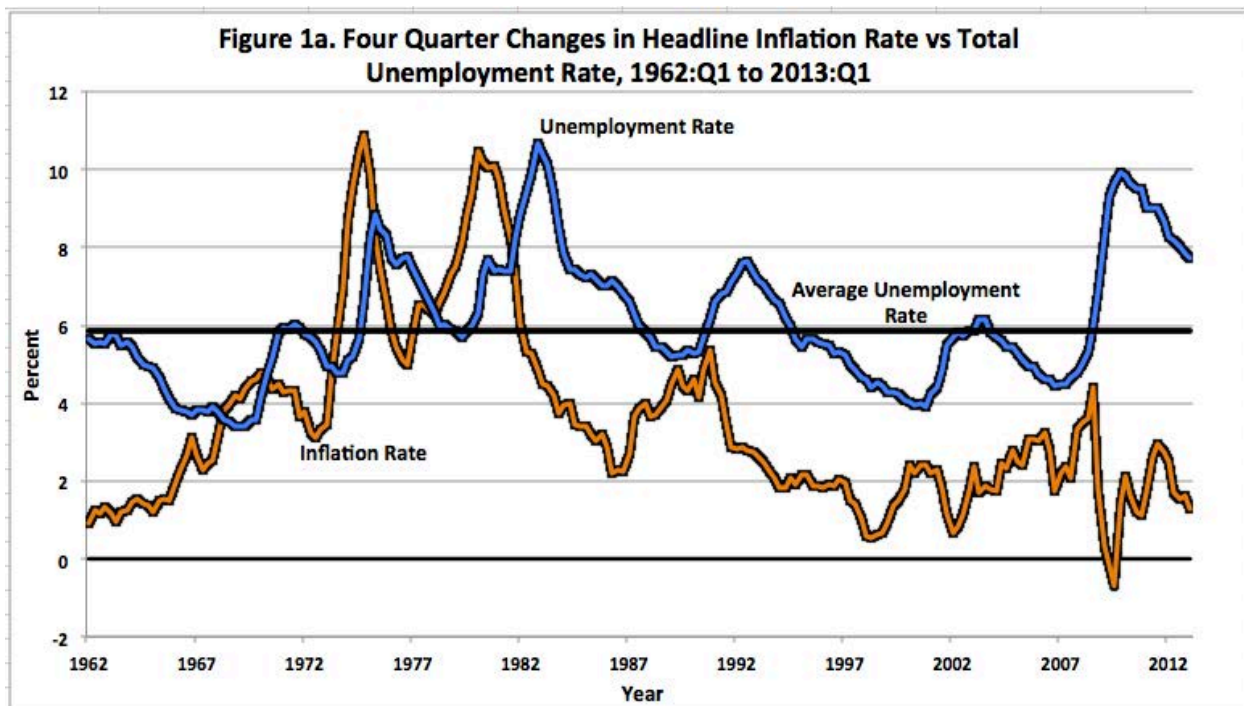
The traditional negative PC relationship is visible between 1962 and 1969, as the decline in the

blue unemployment line below four percent was associated with an acceleration of the orange line from one percent in 1962 to almost five percent by 1970. A milder cyclical dip in the unemployment rate in the late 1980s was accompanied by an increase in the inflation rate from about three percent in 1987 to five percent in 1989-90.

But for the rest of this five-decade history, the expectational PC, including its NKPC cousin, is helpless in the face of the data. During 1973-82, the unemployment and inflation rates were positively correlated, and the lead of inflation ahead of the unemployment rate is clearly visible. In 1976, the *New York Times* announced that: "inflation creates recession." No inflation model has any credibility unless it deals explicitly with the supply shocks that created the positive inflation-unemployment correlation in the 1970s and early 1980s and the lead of inflation ahead of unemployment. But this was not the only episode. Between 1996 and 2000 the unemployment rate descended far below its 5.84 average to less than 4.0 percent, and yet the inflation rate did not speed up as it had done in the late 1960s and late 1980s. The triangle model explains why inflation was so tame, pointing to beneficial supply shocks during the late 1990s – oil prices were low, the dollar was appreciating, and productivity growth was reviving.

The bottom frame of Figure 1 displays a scatter plot of the same data shown in the top frame. Three colors are used to designate particular intervals. The red dots for 1962-1969 show the observations that misled economists in the 1960s to think that there was a permanent tradeoff. These dots suggest that a decline of the total unemployment rate from 6.0 to 3.5 percent

Figure 1b. Four Quarter Changes in Headline Inflation Rate vs Total Unemployment Rate, 1962:Q1 to 2013:Q1
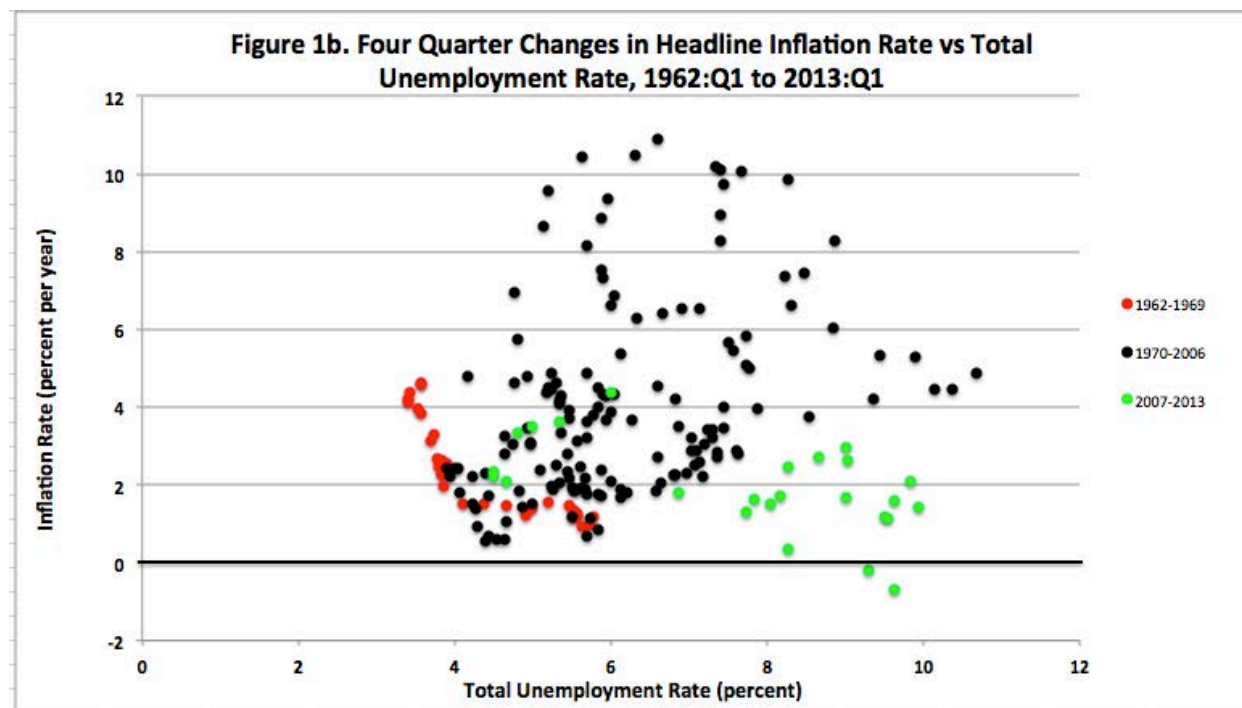
unemployment would boost the inflation rate from about 1.0 to about 5.0 percent. But then the

entire idea of the Phillips Curve appeared to be destroyed. The black dots plot the relationship between 1970 and 2006. The overall correlation appears to be positive but very weak, close to zero, and the 1970-80 observations in the scatter plot once led Arthur Okun to describe the PC as "an unidentified flying object."
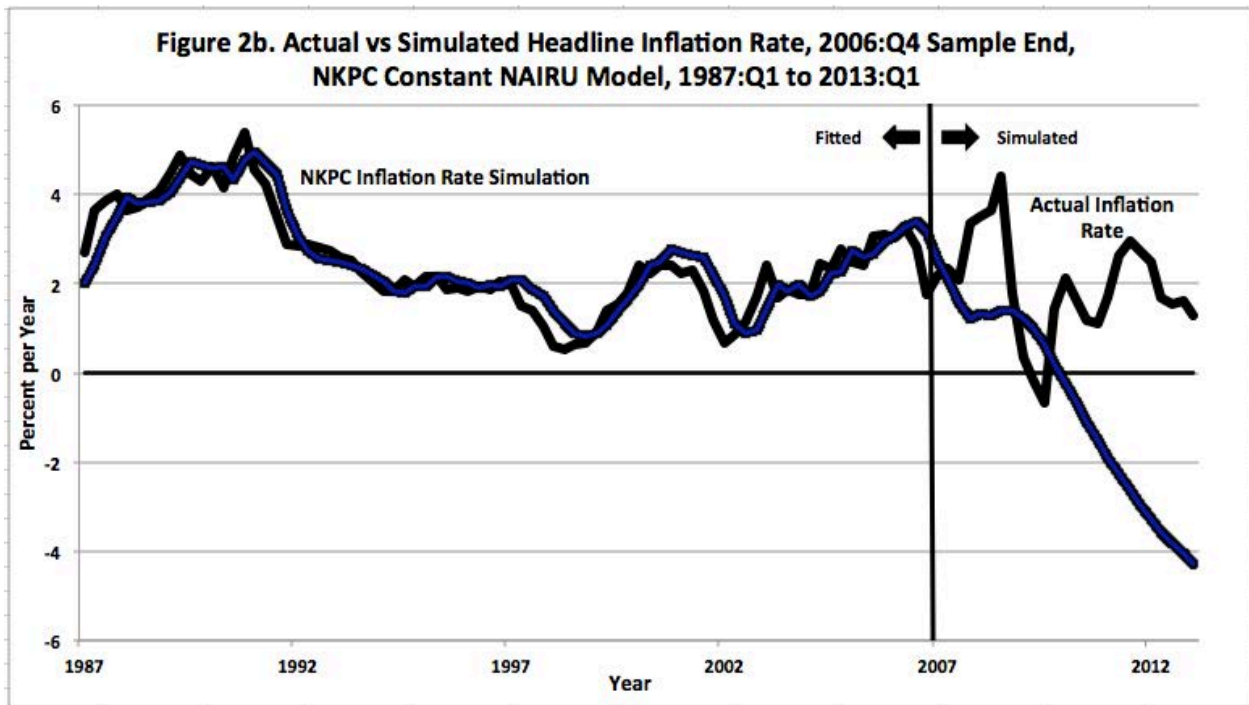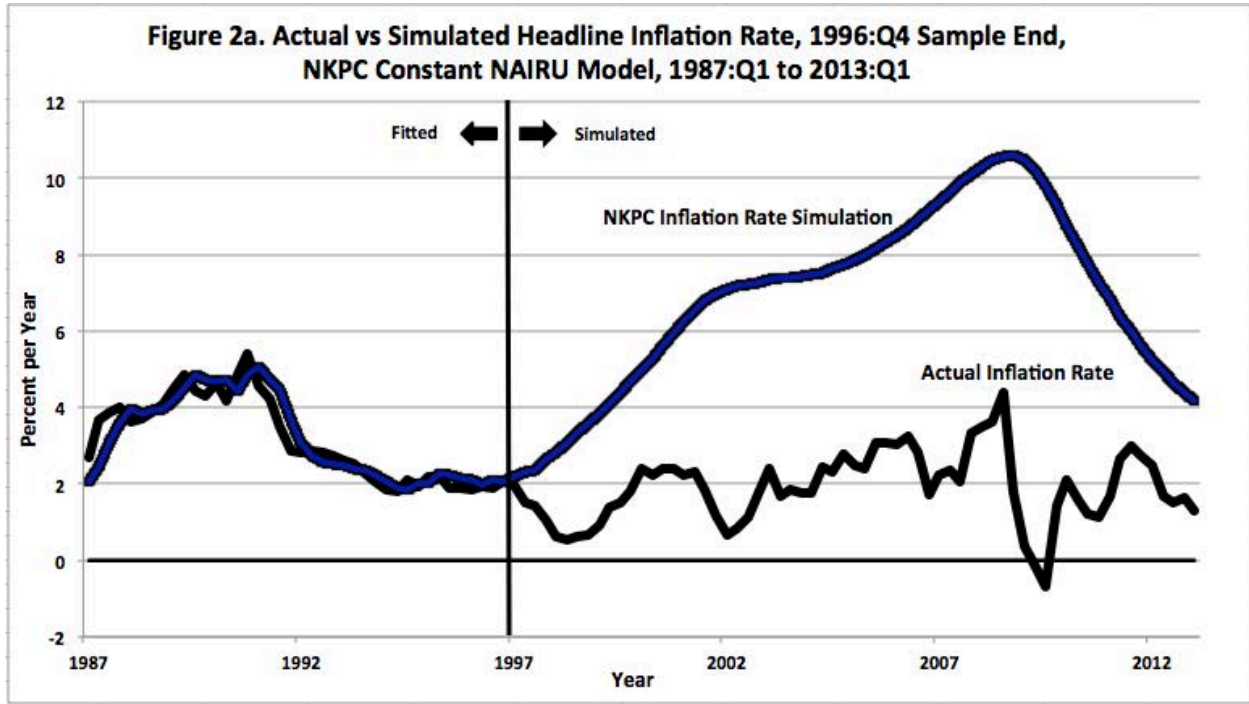
The light green color is affixed to the scatter plots for 2007-2013. There is a weak negative correlation among the green points but it is very flat, apparently supporting the idea that the slope of the unemployment coefficient in the PC inflation equation has declined sharply, probably by more than half. Yet from the perspective of the triangle model, there is nothing in the scatter plot diagram any more interesting than a historical plot of the price and quantity of wheat, which might also show a zero correlation. Until the supply curve can be separately identified as different from the variables driving the demand side, then the scatter plot shown in the bottom frame of Figure 1 is just what appears there – a zero and uninteresting correlation.

3.2 Coefficients and Dynamic Simulations of the Two Models

Most econometric studies of inflation, including almost all of the NKPC literature of the past 15 years, present regression results and then stop. Yet, the study of inflation is unique in time-series econometrics because the process is inertial and each current observation on the actual inflation rate is heavily dependent on the behavior of lagged values of inflation. The NKPC literature rarely runs dynamic simulations in which the lagged inflation variable is generated endogenously. Earlier use of the dynamic simulation technique in the development of the NKPC literature would have revealed flaws in the model long ago.[13]

We begin by testing the NKPC model developed by Roberts (2006), an archetype model in the NKPC tradition, which ignores the influence of supply shocks. Figure 2 shows the performance of the Roberts version of the NKPC model in two simulations. Shown in the top frame is a dynamic simulation in which the coefficients are estimated through 1996:Q4, and then for 1997-2013 the lagged inflation variables are calculated endogenously without any reference to the actual inflation data. In the bottom frame the same exercise is carried out with estimates of coefficients extending ten years later to 2006:Q4, with the dynamic simulation covering the period 2007-2013. The top frame shows that the simulation is wildly inaccurate, as predicted inflation soars to seven percent inflation by 2000 and then above ten percent in 2008, before declining to four percent in 2013. The bottom frame shows that for the simulation that begins in 2007:Q1, the simulated inflation rate declines to -4.5 percent per annum by 2013:Q1.

---

[13] To their credit Ball-Mazumdar (2011) and numerous papers by Stock and Watson, e.g., (2010) routinely run dynamic simulations in equations where the explanatory power is heavily dependent on the lagged dependent variable.

Figure 2a. Actual vs Simulated Headline Inflation Rate, 1996:Q4 Sample End, NKPC Constant NAIRU Model, 1987:Q1 to 2013:Q1

Figure 2b. Actual vs Simulated Headline Inflation Rate, 2006:Q4 Sample End, NKPC Constant NAIRU Model, 1987:Q1 to 2013:Q1

Next, we examine the dynamic simulations of the triangle model over the same period. Plots of the variables included in the triangle model are provided in Figures 3 and 4. All changes are plotted as four-quarter moving averages of quarterly changes, expressed at an annual rate (or equivalently the log change in the level from its value four quarters earlier). The top frame of Figure 3 displays the headline PCE deflator with its familiar "twin peaks" in 1973-75 and 1979-81 and its "valley" in 1996-2000 when demand was robust in the dot.com era but inflation remained tame. Also shown is the core PCE deflator that omits the effect of food and energy prices but also exhibits twin peaks in the 1970s and a valley in the late 1990s. Thus it is as important to include supply shock terms in the core inflation equation as in the headline equation.

Figure 3a. Four Quarter Changes of Headline and Core PCE Deflator, 1960:Q1 to 2013:Q1
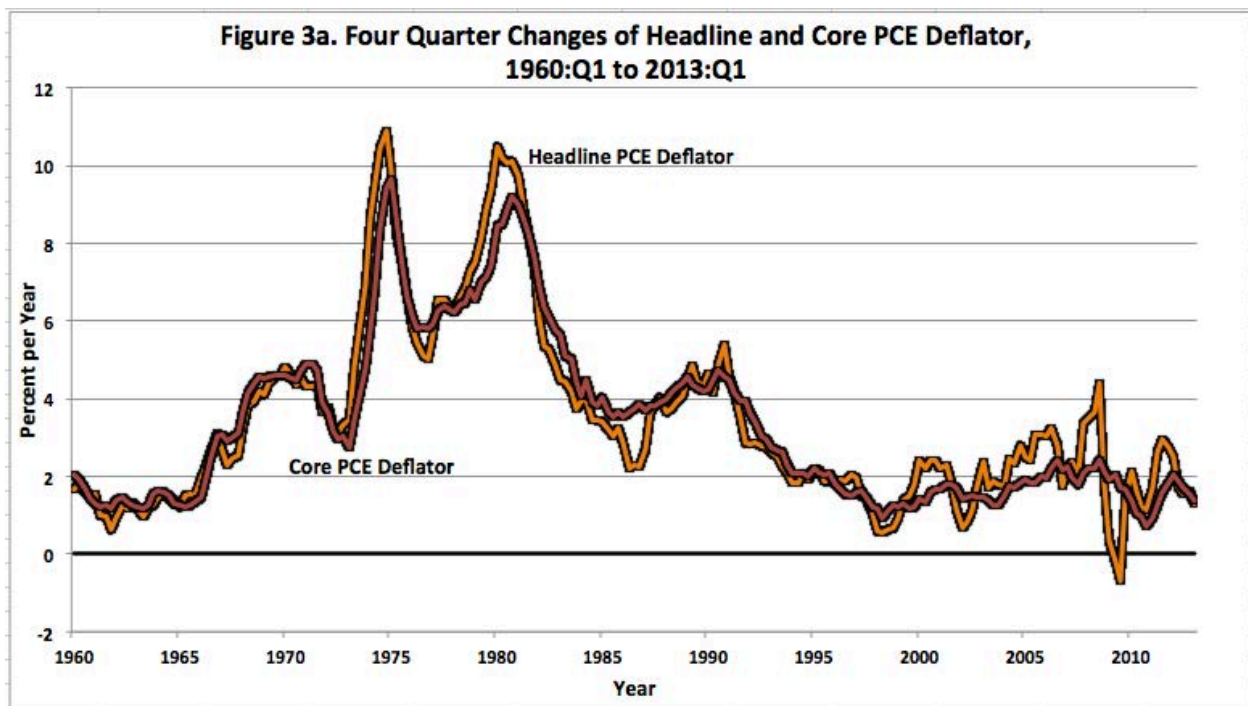
The bottom frame of Figure 3 displays the food-energy effect (the difference between headline and core inflation), which clearly explains some of the short-run fluctuations in the headline PCE deflator, particularly the twin peaks in 1973-75 and 1979-81 and the negative values that contributed to the unexpectedly rapid success of the 1981-86 Volcker disinflation.

Figure 3b. Four Quarter Changes of Food-Energy Effect, 1960:Q1 to 2013:Q1
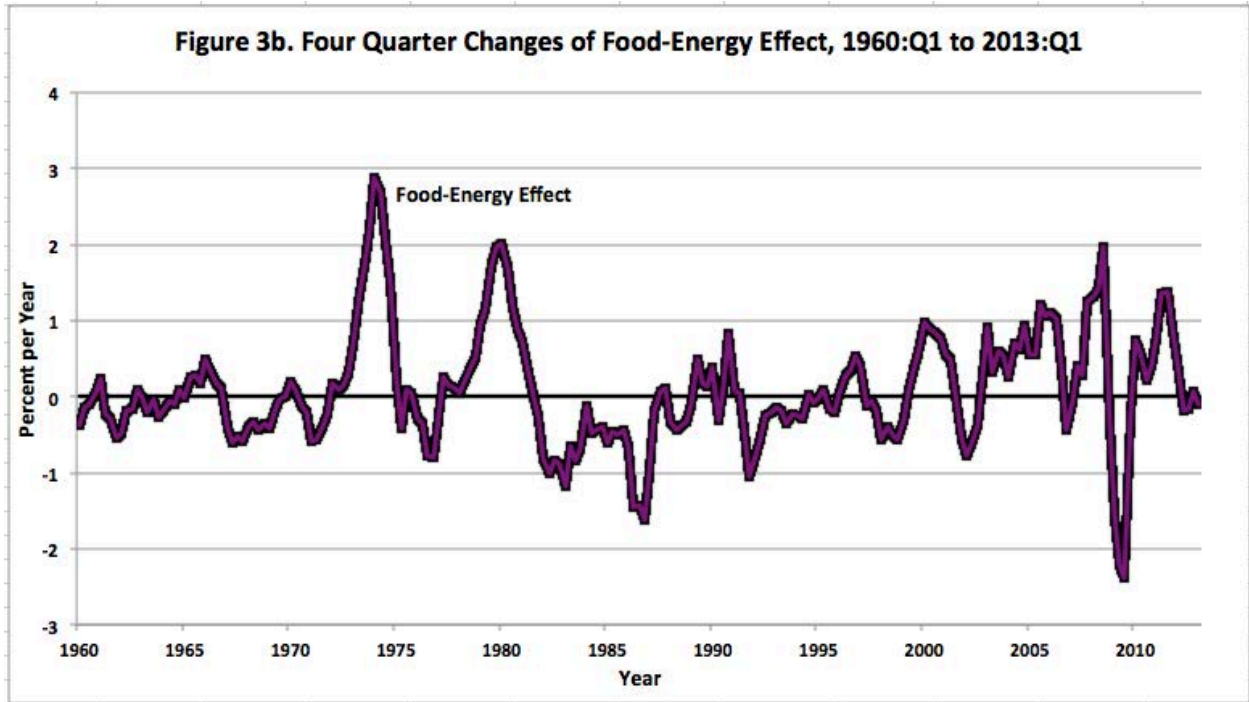
The top frame in Figure 4 displays the change in the relative price of nonfood-nonoil imports. Its central role in explaining the spike of inflation in 1974-75 is visible, as is its role in the Volcker disinflation of 1982-85, the accelerating inflation of the late 1980s, and the surprising absence of inflation in 1997-2001.   The food-energy effect has somewhat different timing than

Figure 4a. Four Quarter Changes of Relative Price of Imports, Non-Food Non-Oil, 1960:Q1 to 2013:Q1
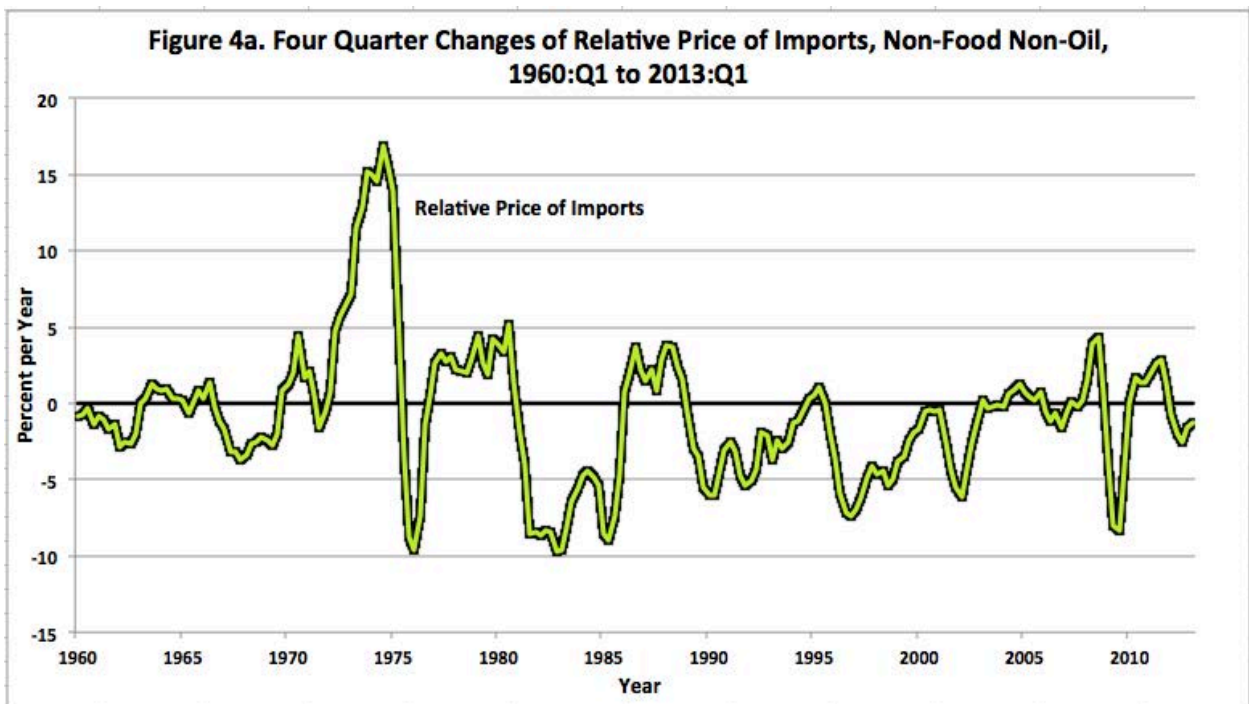
the non-oil non-food import price effect. Note also the different orders of magnitude of the import and food-energy effects, reflecting the fact that they are defined differently.[14]

The only major change in the current inflation equation from its original 1982 specification involves productivity growth, where we follow the approach introduced in Dew-Becker and Gordon (2005). In prior papers the difference in the growth rates of actual and trend productivity or "productivity deviation" had been entered into the inflation equation. But this misses the main impact of the 1965-80 productivity growth slowdown and post-1995 productivity growth revival, which is the change in the growth of the trend itself. Dew-Becker and Gordon created a productivity trend growth acceleration variable equal to a Hodrick-Prescott filter version of the productivity growth trend minus that trend eight quarters earlier. The same productivity trend acceleration variable is plotted in the bottom frame of Figure 4. Its deceleration into negative territory during 1964-1980 might be as important a cause of accelerating inflation in that period as its post-1995 acceleration was a cause of low inflation in the late 1990s. Note also that the productivity growth trend revival of 1980-85 may have contributed to the success of the "Volcker disinflation," a link that has been missed in most of the past PC literature. There has been a sharp deceleration of trend productivity growth since 2004, helping to explain the absence of deflation in the past few years.

Figure 4b. Eight Quarter Changes of Productivity Trend, 1960:Q1 to 2013:Q1

---
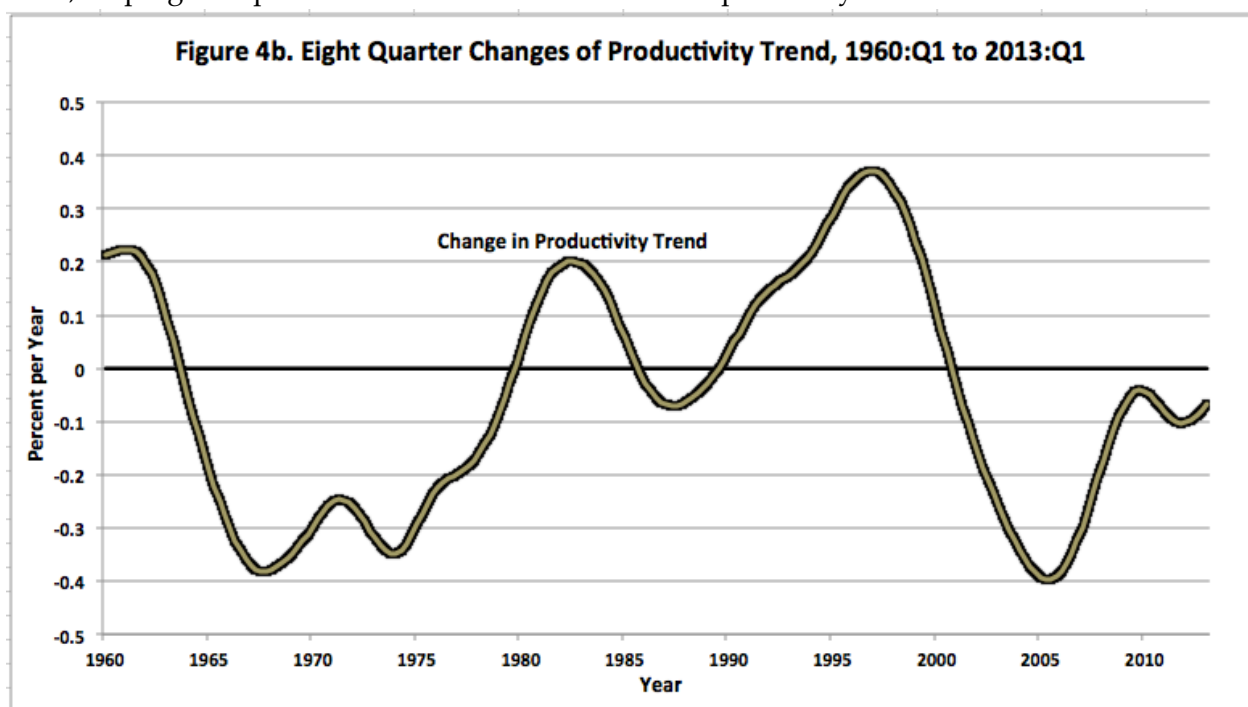
14. The import variable is the change in the relative price of imports, which reaches a peak of about 15 percent in 1974-75. The food-energy variable is *not* the relative price of food and energy, but rather the difference between the growth rates of the PCE deflator including and excluding food and energy, and this variable peaks at 3.3 percent in 1974-75.

Figure 5 provides our first look at the dynamic simulation performance of the triangle model as compared to the constant-NAIRU version of the NKPC model. The top frame shows that the predicted values in a dynamic simulation of the triangle model starting in 1997:Q1, based on coefficients estimated from 1962:Q1 to 1996:Q4, cling closely to the actual values. Regression coefficients, statistics on goodness of fit, and summaries of dynamic simulation results are presented in Table 1 for the constant-NAIRU version of the NKPC and the triangle model, both using the total unemployment rate as the demand variable. The first two columns show coefficients estimated through 1996, the middle two columns through 2006, and the final column estimated through 2013:Q1. The goodness of fit statistics show that the constant-NAIRU NKPC model has a standard error in each sample period at least double that of the triangle model, and a sum of squared residuals (SSR) between four and five times that of the triangle model.

Figure 5a. Actual vs Simulated Headline Inflation Rate, 1996:Q4 Sample End, NKPC vs Triangle Model, 1987:Q1 to 2013:Q1
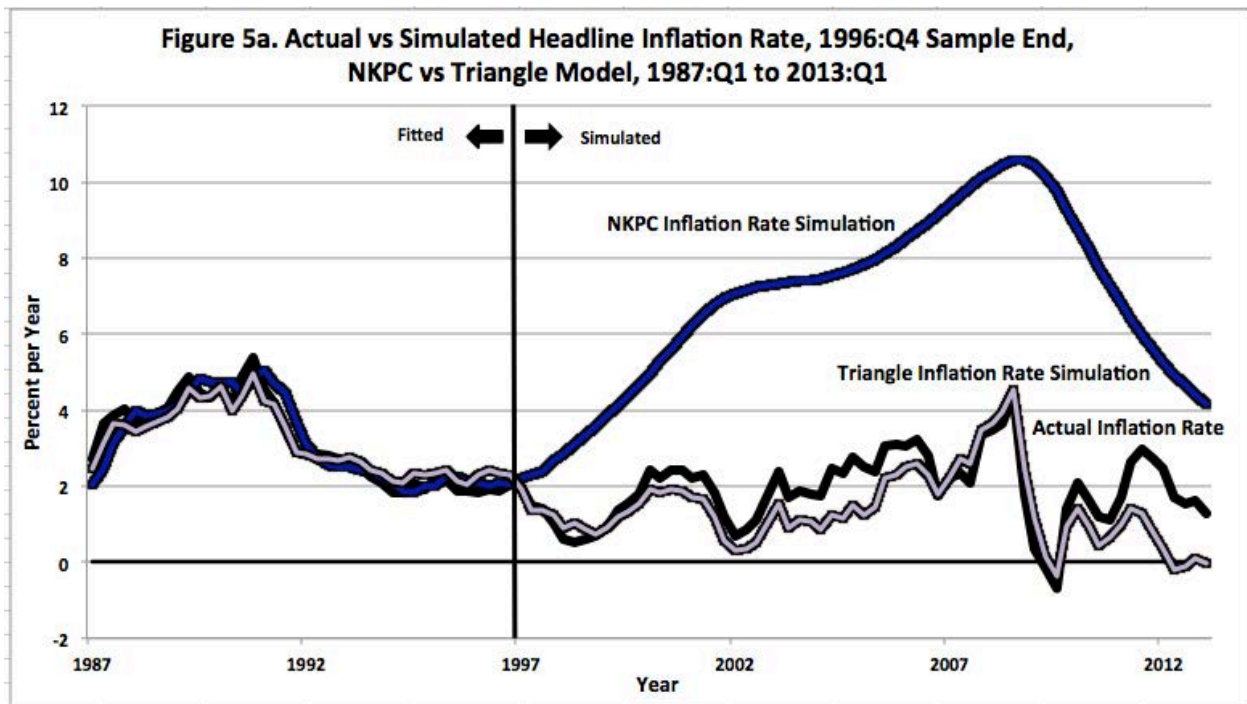
When the sample period ends in 1996:Q4, the mean error in the NKPC dynamic simulation over 1997-2013 is -5.0 percent, compared to +0.53 percent for the triangle model. The RMSE of the NKPC is more than five times higher than that of the triangle simulation (5.61 vs. 0.96). Errors are just as large when the simulations begin in 2007 instead of 1997, but now

Figure 5b. Actual vs Simulated Headline Inflation Rate, 2006:Q4 Sample End, NKPC vs Triangle Model, 1987:Q1 to 2013:Q1
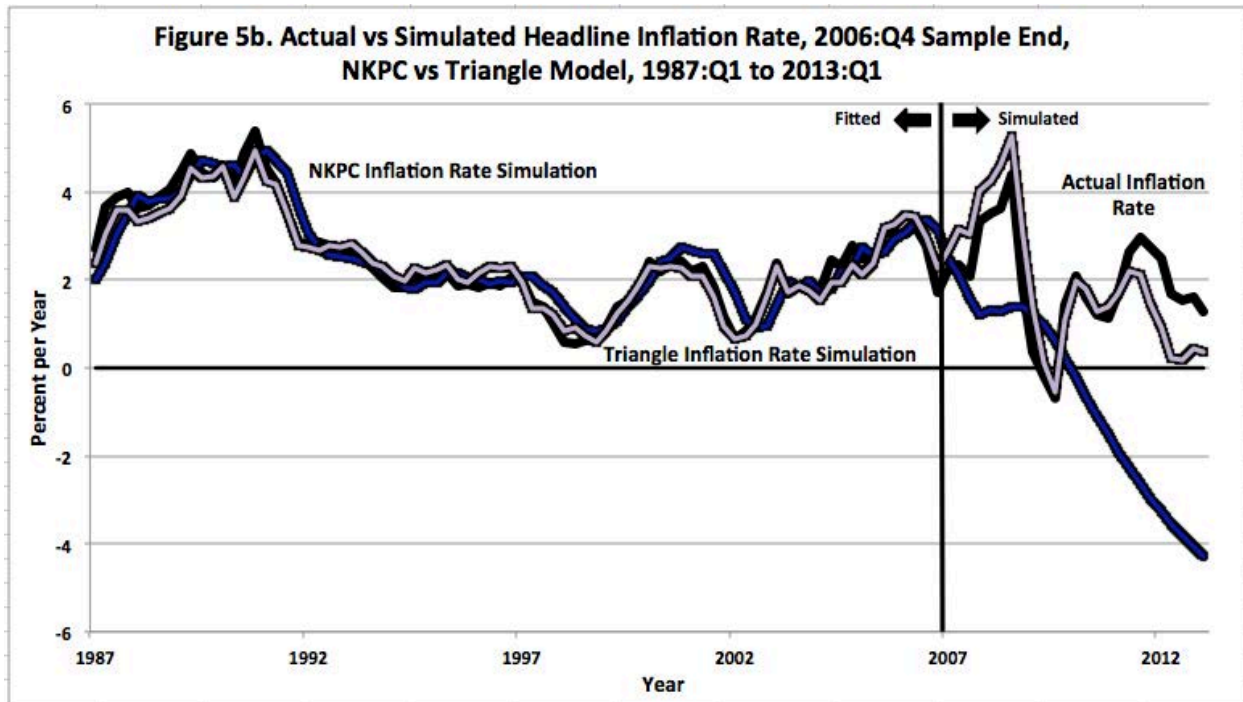
Table 1

NKPC vs Triangle Model: Estimated Equations for Quarterly Changes in the Headline PCE Deflator, Total Unemployment Rate

Variable	Lags	1962:Q1 to 1996:Q4				1962:Q1 to 2006:Q4				1962:Q1 to 2013:Q1			
		NKPC		Triangle		NKPC		Triangle		NKPC		Triangle	
Constant		1.42	**			1.00	*			0.95	*		
Lagged Dependent Variable	1-24[a]			1.01	**			1.01	**			1.00	**
	1-4	0.95	**			0.95	**			0.90	**		
Unemployment Gap	0-4			-0.50	**			-0.47	**			-0.31	**
Unemployment Rate	0	-0.19	*			-0.14				-0.10			
Relative Price of Imports, NFNO	1-4			0.05	*			0.05	**			0.03	
Food-Energy Effect Full Period	0-4			1.10	**			1.09	**			1.04	**
Food-Energy Effect Late Period	0-4			-0.38				-0.31				-0.49	**
Productivity Trend Change	1 5			-1.06	*			-0.96	**			-1.09	**
Nixon Controls "on"	0			-2.02	**			-1.98	**			-1.84	**
Nixon Controls "off"	0			2.18	**			1.95	**			1.85	**
Adj. R2		0.79		0.94		0.78		0.95		0.69		0.94	
S.E.E		1.18		0.62		1.19		0.59		1.43		0.61	
S.S.R		186.53		42.66		247.87		52.34		409.02		66.00	
Dynamic Simulations		1997:Q1 to 2013:Q1				2007:Q1 to 2013:Q1							
Mean Error		-5.00		0.53		3.07		0.12					
Error in 2013:Q1		2.65		-1.07		-5.77		-0.62					
Root Mean-Square Error		5.61		0.96		4.26		1.01					

a) Lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17, and 21,

b) *indicates coefficient or sum of coefficients is statistically significant at the 5 percent level, ** indicates significance at the 1 percent level.

the NKPC simulations predict inflation that dives into deflationary territory; the mean error for 2013:Q1 for the NKPC simulation is +5.77 percent compared to +0.62 percent for the triangle equation. As shown in Table 1, the estimated coefficient on the unemployment rate in the NKPC version falls by half from a significant -0.19 when the sample period ends in 1996:Q4 to an insignificant -0.10 when the sample period ends in 2013:Q1.

The explanatory variables used by the triangle model in Table 1 are the same as in the original (1982a) specification, with two exceptions. As noted above, the treatment of productivity was changed in 2005 to reflect changes in the underlying trend rate of productivity growth. In addition, numerous authors (see Blanchard-Galí, 2010) have noted the declining pass-through from movements in oil prices to overall inflation, and this hypothesis is tested by supplementing the original food-and-energy term by the same variable multiplied by a 0,1 dummy that shifts from 0 to 1 in 1987:Q1. The coefficient on the "late period" term indicates the extent to which the food-energy pass-through has declined and whether that decline is significant. In Table 1 the late period effect is an insignificant -0.38 and -0.31 in the sample periods ending in 1996 and 2006 but is a highly significant -0.49 in the full sample period through 2013:Q1.

3.3 The Distinction Between Short-run and Long-run Unemployment

Despite the superior performance of the triangle model and its ability to avoid the prediction of a deflation, still the simulation values shown in Figure 5 display a tendency to predict an inflation rate that is too low, a less severe version of the deflation-prediction disease. As shown in Table 1, the dynamic simulations result in a simulated value in 2013:Q1 that is 1.07 percentage points below the actual values of the inflation rate in the sample period that ends in 1996:Q4 and 0.62 percentage points below in the sample period that ends in 2006:Q4. A further problem evident in Table 1 is that when the end of the sample period is extended from the end of 2006 to 2013:Q1, the coefficient on the unemployment gap variable declines by one third, from -0.47 to -0.31.

It has long been recognized since the 1980s European literature on hysteresis cited above that long-run unemployment is a structural problem, and that the portion of the unemployed with durations of six months or more may not be considered viable applicants by employers and thus may put little downward pressure on wage rates and prices. One of the most unique aspects of the U.S. labor market in the last five years has been the persistence of long-run unemployment, the subset of those unemployed who are out of work for 27 weeks or more. Because some European nations since the late 1980s have faced large percentages of their unemployed populations out of work for more than a year, this increased prevalence of long-run unemployment in the U.S. raises the question as to whether this country is becoming "more like Europe."

Figure 6 displays three BLS unemployment rates. The top blue line displays the total unemployment rate, the same as was plotted above in Figure 1. The red line shows the percentage of the labor force unemployed less than 27 weeks, while the green line shows the difference between the blue and red lines, i.e., the percentage of the labor force experiencing an unemployment spell of 27 weeks or longer. In almost every year between 1960 and 1975, the long-run unemployment rate was below 1.0 percent. It peaked above 2.0 percent only briefly in the 1981-82 recession. But during 2009-2010 the long-run unemployment percentage peaked at above four percent, and by 2013:Q1 was down only to three percent.

Figure 6. Total, Short Run, and Long Run Unemployment Rate, 1960:Q1 to 2013:Q1
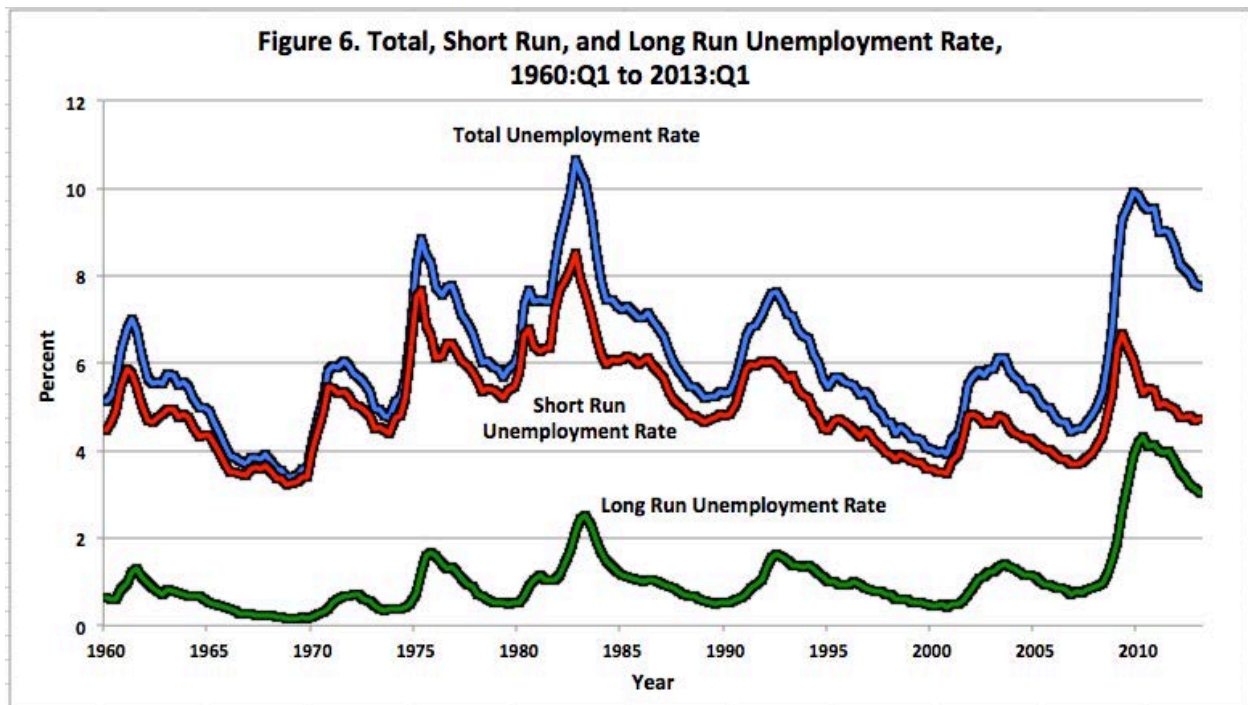
The distinction between short-run and long-run unemployed may help to solve the post-2008 "case of the missing deflation" if the downward pressure on wages and the inflation rate comes mainly from the short-run unemployed.

Figure 7 displays the triangle model simulations that use short-run unemployment (hereafter SRU) as the demand variable, as well as the previously displayed simulations that use the total unemployment rate (TU). In the top frame showing the simulation for 1997-2013, the two simulations lie on top of each other through early 2010, but after that the TU simulation drifts down below the actual realized inflation rate while the SRU simulation hugs the actual inflation rate closely. The same pattern is visible in the shorter simulations that span 2007-2013.

Figure 7a. Actual vs Simulated Headline Inflation Rate, 1996:Q4 Sample End, Total vs Short Run Unemployment Rate, 1987:Q1 to 2013:Q1

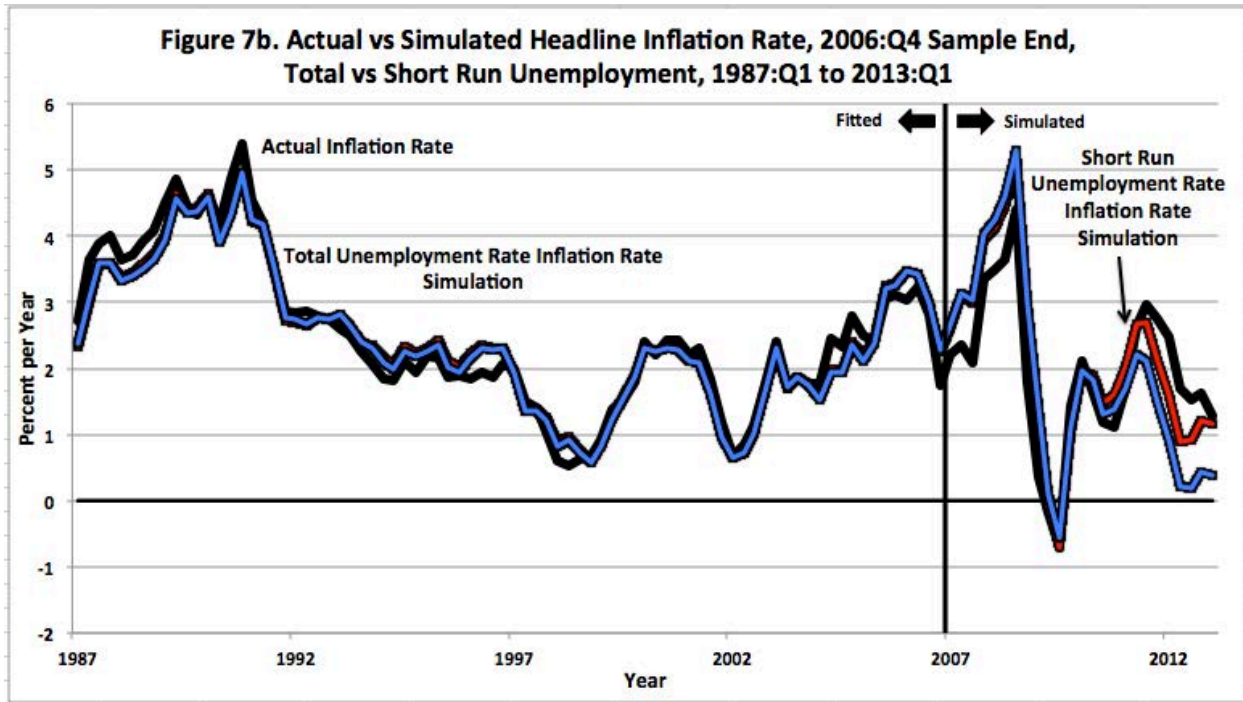Figure 7b. Actual vs Simulated Headline Inflation Rate, 2006:Q4 Sample End, Total vs Short Run Unemployment, 1987:Q1 to 2013:Q1
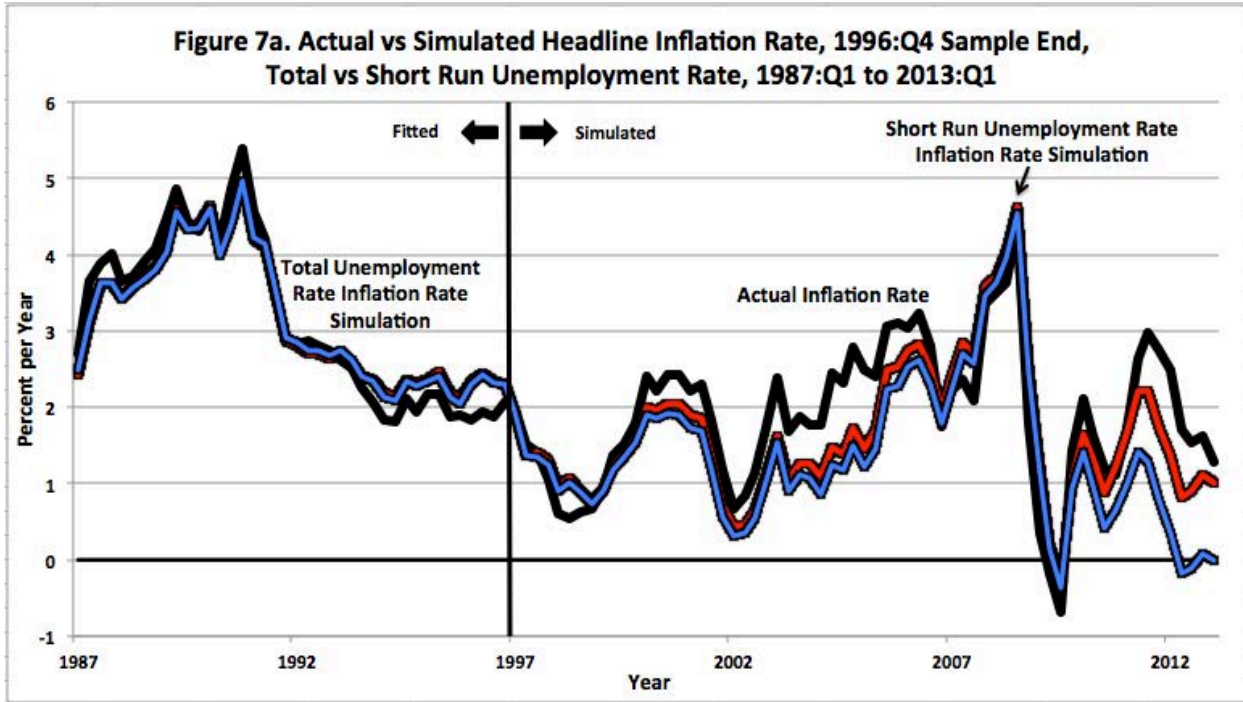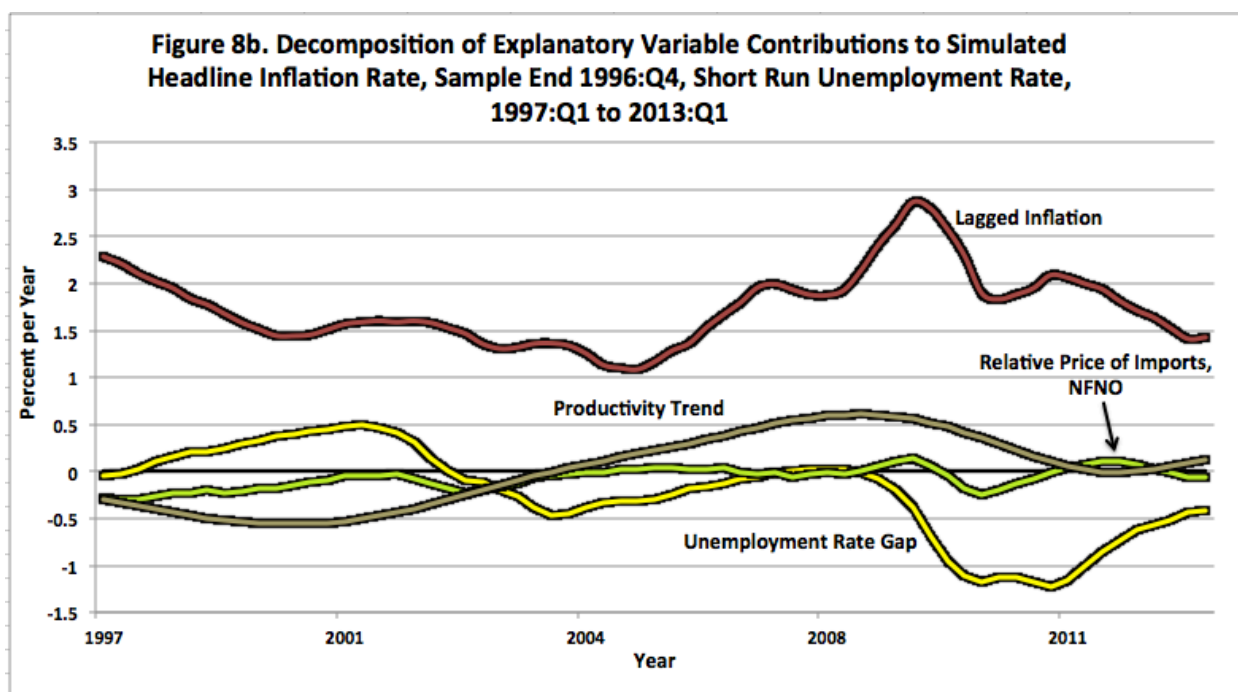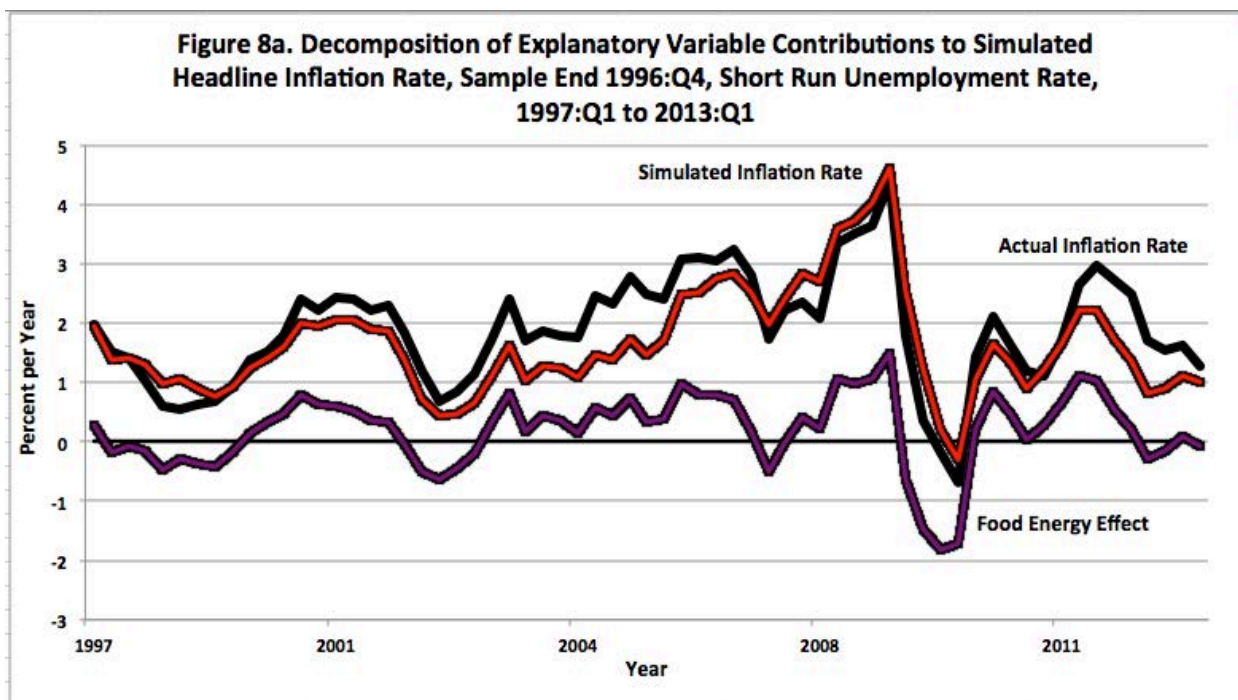
Table 2 has the same format as Table 1, but it now compares the results for the same three sample periods for the TU versus SRU variants of the triangle model. For the sample periods ending in 1996 and 2006 the TU and SRU variants perform identically in terms of their goodness of fit statistics, but the dynamic simulations through 2013 reveal much smaller mean errors and RMSE's for the SRU version. Another difference is that the coefficient on the unemployment gap declines when the sample period is extended from 1996 to 2013 by -42 percent for the TU version and only -13 percent for the SRU version, indicating greater stability in the PC relationship based on SRU rate.

Table 2							
Estimated Equations for Quarterly Changes in							
the Headline PCE Deflator, Total vs Short Run Unemployment Rate							
Variable	Lags	1962:Q1 to 1996:Q4		1962:Q1 to 2006:Q4		1962:Q1 to 2013:Q1	
		TU	SRU	TU	SRU	TU	SRU
Constant							
Lagged Dependent Variable	1-24ª	1.01 **	1.01 **	1.01 **	1.01 **	1.00 **	1.01 **
Unemployment Gap	0-4	-0.50 **	-0.77 **	-0.47 **	-0.73 **	-0.31 **	-0.64 **
Relative Price of Imports, NFNO	1-4	0.05 *	0.05 *	0.05 **	0.05 **	0.03	0.04
Food-Energy Effect Full Period	0-4	1.10 **	1.07 **	1.09 **	1.06 **	1.04 **	1.08 **
Food-Energy Effect Late Period	0-4	-0.38	-0.33	-0.31	-0.32	-0.49 **	-0.46 **
Productivity Trend Change	15	-1.06 *	-1.01	-0.96 **	-0.92 **	-1.09 **	-1.00 **
Nixon Controls "on"	0	-2.02 **	-1.81 **	-1.98 **	-1.77 **	-1.84 **	-1.76 **
Nixon Controls "off"	0	2.18 **	2.07 **	1.95 **	1.90 **	1.85 **	1.88 **
Adj. R2		0.94	0.94	0.95	0.95	0.94	0.95
S.E.E		0.62	0.63	0.59	0.59	0.61	0.59
S.S.R		42.66	43.38	52.34	52.48	66.00	61.58
Dynamic Simulations		1997:Q1 to 2013:Q1		2007:Q1 to 2013:Q1			
Mean Error		0.53	0.25	0.12	-0.11		
Error in 2013:Q1		-1.07	-0.11	-0.62	0.11		
Root Mean-Square Error		0.96	0.69	1.01	0.76		
a) Lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17, and 21,							
b) *indicates coefficient or sum of coefficients is statistically significant at the 5 percent level, ** indicates significance at the 1 percent level.							

How is the SRU equation capable of tracking the actual inflation rate so tightly over the 16 years since 1996:Q4, with no information on the actual behavior of inflation? The contribution of each of the sets of explanatory variables (including their lags) can be plotted separately as in the top and bottom frames of Figure 8. The top frame shows the actual values of headline inflation in black, the simulated values in red, and the contribution of the food-energy effect in purple. The bottom frame shows the contribution of the other explanatory variables. This chart is helpful not only in understanding why the triangle model does not

forecast a deflation in 2010-2013, but also why it does not forecast a rise in inflation despite the low unemployment rate of the late 1990s.

Figure 8a. Decomposition of Explanatory Variable Contributions to Simulated Headline Inflation Rate, Sample End 1996:Q4, Short Run Unemployment Rate, 1997:Q1 to 2013:Q1

Figure 8b. Decomposition of Explanatory Variable Contributions to Simulated Headline Inflation Rate, Sample End 1996:Q4, Short Run Unemployment Rate, 1997:Q1 to 2013:Q1

The contribution of each variable (including its lags) to the simulated inflation rate is shown in Table 3 for four sub-intervals within the 1997-2013 dynamic simulation, namely 1997-2000, 2001-2007, 2008-2009, and 2010-2013. The first column shows why the triangle model accurately explains how low unemployment in the late 1990s did not cause an increase of inflation. The 0.31 contribution of the unemployment gap was supplemented by the 0.10 contribution of the food-energy effect.[15] But these were offset by -0.17 from import prices caused by the dollar's appreciation between 1995 and 2002, and also by the -0.50 contribution made by the productivity growth revival which held inflation down by more than low unemployment pushed inflation up.

	Table 3				
Decomposition of Contributions in 1997-2013 Dynamic Simulation,					
Headline Inflation Rate, Short Run Unemployment Rate, Annual Growth Rates over Selected Intervals					
	1997:Q1-	2001:Q1-	2008:Q1--	2010:Q1-	1997:Q1-
Variable	2000:Q4	2007:Q4	2009:Q4	2013:Q1	2013:Q1
Lagged Dependent Variable	1.68	1.54	2.38	1.76	1.72
Unemployment Gap	0.31	-0.14	-0.78	-0.76	-0.23
Relative Price of Nonfood Nonoil Imports	-0.17	-0.05	-0.06	0.01	-0.07
Food-Energy Effect, Sum Full Period + Late Period	0.10	0.32	-0.20	0.26	0.19
Productivity Trend Change	-0.50	0.17	0.46	0.07	0.02
Total Contribution = Simulated Rate of Inflation	1.43	1.84	1.80	1.33	1.63
Actual Rate of Inflation	1.48	2.24	1.61	1.78	1.88
Error = Actual minus Simulated	0.05	0.40	-0.19	0.45	0.25

The opposite situation occurred during 2008-09 and 2010-13, when the average contribution of high unemployment was to reduce the inflation rate by -0.76 percent at an annual rate, which then fed back into the endogenous lagged dependent variable. But the lagged inflation rate going back six years had inherited other influences that pushed up the endogenously-generated inflation rate. These included a positive contribution of the food-energy effect in 2001-07, a large positive impact of slowing productivity growth in 2008-09 even as the food-energy effect temporarily turned negative, and then in 2010-13 a combined contribution from food-energy and productivity of 0.33 percentage points.

The simulations are not, of course, perfect. The mean error over 1997-2013 as reported in Table 2 for the SRU rate is 0.25, that is, actual realized inflation over that 16-year period was 0.25 percentage points higher than the simulated inflation rate. In the final 2010-13 period, the

---

[15] The calculated contribution of the food-energy effect in Figure 8 and Table B takes account of the downshift in the estimated food-energy coefficient after 1987 as shown in Table 2.

error was higher, 0.45 percentage points. But to achieve a simulation error of less than half a percentage point more than a decade after the sample period used to estimate the coefficients is a remarkable achievement,

4. Implied NAIRUs and Policy Implications

4.1 The Implied Time-Varying NAIRUs and the Question of Whether Structural Unemployment Has Increased

The time-varying (TV) NAIRU is a byproduct of the estimation of any inflation model in which the constant-inflation unemployment rate is allowed to vary.[16] Viewed through 2007, the blue line in Figure 9 showing the TV-NAIRU for total unemployment is very similar to those estimated in my previous work and that of others.

Figure 9. Total, Short Run, and Implied Long Run NAIRU, 1961:Q1 to 2013:Q1
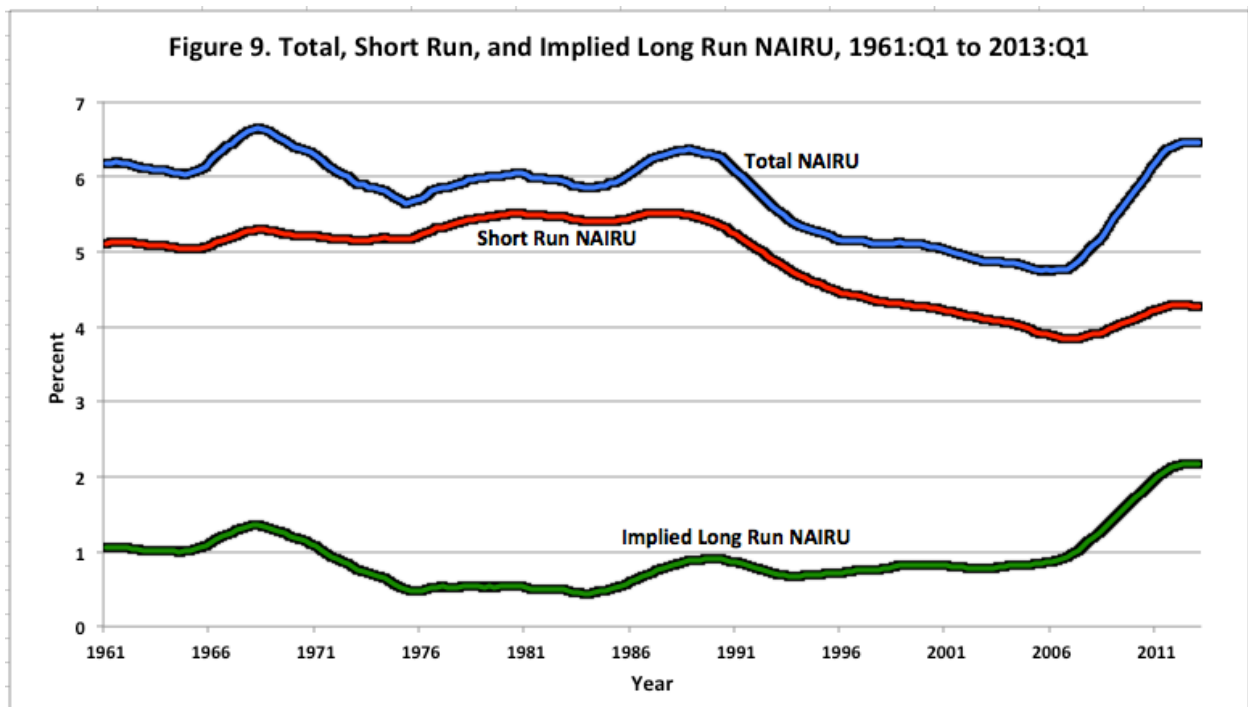
There is a peak in the NAIRU in the late 1970s until the mid-1980s, and then a

---

[16] Despite the contribution of Staiger-Stock-Watson (1997) in developing the econometric method of backing the NAIRU out of the inflation equation, their interest in estimating the TV-NAIRU was short-lived. By their 2001article they retreated from estimating a NAIRU as an indirect byproduct of the inflation equation and began estimating the TV-NAIRU by a method that produced results very similar to the HP 6400 detrended value as displayed below in Figure A-1. Results for the NKPC specification with a HP trend for the NAIRU are reported below in Appendix A.

substantial decline after 1990. The striking decline in the TV-NAIRU from 1990 to 2000 has attracted much attention, most notably by Lawrence Katz and Alan Kreuger (1999), who provide numerous explanations including demographics, the explosion of the prison population, and modern technology, which makes labor market matches quicker and more efficient.

Since 2007 there has been a relatively large increase in the TV-NAIRU for the total unemployment (TU) rate that brings the NAIRU back up to its maximum values reached during the 1980s. The sources of this increase are better understood when we plot in Figure 9 the red line showing the NAIRU for short-run unemployment (SRU). The SRU NAIRU shares the same decline between 1990 and 2006 as the TU NAIRU, but it increases much less after 2007. This is consistent with the results in the dynamic simulations and regression results above showing that the triangle model is more stable, in the sense of having smaller coefficient shifts and better dynamic simulation results, when the usual TU rate series is replaced by the SRU rate. The NAIRU for the SRU rate in Figure 9 dips briefly from 4.3 in the late 1990s to a low of 3.8 in 2007 before rising back to 4.3 in 2013:Q1. The NAIRU for the TU rate over the same interval drops from 5.1 to 4.8 and then rises to 6.5.

Arithmetic produces the implied NAIRU for the long-run unemployment (LRU) rate, as shown by the green line in Figure 9. The implied LRU NAIRU was extremely stable from 1962 to 2007, with an average value of 0.80 percent and a standard deviation of only 0.23. Yet after 2007 the LRU NAIRU rose steadily to 2.17 percent in the year ending in 2013:Q1 (the actual LRU rate hit a peak of 4.3 percent in 2010:Q3). Between 2006:Q4 and 2013:Q1, the TU NAIRU increased from 4.77 to 6.45 percent, the SRU NAIRU from 3.84 to 4.28 percent, and the LRU NAIRU from 0.93 to 2.17 percent. Thus, of the total increase in the TU NAIRU of 1.68 percent, 1.24 is associated with the rise in the LRU NAIRU, and the remaining 0.44 with the rise in the SRU NAIRU.

The question of whether the TV-NAIRU for the total unemployment rate has increased since 2008 is a central issue for the Fed. Most of the literature to date attempts to address the issue of higher structural unemployment without estimating explicit inflation equations. Daly *et al.* (2011) provide an analysis of the Beveridge curve (vacancies vs. unemployment) and the job-creation curve (which can be "loosely interpreted as the aggregate labor demand curve"). Their conclusion is that the equilibrium unemployment rate has increased from 5.0 percent before 2008 to about 5.9 percent in mid-2011.[17] This is remarkably close to our findings based on an entirely different method and set of data, since the value of the NAIRU for total unemployment in Figure 9 above is 6.0 in 2011:Q2, almost identical to theirs for the same quarter.

---

[17] They state that this is the midpoint of a range between 5.4 and 6.4 (2011, p. 20).

Marcello Estevao and Evridiki Tsounta (2011) have reached an even stronger conclusion of higher structural unemployment by examining variation across states. Using econometric evidence that controls for the usual cyclical relation between unemployment, skill mismatches, and housing market conditions, they conclude that the "aggregate equilibrium unemployment rate is about 1.75 percentage points higher than the 5 percent or so before the crisis." They predict that unless structural problems are addressed, inflationary pressures may emerge if the unemployment rate is allowed to decline below 7 percent.

But other research argues against any significant increase in structural unemployment. Jesse Rothstein (2012) looks for evidence of skill mismatch in the behavior of occupational wage data. He does not find any tendency for wages to rise more in industries with substantial job openings. In a separate analysis of the 2009-13 increase in the LRU rate, he attributes most of it to normal cyclical factors and long-run trends that have increased the prevalence of LRU. Yet in Figure 5 above it is hard to discern any upward trend in the LRU rate between 1975 and 2008. Rothstein admits that a period of prolonged unemployment will cause the victims to "become less employable and less productive as their skills deteriorate and/or become obsolete." To the extent that the long-run unemployed are not considered as viable job candidates by employers, our suggestion to shift to SRU as the driving demand variable in econometric inflation equations gains support.
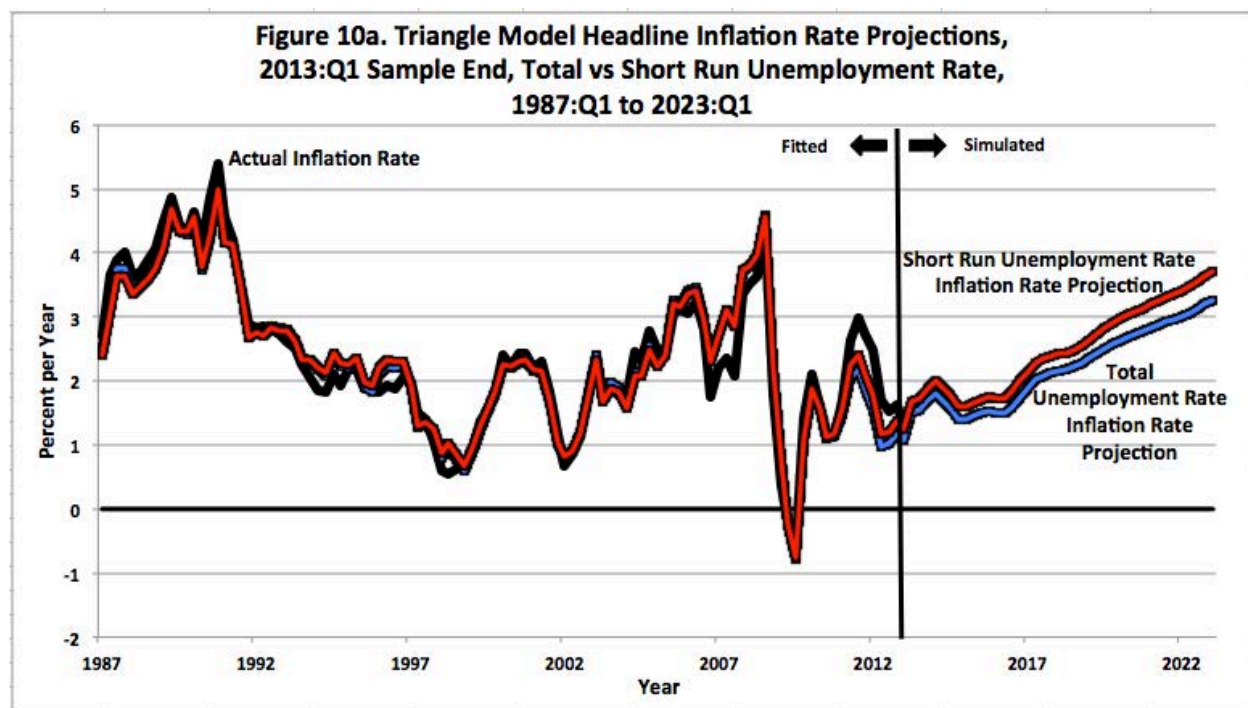
Finally, among the strongest advocates against a structural shift are Edward Lazear and James Spletzer (2012). They attribute the increase in long-run unemployment to the weakness of aggregate demand, not structural shifts or any evidence of a skills mismatch that prevents the long-run unemployed from being hired. They interpret the high, sustained level of long-run unemployment as entirely a result of the "depth of the current recession." They do not comment on the reason why the mix of short-run and long-run unemployment is so different when the 2009-2013 recovery is compared with 1982-86.

4.2 Simulation of Inflation to 2023 Along Alternative Recovery Paths

The central concern of the Fed, including its Governors, regional bank presidents, staff, and Fed-watchers is the extent to which accommodative monetary policy can push down the total unemployment rate without igniting an increase in the inflation rate. Because of its success thus far in long-duration post-sample dynamic simulations, the triangle model estimated and simulated above is the ideal tool with which to assess the future. In this section we examine two scenarios. In the first, the total unemployment rate is pushed down to 5.0 percent at exactly the same rate of decline that it actually fell between 2010:Q1 and 2013:Q1, namely at 0.5 of a percentage point per year, and that brings the TU rate from 7.73 percent in 2013:Q1 to 5.00 percent in 2018:Q3, after which the TU rate is held at 5.0 through 2023:Q4.
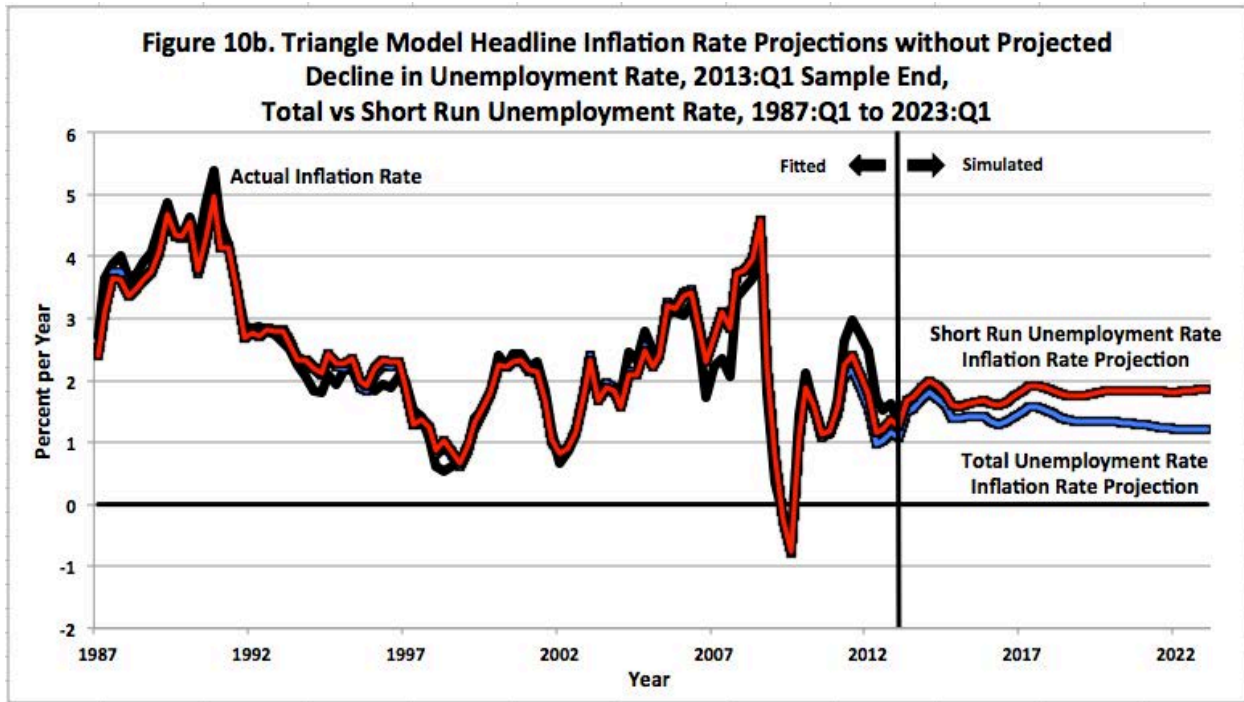
Likewise, short-run unemployment is assumed to fall at its actual rate of decline as between 2010:Q3 and 2013:Q1, and this implies a decline over 2013-2018 at an annual rate of -0.34 percent per year. Both the TU and SRU assumed paths "break through" their estimated NAIRUs in 2015:Q1, after which the assumed paths decline below the estimated NAIRUs. How much does inflation speed up as a result? We treat the supply shock variables as unforecastable and set them at zero starting in 2013:Q2.

The top frame of Figure 10 shows the future simulation of the headline inflation rate, with the blue line representing the result using the TU rate and the red line the SRU rate. There is a lag between the time the NAIRU is breached in 2015:Q1 and the emergence of rising inflation in 2016:Q4. In the SRU red version, the headline inflation rate rises above 2.0 percent for the first time in 2016:Q4 and in the TU blue version in 2017:Q2. By 2023 the inflation rate has reached 3.8 percent in the SRU version and 3.4 percent in the TU version.[18] The slowness of the increase in the inflation rate reflects the inertia built into the model with its interacting set of lags on the unemployment rate and inflation rate.

Figure 10a. Triangle Model Headline Inflation Rate Projections, 2013:Q1 Sample End, Total vs Short Run Unemployment Rate, 1987:Q1 to 2023:Q1

An alternative simulation is provided in the bottom frame of Figure 10. Here, the decline in the unemployment rate (both TU and SRU) is halted at the point when their values

---

[18] The simulation results for the core inflation equations developed in the next section are almost identical and are not presented separately. By 2023:Q4 the SRU simulation for core inflation reaches 3.7 and the TU equation reaches 3.3 percent.

Figure 10b. Triangle Model Headline Inflation Rate Projections without Projected Decline in Unemployment Rate, 2013:Q1 Sample End, Total vs Short Run Unemployment Rate, 1987:Q1 to 2023:Q1

reach the estimated 2013:Q1 NAIRU of 6.45 for the TU rate and 4.2 for the SRU rate. Because no negative unemployment gap emerges, the inflation rate remains steady in the range of one to two percent throughout the 2013-2023 interval.

5. Core Inflation and Coefficient Stability

5.1 Triangle Results for Core Inflation

Much of the literature on the inflation process attempts to evade the joint determination of prices by supply and demand by limiting its investigation to core inflation, that is, the inflation rate of all goods and services excluding food and energy. However, the top frame of Figure 3, which compares the four-quarter inflation rate of headline and core inflation, shows that supply shocks had a sharp impact on core inflation, as is evident in the twin peaks of core inflation in the 1970s and the otherwise inexplicable valley of low core inflation in the late 1990s.

Table 4 displays over the same three sample periods as in previous tables the results for headline vs. core inflation, using the SRU rate as the demand variable and specifying all supply variables as before, including the food-energy effect. Since by definition headline inflation equals core inflation plus a coefficient of unity on the food-energy effect, one would expect that a coefficient of unity in the headline equation, as in Table 2 prior to 1987, would translate into a coefficient of zero in the core inflation results.

		Table 4					
		Estimated Equations for Quarterly Changes in					
		the PCE Deflator, Headline vs Core Specifications, Short Run Unemployment Rate					
Variable	**Lags**	**1962:Q1 to 1996:Q4**		**1962:Q1 to 2006:Q4**		**1962:Q1 to 2013:Q1**	
		Headline	**Core**	**Headline**	**Core**	**Headline**	**Core**
Constant							
Lagged Dependent Variable	1-24ª	1.01 **	1.01 **	1.01 **	1.01 **	1.01 **	1.01 **
Unemployment Gap	0-4	-0.77 **	-0.62 **	-0.73 **	-0.62 **	-0.64 **	-0.57 **
Relative Price of Imports, NFNO	1-4	0.05 *	0.03	0.05 **	0.03 *	0.04	0.03
Food-Energy Effect Full Period	0-4	1.07 **	0.55 **	1.06 **	0.58 **	1.08 **	0.60 **
Food-Energy Effect Late Period	0-4	-0.33	-0.30	-0.32	-0.42 *	-0.46 **	-0.52 **
Productivity Trend Change	15	-1.01	-1.28 *	-0.92 **	-1.11 **	-1.00 **	-1.18 **
Nixon Controls "on"	0	-1.81 **	-1.87 **	-1.77 **	-1.90 **	-1.76 **	-1.86 **
Nixon Controls "off"	0	2.07 **	2.23 **	1.90 **	2.18 **	1.88 **	2.10 **
Adj. R2		0.94	0.92	0.95	0.93	0.95	0.93
S.E.E		0.63	0.63	0.59	0.58	0.59	0.58
S.S.R		43.38	43.78	52.48	51.07	61.58	58.58
Dynamic Simulations		1997:Q1 to 2013:Q1		2007:Q1 to 2013:Q1			
Mean Error		0.25	0.15	-0.11	-0.07		
Error in 2013:Q1		-0.11	-0.09	0.11	-0.11		
Root Mean-Square Error		0.69	0.60	0.76	0.65		
a) Lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17, and 21,							
b) Lagged Food-Energy Effect variable (full and late period) is entered as the four-quarter moving average for lags 1, 5, and 9 in varying combinations							
c) *indicates coefficient or sum of coefficients is statistically significant at the 5 percent level, ** indicates significance at the 1 percent level.							

But, this is not what happens. In the pre-1987 period, the response of core inflation to the food-energy effect is not zero but a highly significant 0.6. The decline in responsiveness is evident by adding the full period food-energy effect with the late-period impact – this negative coefficient measures by how much the food-energy coefficient was lower in 1987-2013 than in 1962-1986. When the difference term is added to the full-period term, the net coefficient is 0.25 in the sample period ending in 1996, 0.16 ending in 2006, and 0.08 ending in 2013.

The goodness of fit statistics and simulation results are almost identical for the core equations in Table 4 as for the headline equations in Tables 1 and 2. The mean error in the post-1996 simulation is 0.15 with the core equation, slightly more accurate than the 0.25 for the headline equation. All simulations in Table 4 hit a bulls-eye on the value of actual inflation in 2013:Q1, with errors of 0.1 percent, plus or minus. A notable aspect of the core equations is that the RMSE in the dynamic simulations, whether over 16 years or 6 years, is roughly equal to the SEE of the estimated equations themselves. Figure 11 plots the actual core inflation rate against the simulated values, and shows how remarkably the simulations stay on track throughout

1997-2013 (top frame) or 2007-2013 (bottom frame) despite the absence of any input about the behavior of actual inflation.

Figure 11a. Actual vs Simulated Core Inflation Rate, 1996:Q4 Sample End, Triangle Model, Short Run Unenemployment Rate, 1987:Q1 to 2013:Q1

Figure 11b. Actual vs Simulated Core Inflation Rate, 2006:Q4 Sample End, Triangle Model, Short Run Unemployment Rate, 1987:Q1 to 2013:Q1
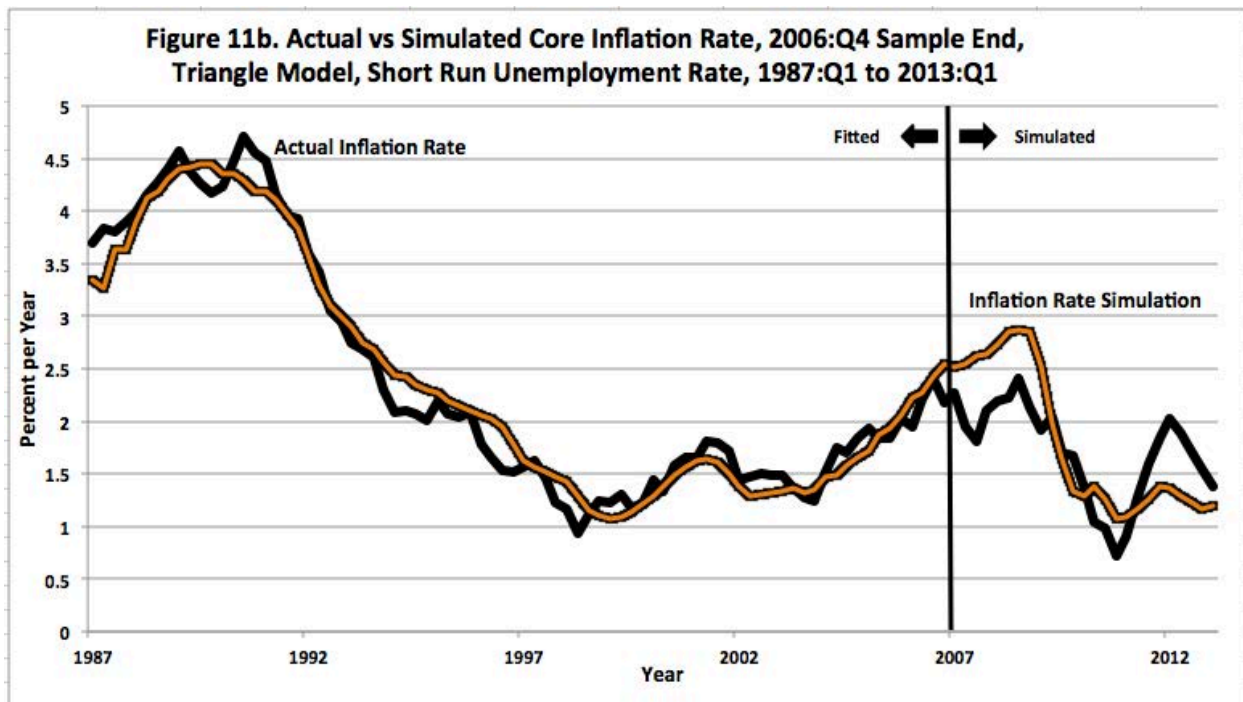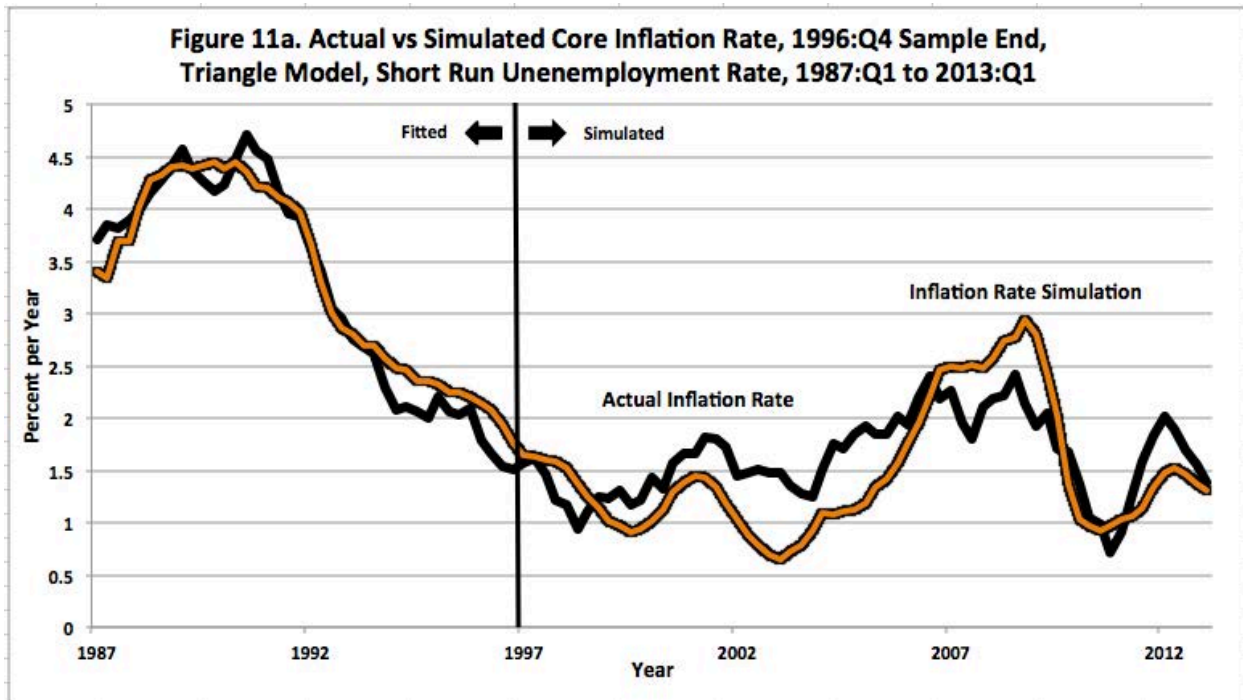
5.2 Specification Bias and Changes of Coefficients in Rolling Regressions

We have already seen in Table 1 that the coefficients on the unemployment rate in the constant-NAIRU version of the NKPC specification are much lower, i.e., closer to zero, than in the triangle specification. This provides an occasion to revisit the econometrics of coefficient bias in the presence of omitted variables. Assume that the triangle model is correct, and inflation has a negative correlation with unemployment and a positive correlation with supply shocks, and to simplify assume there is only one supply-shock variable, namely the change in energy prices. The true PC relationship includes a negative response to the unemployment rate and a positive relationship to energy prices. When energy prices exhibit serially correlated major upward movements, this will cause a positive response of the overall inflation rate, will reduce real incomes and drain purchasing power, and will create a recession that drives up the unemployment rate.[19] This scenario is consistent with the pronounced lead of the inflation spikes in advance of the unemployment spikes evident in the top frame of Figure 1 above.
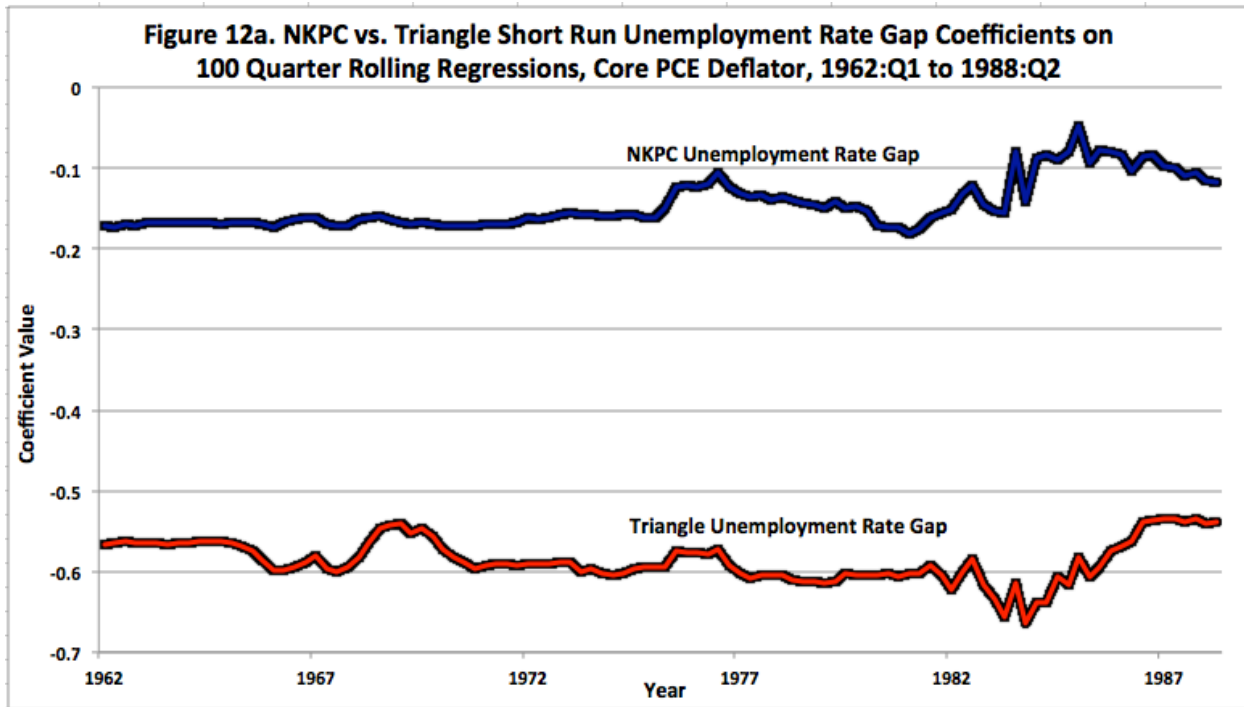
Consider the bias of the coefficient on the unemployment term when the energy price effect is omitted from the equation. When this equation is estimated over a time period that includes sharp increases and decreases in energy prices, those omitted variables will create a positive correlation between inflation and unemployment that will offset the true structural negative relationship. The coefficient on unemployment in the inflation rate equation will be biased downward, perhaps to zero, because the true inflation equation includes a negative relationship with unemployment and a positive relationship with energy prices and other supply-shift terms. Yet all of the NKPC literature over the past 15 years, as well as most other research on inflation, fails to include explicit variables to measure the impact of supply shocks.[20] As a result, their misspecified equations attempt to explain the inflation rate that depends on both demand and supply with only a demand variable. The sample observations in which inflation and unemployment are positively correlated, as in 1973-82 and 1996-2000, cause a significant downward bias in the unemployment coefficient.

The consequence of this misspecification is illustrated in the top frame of Figure 12 for the core inflation rate, which displays the sums of coefficients on the unemployment gap in "rolling regressions" that apply to part of the sample period and then advance, quarter-by-quarter, through time. Because there are now somewhat more than 200 quarterly observations since 1962, our rolling regressions cover 100 quarters, i.e., 25 years. The first points plotted in the top frame are the coefficients on the unemployment gap for the two models covering the 100 quarters between 1962:Q1 and 1986:Q4. Then the regressions are repeatedly re-estimated for

---

[19] This was the main point of Gordon (1975, 1984) and Phelps (1978).

[20] One of the few exceptions is the recent paper by Blinder and Rudd (2013), but while this paper includes explicit supply shock terms, it is estimated only for the sample period 1961-1979 and is not used to assess inflation behavior after 1984.
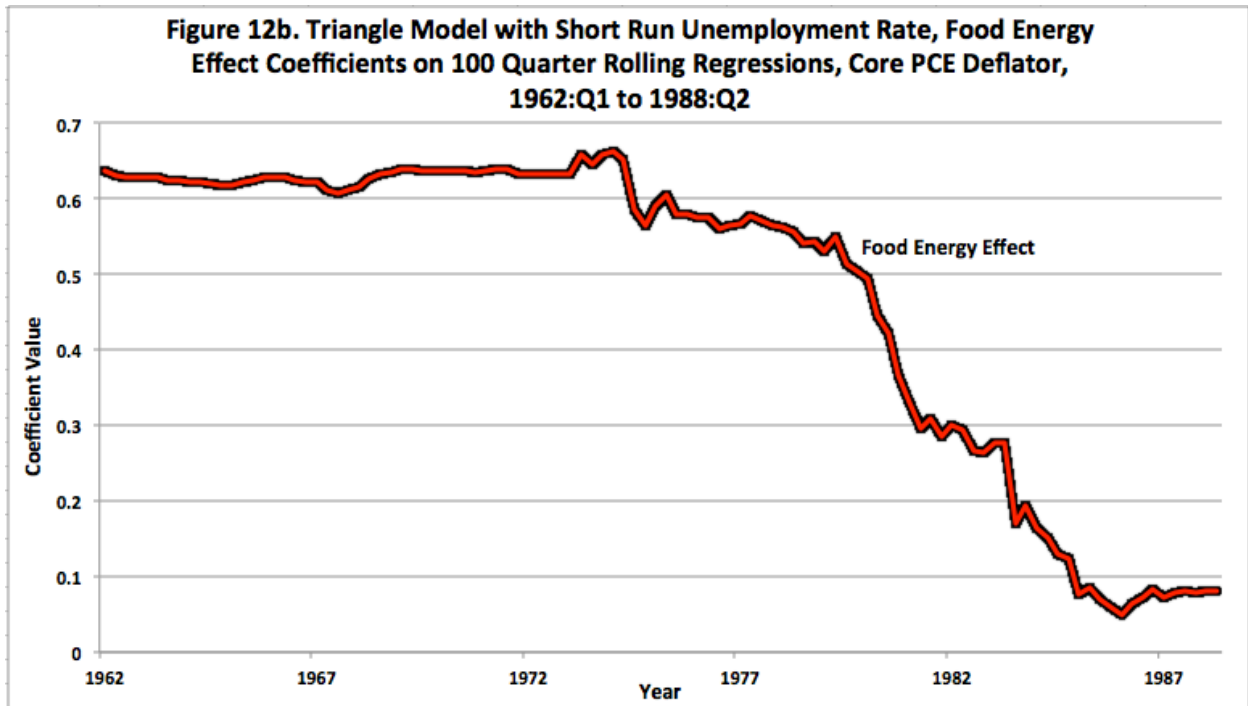
each successive quarter running up to the end of the data, i.e., 1988:Q2-2013:Q1, so that there are coefficients for each equation from 106 successive regressions. Thus the left observation plotted in Figure 12 is the first of these regressions and the rightmost observation is the last of the 106 equations.

Figure 12a. NKPC vs. Triangle Short Run Unemployment Rate Gap Coefficients on 100 Quarter Rolling Regressions, Core PCE Deflator, 1962:Q1 to 1988:Q2

The rolling regressions for the constrant-NAIRU version of the NKPC model begin with an unemployment coefficient of about -0.17 for regressions starting in 1962 and end in regressions beginning in 1984-1988 with an unemployment coefficient lower in absolute value than -0.10. The triangle version using the SRU rate has a coefficient that is much larger and more stable, averaging -0.59 (with a standard deviation of 0.02) in regressions starting between 1962 and 1985, declining only to -0.54 (with a standard deviation of 0.01) in regressions starting between 1986 and 1988. We interpret the small absolute value of the fixed-NAIRU NKPC unemployment coefficient in the top frame of Figure 12 as due to specification bias, and in Appendix B we provide formal nesting tests of the significance of variables excluded from the NKPC model but included in the triangle model.

The bottom frame of Figure 12 confirms the regression results in Table 2 that show that the food-energy coefficient for core inflation declines from an average of 0.62 in regressions starting in 1962 to 1975, drops to an average of 0.43 in regressions starting from 1976 to 1983, and then plummets to an average of only 0.09 in the final 18 quarters of the rolling regressions. Thus these results confirm the premise of the analysis by Blanchard and Galí (2010) that the

response of inflation to changing energy prices has declined sharply since the 1970s, although our results in Table 2 above show that there is still a significant albeit smaller coefficient on headline inflation of 0.6 in response to movements in the food-energy effect.[21]

Figure 12b. Triangle Model with Short Run Unemployment Rate, Food Energy Effect Coefficients on 100 Quarter Rolling Regressions, Core PCE Deflator, 1962:Q1 to 1988:Q2

This concludes the presentation of results in the main text of the paper. Appendix A contains comparisons of both the constant-NAIRU NKPC results and the triangle results with those when the NKPC implicit NAIRU is not held constant but is allowed to vary over time. Appendix B develops formal "nesting tests" showing that the constant-NAIRU NKPC is fully nested in the triangle model, differing by omitting specific lagged terms and specific variables. These tests show that all of the additional lags and terms in the triangle model are strongly statistically significant.

6. Conclusions and Policy Implications

It has widely been assumed that the Phillips Curve (PC) approach to explaining the behavior of the inflation rate is dead. The core inflation rate shows little variation in the past 20

---

21. Blanchard and Marianna Riggi provide a structural model that explains the decline in the impact of the price of oil on the increased energy-efficiency of the economy, a decline in the importance of labor unions and wage indexation, and increased credibility of the Fed.

years. Attempts to estimate Phillips curves by such authors as Ball-Mazumder (B-M, 2011) generate inflation simulations that predict an accelerating deflation after 2009, leading to the puzzle of the "missing deflation."   How could the PC still be relevant when the core inflation rate has remained within in a narrow range of one to two percent over the past two decades despite soaring unemployment and persistent weakness in the U. S. labor market since 2008? It is widely believed that the stability of core inflation over the past two decades reflects the success of the Federal Reserve in gaining credibility and "anchoring" the inflation rate.

Yet, if there is no PC correlation between inflation and unemployment, then there is no "natural rate of unemployment", or NAIRU. Without an estimate of the current NAIRU, the Fed cannot estimate the size of the unemployment gap, that is, the amount of excess unemployment above the level that would cause the inflation rate to move away from its apparent steady state and begin to accelerate. In such a world, the Fed would be operating like a captain of a giant ocean liner operating in a fog, with no instruments to warn of icebergs to the left or to the right.

This paper shows that the Phillips Curve is alive and well, fully capable of explaining the behavior of the U. S. inflation rate, whether the headline or core deflator for Personal Consumption Expenditures, over the last five decades. The "triangle" econometric model of U. S. inflation behavior, developed more than 30 years ago, can predict the inflation rate accurately over 16-year dynamic simulations starting in 1997 and extending to 2013 with a mean error of 0.25 of a percentage point. In rolling regressions the triangle model exhibits a stable coefficient on the unemployment rate, contradicting the verdict of B-M and many other authors that the coefficient on the unemployment rate in the inflation equation has declined by more than half in the past few decades to a value close to zero. The triangle model, with its stable unemployment coefficient, generates an endogenous NAIRU that can provide guidance for the Fed about the level of the unemployment rate that marks the dividing line between faster or slower inflation.

The slow recovery has been marked by a much higher level and persistence of long-run unemployment than in previous postwar recoveries. If the difference between short-run and long-run unemployment is set at a dividing point of spells lasting more or less than 26 weeks, the new triangle estimation results suggest that inflation is better predicted by the short-run rate than by the total unemployment rate. This is consistent with a large literature on Europe since the 1980s, and journalistic observations about the U. S. over the last few years, implying that the long-run unemployed do not put downward pressure on wages and prices. They are discriminated against by employers on the basis of time without a job and are assumed to have lost their skills or to have other unobservable negative qualities that are signaled by a long interval without a job.

The increase in the ratio of total unemployment to short-run unemployment translates into a significant increase in the time-varying NAIRU for total unemployment. While the NAIRU for short-run unemployment is relatively stable, the increasing importance of long-run unemployment implies an increase in the NAIRU for the total unemployment rate from 4.8 percent in 2006 to 6.5 percent in 2013. This result is important news for the Fed – there may be less slack in the U. S. labor market than is generally assumed, and it may be unrealistic to maintain the widespread assumption that the unemployment rate can be pushed down to 5.0 percent without igniting an acceleration of inflation. Indeed, the simulations of future inflation implemented here suggest that an attempt by the Fed to drive down the unemployment rate to 5.0 percent over the next five years will create a very slow acceleration of inflation that will reach between 3.5 and 3.8 percent ten years from now.

Here, we go beyond past and future dynamic simulations to address the central issue in PC research – how could so much research on the inflation process over the past two decades provide such inaccurate dynamic simulations of the inflation process and conclude that the coefficient on unemployment rate in the PC equation is so low and has declined so much? The answer to this question goes back to 1975, when the PC approach suffered from a much more important predictive failure than the "case of the missing deflation" of 2008-2013. The PC had been developed as a negative relationship between the inflation and unemployment rates, and a devastating error occurred in 1974-75 when inflation and unemployment turned out to have a strong *positive* correlation as is shown in the top frame of Figure 1 above. Even worse, also shown in Figure 1, apparently autonomous movements in the inflation rate led to a positive response by the unemployment rate with a lag of at least one year. Far from causing inflation with a negative correlation, unemployment turned out to be *caused by inflation* with a positive correlation. There could be no bigger failure than that.

The resolution to the apparent 1975 failure of the PC was immediate and fundamental. Supply shocks mattered for macroeconomics. Just as the price and quantity of wheat could be positively or negatively correlated in microeconomics, so could the macroeconomic inflation and unemployment rates. By 1980 macro and micro were unified, not just in econometric models that explicitly incorporated supply variables, but also in textbooks. The years 1975-1980 represented perhaps the most fundamental five years of change in the history of macroeconomics textbooks since the 1930s, because by 1980 every macro textbook had shifting supply and demand curves.

The central role of supply in the determination of inflation, so obviously central to the understanding of inflation in the twin peaks of the 1970s and inflation valley of the late 1990s, was left behind during the development of the New Keynesian Phillips Curve approach (NKPC). It was as if microeconomics forgot that the price and quantity of wheat could be

negatively correlated during a drought. Yet supply shocks matter, and these include not just food and energy prices but also the relative price of non-food non-oil imports and changes in the trend growth of productivity. A highly significant determinant of the first peak of U. S. inflation in 1974-75 was caused by the timing of the Nixon price controls, as was recognized at the time by Blinder (1979, 1982), but the collective amnesia of inflation research carried out over the past two decades includes forgetfulness that the price controls and their abandonment had anything to do with U. S. inflation history.

Supply shifts still matter. The puzzle of low inflation in the late 1990s, despite low unemployment, is easily explained in the triangle model by low oil prices, declining import prices as a result of the appreciation of the dollar during 1995-2002, and the revival of productivity growth during 1995-2004. How is the "case of the missing deflation" resolved in this paper? Figure 8 decomposes the contribution of each explanatory variable. While the high unemployment rate pushed the inflation rate down in 2009-2013, the inflation rate was pushed up by higher energy prices and declining productivity growth. The inertial behavior of core inflation usually attributed to the Fed's credibility is explained in the model by unusually long lags on both the unemployment rate and the lagged dependent variable (the inflation rate).

The success of the triangle model in retaining stable coefficients in the face of slack labor markets over the past five years has implications for the past two decades of Phillips Curve research. While Sargent was right to emphasize the role of forward-looking expectations in the contexts of the ends of major hyperinflations, the NKPC approach has turned out to be unsuccessful when applied to U. S. data. Empirical implementation of the NKPC equations in dynamic simulations cannot explain why inflation was so low in the high demand environment of the late 1990s or why deflation did not occur in the low-demand environment of 2009-2013. If the practitioners of NKPC research had tested their models by calculating long post-sample dynamic simulations, they would have discovered that their model has little ability to explain the behavior of U.S. postwar inflation.

For Phillips curve specialists, the paper contains in Appendix A some comparisons of the performance of a NKPC model that allows for a time-varying NAIRU. Appendix B provides the results of nesting tests. Since the NKPC specification is a special case of the triangle model with numerous lags and supply shock terms omitted, the statistical significance of each of these extra terms in the triangle model can be assessed. The most important result in Appendix B is that the set of supply-shock variables pass a joint exclusion test with a F statistic of 19.6 for headline inflation and 9.4 for core inflation. This contradicts the standard view in the Phillips Curve literature that supply shocks have nothing to do with the core inflation rate.

For the Fed, the simulations of the triangle model suggest that it will be risky to allow the total unemployment rate to decline much below 6.5 percent. There is always the possibility

that this paper could be wrong, and that the core inflation rate is permanently anchored at 1 to 2 percent no matter what may be the state of the U.S. labor market. Unfortunately, because of long lags in the inflation process, two or three years may separate the time that the actual unemployment rate declines below the NAIRU and the first hints of the resulting rise of the inflation rate. This paper raises the possibility that a structural shift in U. S. labor markets may have permanently increased the feasible steady-inflation total unemployment rate, and that much of the sharp decline in the employment-population ratio from 63 to 59 percent since 2007 may also be permanent. In this sense the U. S. economy may have become more like Europe.

APPENDIX A

NKPC Results with a Time-Varying NAIRU,

The NKPC With a Time-Varying NAIRU

Previously shown are the regression coefficients and simulation errors of the constant-NAIRU version of the NKPC model (see Figures 2 and 12 and Table 1). This model generates enormous residuals that have a SSR (sum of squared residuals) four times that of the triangle model when applied to the same data (see Table 1). The simulation performance is poor, as the model estimated through 1996 predicts that inflation would soar to 10 percent by 2007. When the model is estimated through 2006, it predicts that inflation would have reached a deflationary rate of more than minus four percent by 2013.

In light of the fact that the triangle model endogenously generates a time-varying NAIRU, it seems reasonable to allow the NKPC model to have an implicit NAIRU (U^* in the context of equations 1, 2, and 3 above) that varies over time. Numerous papers attempting to explain the inflation rate with the NKPC model have adopted a time-varying NAIRU. Rather than generating it endogenously as in the triangle model, these papers have typically used the Hodrick-Prescott (HP) filter to establish a trend version of the unemployment rate, and then have used as the demand variable in their inflation equations the actual unemployment rate minus the HP filtered trend unemployment rate ($U - U^*$). For this exercise we choose not the typical HP quarterly parameter of 1600 that makes the trend extremely variable in response to actual movements, but rather the parameter of 6400 that yields a smoother trend. The HP 6400 version of the trend unemployment rate is very similar to that estimated for pre-2001 data by Staiger, Stock, and Watson (2001).

In this section we examine the differences in performance of the constant-NAIRU NKPC, the HP 6400 NKPC, and the triangle model. All results are for core inflation, and thus differ from the regression and simulation results shown in Figure 2 and Table 1 in the main body of the paper for the constant-NAIRU version of the NKPC.

Figure A-1 compares the average TU rate with the three alternative TU NAIRUs. The TU, rather than the SRU, is used, because readers are more familiar with the postwar behavior of that standard unemployment concept. Two horizontal lines are shown – a black line for the average TU rate during 1962-2013 (5.84 percent) and the dark blue horizontal line is the implicit NAIRU generated by the constant-NAIRU (Roberts-type) NKPC equation. The triangle NAIRU for total unemployment is copied from Figure 9, and in Figure A-1 is supplemented by the

HP6400 trend of the unemployment rate that provides the time-varying NAIRU for the NKPC model using the symbol U* introduced above in equations (1), (2), and (3) in the main body of the paper.

Figure A-1. Triangle TV-NAIRU, NKPC HP 6400 Trend, and NKPC Constant NAIRU, 1961:Q1 to 2013:Q1
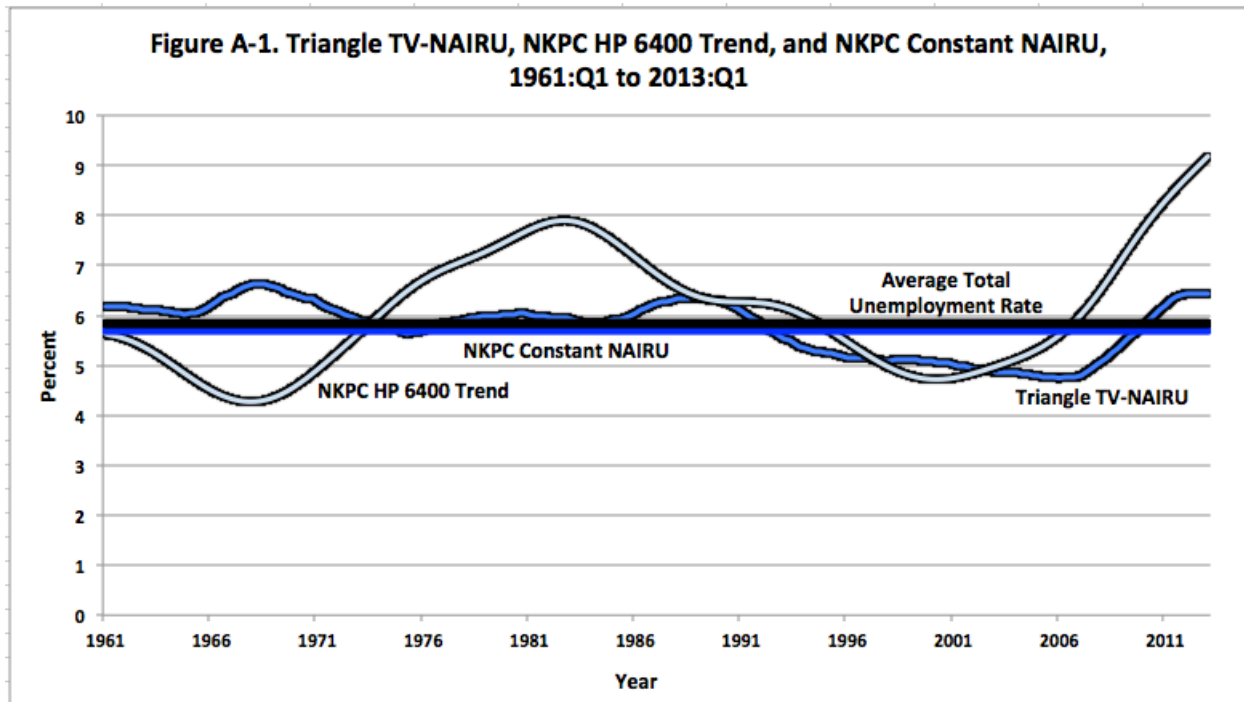
The HP 6400 unemployment trend plotted in Figure A-1 has predictable properties that help the NKPC inflation achieve a decent fit. It soars from 4.3 percent in 1968:Q3 to 7.9 percent in 1983:Q1. This rising HP NAIRU greatly reduces the unemployment gap from highly positive to zero or negative and helps to explain why inflation did not slow down in response to high unemployment in the in the 1970s and early 1980s. The opposite development occurs in the late 1990s, when the HP 6400 NAIRU swoons to 4.7 percent, helping to explain why the Clinton dot-com boom did not generate rising inflation. While the HP filter technique is univariate, using no information about inflation when detrending the unemployment rate, its tendency to "bend" to track the actual values automatically reduces the size of the unemployment gap (U – U*) and reduces the specification bias evident in the constant-NAIRU version of the NKPC.

A weakness in the HP 6400 version of the NKPC occurs in its mechanical verdict that the NAIRU almost doubled from 4.7 percent in 2000:Q1 to 9.2 percent in 2013:Q1. This helps in explaining the "case of the missing deflation" because the unemployment gap is negative in 2012-2013. But this is a mechanical outcome that has no credibility.

Table A-1

NKPC vs Triangle Model: Estimated Equations for Quarterly Changes in
the Core PCE Deflator, Short Run Unemployment Rate

Variable	Lags	1962:Q1 to 1996:Q4			1962:Q1 to 2006:Q4			1962:Q1 to 2013:Q1		
		Constant NAIRU	HP 6400 NAIRU	Triangle	Constant NAIRU	HP 6400 NAIRU	Triangle	Constant NAIRU	HP 6400 NAIRU	Triangle
Constant		1.28 **			1.04 **			0.99 **		
Lagged Dependent Variable	1-24[a]			1.01 **			1.01 **			1.01 **
	1-4	1.01 **	0.99 **		1.02 **	0.99 **		1.01 **	0.99 **	
Unemployment Gap	0-4			-0.62 **			-0.62 **			-0.57 **
	0		-0.59 **			-0.53 **			-0.46 **	
Unemployment Rate	0	-0.25 **			-0.22 **			-0.21 **		
Relative Price of Imports, NFNO	1-4			0.03			0.03 *			0.03
Food-Energy Effect Full Period	0-4			0.55 **			0.58 **			0.60 **
Food-Energy Effect Late Period	0-4			-0.30			-0.42 *			-0.52 **
Productivity Trend Change	1 5			-1.28 *			-1.11 **			-1.18 **
Nixon Controls "on"	0			-1.87 **			-1.90 **			-1.86 **
Nixon Controls "off"	0			2.23 **			2.18 **			2.10 **
Adj. R2		0.84	0.85	0.92	0.87	0.88	0.93	0.87	0.88	0.93
S.E.E		0.88	0.85	0.63	0.82	0.79	0.58	0.80	0.77	0.58
S.S.R		104.84	96.97	43.78	116.56	108.36	51.07	126.07	119.01	58.58
Dynamic Simulations		1997:Q1 to 2013:Q1			2007:Q1 to 2013:Q1					
Mean Error		-5.92	-0.90	0.15	-0.45	0.02	-0.07			
Error in 2013:Q1		9.07	0.97	-0.09	0.48	-0.03	-0.11			
Root Mean-Square Error		6.47	1.24	0.60	0.71	0.83	0.65			

a) Lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17, and 21, respectively
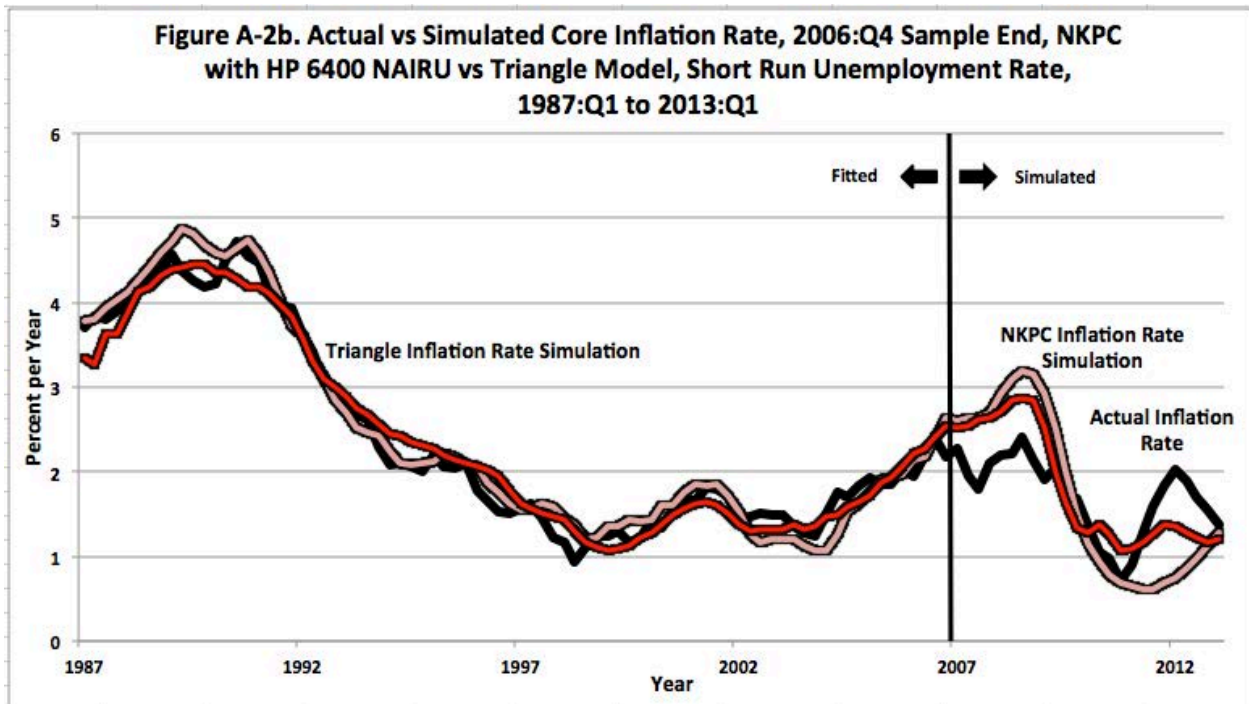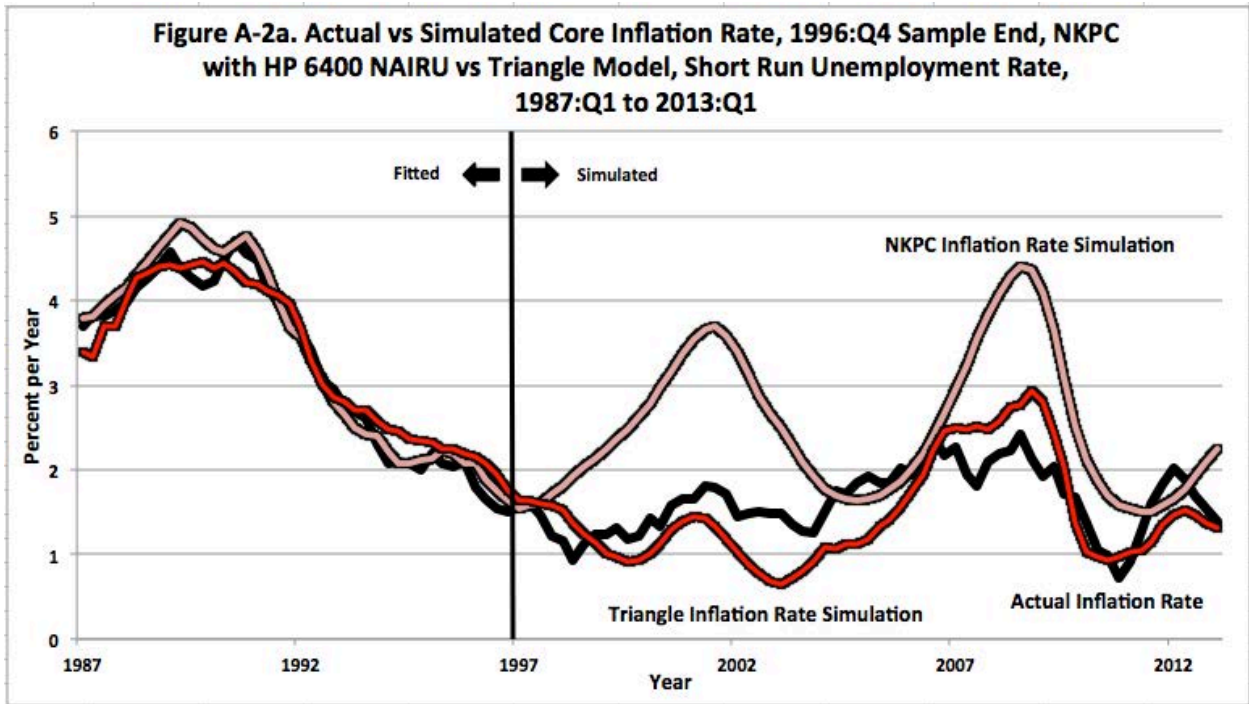
b) *indicates coefficient or sum of coefficients is statistically significant at the 5 percent level, ** indicates significance at the 1 percent level.

Table A-1 displays a comparison of three specifications – the constant-NAIRU NKPC as already examined in Table 1, but now re-estimated for core rather than headline inflation, the HP 6400 TV-NAIRU version of the NKPC, and the triangle model results already displayed above in Table 4. To simplify the table, only results for the SRU rate and core inflation are displayed. The first difference to notice in Table A-1 is the coefficient on the unemployment rate vs. the unemployment gap. The HP 6400 version of the NKPC generates coefficients on the unemployment rate in the range of -0.5 to -0.6, roughly the same as in the triangle model, whereas the constant-unemployment version of the NKPC generates much smaller unemployment coefficients closer to -0.2.
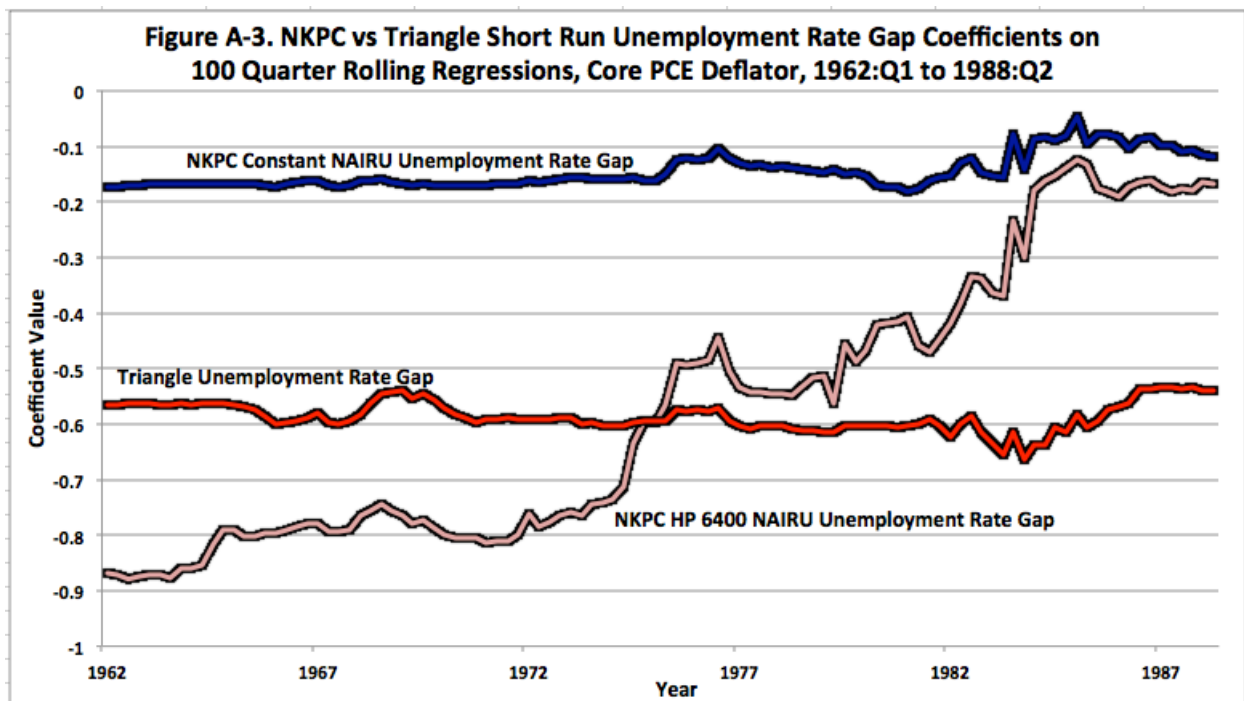
Goodness of fit statistics are modestly better for the HP 6400 version than the fixed-NAIRU version, but the real difference comes in the dynamic simulations. Starting with the 16-year simulations in which the sample period ends in 1996:Q4, the mean error when switching to the HP 6400 version declines from -5.9 to -0.9 and the RMSE of the simulation declines from 6.5 to 1.3. When the sample period is moved ten years later to end in 2006:Q4, the mean error falls to zero although the RMSE rises to 0.83 from 0.71 in the constant-NAIRU version of the NKPC.

While the HP 6400 version of the NKPC performs much better than the constant-NAIRU version, it still falls far short of the performance of the triangle version for the core inflation dependent variable and SRU rate as the explanatory unemployment variable. As shown in Table A-1, the 1962-2013 sample period SEE of the triangle model is 0.58 compared to 0.77 for the HP 6400 NKPC model, and the RMSE is 58.6 versus 119.1. The RMSE of the dynamic simulations falls from 1.24 to 0.60 in the post-1996 simulations and from 0.83 to 0.65 in the post-2006 simulations between the HP 6400 NKPC and triangle models.

The top frame of Figure A-2 shows that the HP 6400 version of the NKPC performs much better than the constant-NAIRU version in post-1996 dynamic simulations, but its simulated values are still far away from the actual values during most of the simulation period. The improved performance of the HP 6400 version comes with a heavy price – the implication that the NAIRU had climbed by 2013:Q1 to 9.2 percent (see Figure A-1). This allows the HP 6400 version to track actual inflation behavior in the post-2006 simulation (bottom frame of Figure A-2), but the only reason that the HP 6400 version avoids the prediction of steady deflation in response to labor market slack is to use an unemployment trend that implies no economic slack at all, i.e., a negative value of $U - U^*$.

Figure A-2a. Actual vs Simulated Core Inflation Rate, 1996:Q4 Sample End, NKPC with HP 6400 NAIRU vs Triangle Model, Short Run Unemployment Rate, 1987:Q1 to 2013:Q1

Figure A-2b. Actual vs Simulated Core Inflation Rate, 2006:Q4 Sample End, NKPC with HP 6400 NAIRU vs Triangle Model, Short Run Unemployment Rate, 1987:Q1 to 2013:Q1

The final indictment of the HP 6400 version of the NKPC is the instability of its coefficient on the unemployment gap. As shown in Figure A-3, a rolling regression results in a steadily declining absolute value of the HP 6400 NKPC unemployment gap coefficient from -0.87 in 100-quarter regressions starting in 1962:Q1 to -0.16 in regressions starting in 1988:Q2. The equivalent coefficients for the triangle model are -0.57 for the first rolling regression and -0.54 for the final rolling regression, demonstrating the stability of the triangle model approach.

Figure A-3. NKPC vs Triangle Short Run Unemployment Rate Gap Coefficients on 100 Quarter Rolling Regressions, Core PCE Deflator, 1962:Q1 to 1988:Q2

APPENDIX B

The NKPC Model is Nested in the Triangle Model:
Significance Tests of Omitted Lags and Omitted Variables

This section presents formal statistical tests of the significance of the lags and variables included in the triangle model and omitted in the NKPC model. The NKPC model is entirely nested within the triangle model, because it is a regression of the inflation rate on lagged inflation and either the current unemployment rate or unemployment gap. All the differences with the triangle model are represented by lags on inflation or unemployment that are omitted in the NKPC approach, as well as the NKPC omission of explicit supply-shock variables.

There are 9 lines in Table B-1 corresponding to alternative combinations of included and excluded lags and variables. Line 1 reports on the fixed-NAIRU version of the NKPC model and line 2 on the HP 6400 version of the NKPC model. Line 9 is the triangle model, and lines 3 through 8 include various permutations of lag lengths and the inclusion or exclusion of the supply-shock variables.

The columns start with the SSR of regressions for core inflation and the TU rate with a sample period of 1962:Q1 to 2013:Q1. SSR statistics are shown for headline and core inflation side-by-side. For instance, the SSR for the worst-fitting equation in line 1 for headline inflation is 186.5 and for the best-fitting equation in line 9 is 42.7, less than one-quarter as high. For core inflation the SSR contrast between line 1 and 9 is 104.0 versus 43.2.

The next set of columns show the mean error (ME) and the root mean-square error (RMSE) for both the headline and core inflation versions of dynamic simulations that estimate coefficients for 1962:Q1 to 1996:Q4 and then generated the lagged dependent variable endogenously for the 16 years between 1997:Q1 and 2013:Q1. Both the ME and RMSE simulation summaries are much better for the triangle model in line 9 than for either of the two NKPC models in lines 1 and 2.

The remaining columns display F-statistics and their significance levels, respectively, for the exclusion of lags 5-24 (which are included in the triangle model but excluded in the NKPC model), of lags 1-4 on the unemployment gap, and of the set of supply shock variables that are the distinguishing feature of the triangle model and are uniformly omitted in every NKPC model. The F-tests on lags 5-24 of inflation uniformly show that these lags are jointly, and highly, significant with p-levels of 0.00 in most variants. The tests on lags 1-4 for the unemployment gap are mostly significant for the headline inflation versions but mainly insignificant for core inflation.

Table B-1

Transformation of Phillips Curve from NKPC (line 1) to Triangle (line 9), 1962:Q1-2013:Q1, Headline vs Core PCE Deflator, Total Unemployment Rate

	Inf Lag	U lag length	NAIRU Specification	Supply shock	Regression Statistics SSR		Errors in 1997:Q1-2013:Q1 Simulations ME		RMSE		Exclude inf lags 5-24 F Stat		P Sig Level		Exclude U lags 1-4 F Stat		P Sig Level		Exclude Supply Shocks F Stat		P Sig Level	
					Headline	Core	Headline	Core	Headline	Core	Headline	Core	Headline	Core	Headline	Core	Headline	Core	Headline	Core	Headline	Core
1	1 to 4	0	Fixed	No	186.5	104.0	-5.00	-3.86	5.61	4.23												
2	1 to 4	0	HP 6400	No	179.7	97.6	-1.41	-1.03	2.59	1.54												
3	1 5 9 13 17 21	0	Fixed	No	177.0	106.3	-3.26	-2.73	3.89	3.03	6.62	5.90	0.00	0.00								
4	1 5 9 13 17 21	0	HP 6400	No	182.0	107.2	-1.12	-1.05	2.39	1.53	2.98	2.46	0.01	0.04								
5	1 5 9 13 17 21	0 to 4	Fixed	No	161.3	102.2	-3.34	-2.75	3.91	3.02	6.59	6.18	0.00	0.00	3.11	1.28	0.02	0.28				
6	1 5 9 13 17 21	0 to 4	HP 6400	No	167.4	104.0	-1.19	-1.07	2.39	1.55	3.30	2.86	0.01	0.02	2.83	0.99	0.03	0.41				
7	1 5 9 13 17 21	0 to 4	HP 6400	Yes	48.2	47.1	-0.78	-0.83	1.24	1.17	6.52	6.57	0.00	0.00	2.70	3.04	0.03	0.02	15.25	7.07	0.00	0.00
8	1 5 9 13 17 21	0 to 4	TV	No	143.2	90.0	-0.63	-0.19	1.91	0.86	8.18	8.35	0.00	0.00	3.42	2.08	0.01	0.09				
9	1 5 9 13 17 21	0 to 4	TV	Yes	42.7	43.2	0.53	0.43	0.96	0.81	10.96	10.84	0.00	0.00	1.59	1.89	0.18	0.12	19.64	9.37	0.00	0.00

a) The mean error and root mean square error for the 1997:Q1-2013:Q1 dynamic simulations are based on coefficients for the 1962:Q1-1996:Q4 sample period

The most definitive results of all come in the rightmost four columns, which show that exclusion of the supply shock variables is rejected with uniform p values of 0.00. Those who have estimated PC equations in the past or plan to do so in the future should contemplate the F-test values of 19.6 for headline inflation and 9.4 for core inflation in line 9, with values almost as high in line 7 that uses the HP 6400 version of the NAIRU instead of the endogenously generated NAIRU.

REFERENCES

ASTRAYUDA, INDRA, BALL, LAURENCE, AND MAZUMDER, SANDEEP (2013). "Inflation Dynamics and the Great Recession: An Update," work in progress, February.

BALL, LAURENCE, AND MAZUMDER, SANDEEP (2011). "Inflation Dynamics and the Great Recession," *Brookings Papers on Economic Activity* (Spring), 337-381.

BÅRDSEN, GUNNAR, EILEV S. JANSEN, AND RAGNAR NYMOEN (2002). "Testing the New Keynesian Phillips Curve." Paper presented at Workshop on The Phillips Curve: New Theory and Evidence, Facföreningsrörelsens Institut För Ekonomisk Forskning (Trade Union Institute For Economic Research), Stockholm, May 25-26.

BLANCHARD, OLIVIER J. (2009). "The State of Macro," *Annual Review of Macroeconomics* 1, 209-28.

BLANCHARD, OLIVIER J., AND SUMMERS, LAWRENCE H. (1986). "Hysteresis and the European Unemployment Problem," in *NBER Macroeconomics Annual 1986* 1, 15-90.

BLANCHARD, OLIVIER J., AND GALÍ, JORDI (2010). "The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so Different from the 1970s? in Jordi Galí and Mark Gertler, eds., *International Dimensions of Monetary Policy.* Chicago: University of Chicago Press for NBER, 373-428.

BLANCHARD, OLIVIER J., AND RIGGI, MARIANNA (2009). "Why Are the 2000s So Different from the 1970s? A Structural Interpretation of Changes in the Macroeconomic Effects of Oil Prices," MIT Department of Economics Working Paper 09-27, October 27.

BLINDER, ALAN S. (1979). *Economic Policy and the Great Stagflation.* New York: Academic Press.

BLINDER, ALAN S. (1982). "The Anatomy of Double-Digit Inflation in the 1970s," in Robert E. Hall, ed., *Inflation: Causes and Effects.* Chicago: University of Chicago Press for NBER, 261-82.

BLINDER, ALAN S., AND RUDD, JEREMY B. (2013). "The Supply Shock Explanation of the Great Stagflation Revisited," in Michael D. Bordo and Athanasios Orphanides, eds., *The Great Inflation: The Rebirth of Modern Central Banking.* Chicago: University of Chicago Press for NBER, 119-178.

CALVO, GUILLERMO A. (1983). "Staggered Price in a Utility Maximizing Framework," *Journal of Monetary Economics*, 12, 383-98.

CROSS, ROD, ED. (1988). *Unemployment, Hysteresis, and the Natural Rate Hypothesis.* Oxford and New York: Basil Blackwell.

DALY, MARY, HOBIJN, BART, SAHIN, AYSEGUL, AND VALLETTA, ROB (2011). "A Rising Natural Rate of Unemployment: Transitory or Permanent?" Federal Reserve Bank of San Francisco, Working Paper 2011-05.

DEW-BECKER, IAN AND GORDON, ROBERT J. (2005). "Where Did the Productivity Growth Go? Inflation Dynamics and the Distribution of Income," *Brookings Papers on Economic Activity*, no. 2, 67-127.

ESTEVAO, MARCELLO, AND TSOUNTA, EVRIDIKI (2011). "Has the Great Recession Raised U.S. Sturcutural Unemployment?" IMF Working Paper 11/105, May.

FUHRER, JEFFREY C. (1997). "The (Un)Importance of Forward-Looking Behavior in Price Specifications," *Journal of Money, Credit, and Banking*, 29 (no. 3), 338-50.

GALÍ, JORDI AND GERTLER, MARK (1999). "Inflation Dynamics: A Structural Econometric Analysis," *Journal of Monetary Economics* 44, 195-222.

GALÍ, JORDI AND LOPEZ-SALIDO, DAVID (2005). "Robustness of Estimates of the Hybrid New Keynesian Phillips Curve, *Journal of Monetary Economics* 52, 1107-18.

GORDON, ROBERT J. (1975). "Alternative Responses of Policy to External Supply Shocks," *Brookings Papers on Economic Activity*, no. 1, 183-206.

GORDON, ROBERT J. (1977). "Can the Inflation of the 1970s Be Explained?" *Brookings Papers on Economic Activity*, no. 1, 253-77.

GORDON, ROBERT J. (1982a) "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment." In Martin N. Baily, ed., *Workers, Jobs, and Inflation*, Washington: Brookings, 88-152.

GORDON, ROBERT J. (1982b) "Price Inertia and Policy Ineffectiveness in the United States, 1890-1980," *Journal of Political Economy* 90 (December), 1087-1110.

GORDON, ROBERT J. (1984). "Supply Shocks and Monetary Policy Revisited." *American Economic Review Papers and Proceedings* 74 (May, no. 2), 38-43.

GORDON, ROBERT J. (1997). "The Time-Varying NAIRU and its Implications for Economic Policy." *Journal of Economic Perspectives,* 11 (Winter), 11-32.

GORDON, ROBERT J. (2007). "Phillips Curve Specification and the Decline in U. S. Output and Inflation Volatility." Paper presented at Symposium on the Phillips Curve and the Natural Rate of Unemployment, Institut fur Weltwirtschaft, Kiel Germany, June 4.

GORDON, ROBERT J. (2011). "The History of the Phillips Curve: Consensus and Bifurcation," *Economica* 78 (no. 1), 10-50.

GORDON, ROBERT J. AND KING, STEPHEN R. (1982). "The Output Cost of Disinflation in Traditional and Vector Autoregressive Models," *Brookings Papers on Economic Activity*, no. 1, 205-42.

KATZ, LAWRENCE F., AND KRUEGER, ALAN B. (1999). "The High-pressure U. S. Labor Market of the 1990s." *Brookings Papers on Economic Activity* (Spring), 1-65.

KOHN, DONALD L. (2005). "Inflation Modeling: A Policymaker's Perspective," speech given at Quantitative Evidence on Price Determination Conference, Washington, D.C., September 29.

LAZEAR, EDWARD P., AND SPLETZER, JAMES R. (2012). "The United State's Labor Market: Status Quo or a New Normal?" NBER Working Paper 18386, September.

MANKIW, N. GREGORY (2001). "The Inexorable and Mysterious Tradeoff between Inflation and Unemployment," *Economic Journal*, 111 (May), 45-61.

PHELPS, EDMUND S. (1978). "Commodity-supply Shock and Full-Employment Monetary Policy," *Journal of Money, Credit, and Banking* 10, 206-21.

ROBERTS, JOHN M. (2006). "Monetary Policy and Inflation Dynamics," *International Journal of Central Banking* 2 (September), 193-230.

ROMER, CHRISTINA (1999). "Why Did Prices Rise in the 1930s?" *Journal of Economic History* 59 (March), 167-199.

ROTHSTEIN, JESSE (2012). "The Labor Market Four Years Into the Crisis: Assessing Structural Explanations". NBER Working Paper 17966, March.

SAMUELSON, PAUL A. AND SOLOW, ROBERT M. (1960). "Analytical Aspects of Anti-inflation Policy." *American Economic Review Papers and Proceedings* 50 (May, no. 2), 177-94.

STAIGER, DOUGLAS, STOCK, JAMES H., AND WATSON, MARK W. (1997). "The NAIRU, Unemployment, and Monetary Policy," *Journal of Economic Perspectives* 11 (Winter), 33-49.

_____ (2001). "Prices, Wages, and the U. S. NAIRU in the 1990s," in Alan B. Krueger and Robert M Solow, eds., *The Roaring Nineties: Can Full Employment Be Sustained?* New York: The Russell Sage Foundation and the Century Foundation Press, 3-60.

STOCK, JAMES H. (2011). "Comment" on Ball-Mazumder (2011), *Brookings Papers on Economic Activity* (Spring), 387-402.

STOCK, JAMES H., AND WATSON, MARK W. (2010). "Modeling Inflation After the Crisis," in *Macroeconomic Challenges: The Decade Ahead.* Federal Reserve Bank of Kansas City, 173-220.

WILLIAMS, JOHN C. (2006). "The Phillips Curve in an Era of Well-Anchored Inflation Expectations," unpublished working paper, Federal Reserve Bank of San Francisco, September.

WILLIAMS, JOHN C. (2010). "Sailing into Headwinds. The Uncertain Outlook for the U.S. Economy." Presentation to a Joint Meeting of the San Francisco and Salt Lake City Branch Boards of Directors, Salt Lake City, Utah.