Hysteresis and the European Unemployment Problem Revisited*

Jordi Galí
CREI, Universitat Pompeu Fabra, and Barcelona GSE

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Abstract

The unemployment rate in the euro area displays a significant nonstationary component, suggesting that some shocks have permanent effects on that variable. I explore possible sources of this nonstationarity through the lens of a New Keynesian model, and assess their empirical relevance.

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*Correspondence: CREI, Ramon Trias Fargas 25; 08005 Barcelona (Spain). E-mail: jgali@crei.cat. Prepared for the *ECB Forum on Central Banking*, to be held at Sintra, 21-23 May, 2015. I thank Cristina Manea for excellent research assistance, and Samuel Skoda for help with euro area data. I am grateful for comments and suggestions to an anonymous referee, Davide Debortoli, Athanasios Orphanides, and seminar participants at CREI-UPF.

1 Introduction

The existence of significant differences in the behavior of U.S. and European unemployment has been long recognized, at least since Blanchard and Summer's influential *hysteresis* paper.[1] Such differences are apparent in Figure 1, which displays quarterly time series for the unemployment rate in those two economies, spanning the period 1970Q1-2014Q4, and with the (current) euro area taken to represent Europe (here and throughout the paper). The U.S. unemployment rate shows substantial cyclical volatility, but with a clear tendency to revert back to some (nearly constant) resting point. By contrast, the unemployment rate in the euro area wanders about a (seemingly) upward trend, showing variations that are both smoother and more persistent than its U.S. counterpart. Each recession episode appears to pull the euro area unemployment rate towards a new, higher plateau, from which it eventually drifts away as the economy recovers, but without any apparent tendency to gravitate towards some constant long-run equilibrium value.

In the language of time series analysis, the behavior of the U.S. unemployment rate seems consistent with a *stationary* stochastic process, while in the euro area the same variable displays fluctuations characteristic of a stochastic process with a *unit root*, i.e. a nonstationary process with a random walk-like permanent component.

In the present paper I take seriously the hypothesis of a unit root in euro area unemployment, explore some of its possible causes, and discuss some of its implications.[2]

[1] Blanchard and Summers (1986). See Ball (2008) for a recent analysis of potential hysteresis in unemployment in a large number of OECD countries.

[2] See below for some caveats on a literal interpretation of the unit root property in the

The presence of a unit root in the unemployment rate implies the existence of at least one type of economic disturbance that has a permanent effect on that variable. In the analysis below I seek to uncover *possible sources of that unit root*, and assess their *empirical plausibility*, using as a reference framework a New Keynesian model with unemployment, as developed in Galí (2011a,b) and Galí, Smets and Wouters (2012).

Below I put forward three (non mutually exclusive) hypotheses on the source of the unit root in unemployment, which I refer to as the *natural rate hypothesis*, the *long-run tradeoff hypothesis* and the *hysteresis hypothesis*. The analysis in the paper suggests that none of the three hypothesis can, by itself, account for the evidence on unemployment and wage inflation for the period 1970-2014, though both the long run tradeoff hypothesis and the hysteresis hypothesis appear useful to interpret some episodes (not so much the natural rate hypothesis). In particular, the long run tradeoff hypothesis could in principle account for the secular rise in unemployment in the 1970s and 1980s as a consequence of the disinflation experienced over that period, though the large decline in the unemployment rate is hard to rationalize. The hysteresis hypothesis, on the other hand, can potentially account for the remarkable stability of wage inflation over the post-1994, despite the persistently nonstationary movements in the unemployment rate.

From a modelling point of view, the present paper can be seen as suggesting alternative approaches to allow for a nonstationary unemployment in a standard macro model. That analysis may prove useful in efforts to incorporate unemployment in DSGE models for the euro area.

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unemployment rate.

The paper is organized as follows. Section 2 contains a first pass at the data, focusing on the seemingly nonstationary behavior of the euro area unemployment rate and its comovement with wage inflation. Section 3 sketches the main elements of the New Keynesian model. Section 4 discusses the three possible sources of a unit root in the unemployment rate through the lens of that model, and discusses their relative empirical relevance in accounting for the euro area evidence. Section 5 summarizes and concludes with a brief discussion of the policy implications.

2 Unemployment and Wages in the Euro Area: A First Look at the Data

2.1 The Unit Root Hypothesis

As discussed in the introduction, even a casual glance at a plot of the unemployment rate in the euro area and the U.S. reveals substantial differences in the behavior of that variable between the two economies (see Figure 1). In particular, the unemployment rate in the U.S. appears to behave like a mean reverting variable, while its euro area counterpart displays a random walk-like pattern.

That visual assessment is confirmed by formal statistical tests. As reported in Table 1, an Augmented Dickey-Fuller test of the null of a unit root (against the alternative of a stationary autoregressive process) cannot be rejected for the euro area unemployment rate at conventional significance levels. The opposite result obtains for the U.S., where the null of a unit root is rejected at a 5 percent significance level.

The different persistence properties of the two variables is also reflected in their estimated autocorrelations, displayed in Figure 2. The one for the U.S. unemployment rate declines rapidly as the lag order increases, whereas the corresponding autocorrelation for the euro area remains close to unity even at relatively high lags, showing the very slow decline characteristic of unit root processes.

The previous characterization has potentially dramatic consequences on the long run unemployment gap between the U.S. and the euro area. To illustrate this point, I simulate an out-of-sample path for those variables using two parsimonious statistical models that fit their behavior surprisingly well. In particular, for the U.S. unemployment rate I use the $AR(2)$ process

$$u_t^{US} = \underset{(0.08)}{0.26} + \underset{(0.05)}{1.63} u_{t-1}^{US} - \underset{(0.05)}{0.68} u_{t-2}^{US} + \varepsilon_t^{US}$$

with an estimated standard deviation for the residual of 0.25.

For the euro area, the following $AR(1)$ model for the *first-difference* of the unemployment rate seems to fit the data well

$$\Delta u_t^{EA} = \underset{(0.04)}{0.80} \Delta u_{t-1}^{EA} + \varepsilon_t^{EA} \tag{1}$$

with a residual standard deviation of 0.11.

Figure 3a shows the simulated paths for the unemployment rate in the euro area and the U.S. for the out-of-sample period 2015-2050, as generated by the statistical models above given observed initial conditions at the end of 2014. Figure 3b shows an alternative simulation "draw" of the path for euro area unemployment based on the same model, while keeping the U.S. one unchanged. Note that in the simulation shown in Figure 3a, the euro area unemployment rate drifts gradually away from its U.S. counterpart, hovering about a 15 percent plateau at the end of the simulation period, while in the U.S. it fluctuates around a value of about 5 percent, as it has done over the past decades. In the simulation shown in Figure 3b, by contrast, the unemployment rate in the euro area starts declining rapidly at the end of the present decade, crossing paths with its U.S. counterpart, and (seemingly) converging towards the low values last seen in the early 1970s. The Figures illustrate a key difference in the properties of the two models: while the fluctuations in the U.S. unemployment rate remain (statistically) bounded around an unchanged mean, in the euro area *the uncertainty about the future values of that variable increases with the horizon*, a property characteristic of unit root processes.

A first caveat must be raised at this point: a unit root process like (1) cannot describe the behavior of the unemployment rate unconditionally, given that by definition that variable is bounded between 0 and 100 and nothing prevents model (1) to generate unemployment paths that eventually violate those bounds, as illustrated by Figure 3c. Thus, a stochastic process with a unit root like (1) should only be taken as a (local) *approximation* to the behavior of unemployment in the euro area during a particular sample period. In other words, one should not interpret (1) as a data generating mechanism that will remain valid independently of the evolution of the unemployment rate.

A second caveat has to do with the power of unit root tests. Whether or not it is possible to uncover a unit root using a finite number of observations spanning a limited period has been the subject of long controversies in the literature.[3] I do not plan to contribute to that debate. Instead, in the remainder of the paper, I take seriously (i.e. as a fact) the presence of a unit root in the euro area unemployment rate in a sense that I find both meaningful and highly plausible, namely, that some shocks may have a permanent effect on that variable. With that premise in mind, I explore the possible sources for that unit root and some of its implications.

2.2 Unemployment and Wages: Some Reduced Form Evidence

A central element in the analysis of Blanchard and Summers (1986) was the hypothesis that the high persistence of unemployment in Europe may be due to the nature of its wage setting institutions and the impact of the latter on the sensitivity of wages to unemployment. In particular, one may consider the hypothesis that wages are *insufficiently* responsive to unemployment as a possible explanation for the high persistence of unemployment fluctuations in the euro area. Understanding the relation between wages and unemployment thus seems a good first step in the quest for an explanation for the unit root behavior in unemployment. The model in section 3 below also provides a justification for focusing on those variables.

Next I present some basic evidence on the joint comovement between wage inflation and the unemployment in the euro area, in the form of pictures and simple regression estimates. That evidence will lay the ground for some of the analysis and discussion in subsequent sections.

Figures 4 and 5 provide two perspectives on the evolution of the unem-

[3] See, e.g., Cochrane (1991), Christiano and Eichenbaum (1990).

ployment rate and wage inflation in the euro area.[4] Figure 4 plots those two variables against time, while Figure 5 displays them against each other on a scatterplot. That graphical evidence is supplemented with OLS estimates of the *reduced form* Phillips curve equation.

$$\pi_t^w = \alpha_0 + \alpha_\pi \pi_{t-1}^p + \alpha_u u_t + \varepsilon_t$$

which are reported in Table 2, where π_t^w is (quarter-to-quarter) wage inflation, u_t is the unemployment rate and π_{t-1}^p denotes average price inflation over the past four quarters. The presence of the latter variable is meant to capture the effects on wages of possible indexation to past inflation.[5] All data are drawn from the ECB's *Area Wide Model* (AWM) data set, which I update through the end of 2014.[6]

A number of observations stand out, which I summarize in the form of bullet points.

- As shown in Figure 4, wage inflation shows a marked downward trend over the period 1970-1992. The decline in wage inflation coexists with a substantial rise in the unemployment rate. Wage inflation appears to stabilize after 1993, hovering about a (seemingly constant) mean of about 2.2 percent, in annual terms. The unemployment rate, however, persists in its seemingly nonstationary behavior. The two variables, thus, appear to have decoupled.

[4] Year-on-year wage inflation is shown in the Figure, for smoothing purposes. Regression estimates are based on quarter-on-quarter wage inflation.

[5] See Blanchard and Katz (1999) and Galí (2011b) for estimates of a similar specification using U.S. data.

[6] See Fagan, Henry and Mestre (2001). The wage refers to compensation per worker. The inflation variable corresponds to the average growth rate in the harmonized index of consumer prices (HICP) over the past four quarters.

- The previous impression is verified by some formal tests. Thus, an ADF test cannot reject the null of a unit root in wage inflation for the full sample period as well as for the 1970Q1-1992Q4 period. However, it is rejected for the post-1992 period. This contrasts with the results of an analogous test applied to the unemployment rate, for which a unit root cannot be rejected in both subsample periods. The previous findings are consistent with the idea of a near-decoupling between wage inflation (which appears well anchored) and the unemployment rate (that keeps behaving in a random walk-like manner). Furthermore, A Phillips-Ouliaris test rejects the null of no cointegration between wage inflation and the unemployment rate (with and without price inflation) for the full sample period, as well as for the 1970Q1-1993Q4 period. Thus the marked (stochastic) trends in wage inflation and the unemployment rate observed in the data before 1993 seem to be related.

- The previous observations are clearly reflected in the wage Phillips curve displayed in Figure 5a, which shows a marked negative slope in the first part of the sample, but appears to flatten out almost completely after 1993. Figure 5b zooms in on the post-1993 subsample period, revealing the persistence of a seemingly inverse relation between the two variables, but one that, if present, is much weaker than in the pre-1993 period.

- The estimates of the reduced form wage equation, shown in Table 2, capture well some of the previous observations. For the overall 1970-2014 period they point a strong inverse relation between that variable and the unemployment rate. That relation is highly significant, statistically and economically.[7] After 1992, however, the sensitivity to unemployment drops considerably, though the relation remains statistically significant. Finally, note that there is evidence of partial indexation to lagged inflation in the first part of the sample period, but not after 1994.

- The economic significance of the changes in the estimated coefficients is illustrated in Figure 5c, which displays a counterfactual path for wage inflation using estimates from the sample up to 1993, and conditional on the actual path of unemployment and price inflation.

Below I use the previous evidence to assess some of the hypotheses on the sources of the unit root in euro area unemployment.

3 A New Keynesian Model with Unemployment

In the present section I sketch the main elements of the model I use to understand the possible sources of a unit root in the unemployment rate. The model is an extension of the standard New Keynesian (NK) model allowing for unemployment. Details of the model and derivations are relegated to the technical appendix.

The main difference with respect to the standard NK model lies in the use of a formulation of the household problem which allows for an explicit

[7] The presence of unit root in both wage inflation and the unemployment rate should make us view with caution the estimated standard errors, however.

definition of unemployment, as well as a notion of its natural rate. That formulation of the labor market was originally introduced in Galí (2011a,b) and further developed in Galí, Smets and Wouters (2012). From a modelling point of view, the main novelty here is the consideration of a wage setting framework inspired by the insider-outsider models of Lindbeck and Snower (1988) and Blanchard and Summers (1986), as an alternative to the wage setting model generally assumed in the literature.

3.1 Unemployment and the Wage Markup

A key ingredient of the model is the (log) reservation nominal wage $\underline{w}_t$ of the marginal worker employed (averaged across labor types or occupations), which is assumed to be given (in logs) by

$$\underline{w}_t = p_t + c_t + \varphi n_t + \xi$$

where p_t is the (log) price level, c_t is (log) consumption, n_t is (log) employment, and ξ is an exogenous labor supply shifter. The model described in the appendix provides microfoundations for that assumption, based on the optimizing behavior of a representative household.

A second ingredient is the (log) labor force, l_t, which is implicitly determined by

$$w_t = p_t + c_t + \varphi l_t + \xi \tag{2}$$

and which can be interpreted as the measure of individuals whose reservation wage is no higher than the current average wage, given the price level and consumption. By definition, those individuals will choose to participate in the labor market–and hence make up the labor force– though only a subset n_t of them will be employed.

A third key element of the model is the average wage markup, $\mu_{w,t}$, which is defined as the gap between the average (log) nominal wage and the (log) reservation wage of the average marginal worker:

$$\mu_{w,t} \equiv w_t - \underline{w}_t$$

Finally, the unemployment rate is defined as the (log) difference between the labor force and employment:

$$u_t \equiv l_t - n_t$$

Combining the previous equations one can derive a simple relation between the unemployment rate and the average wage markup, namely

$$\mu_{w,t} = \varphi u_t \tag{3}$$

Figure 6 represents graphically the relationship between the average wage markup and the unemployment rate, using a conventional labor market diagram. The labor supply is given by the participation equation (2). The unemployment rate corresponds to the horizontal gap between the labor supply and labor demand schedules, at the level of the prevailing average real wage. The wage markup $\mu_{w,t}$, on the other hand, is represented in the figure by the gap between the wage and the reservation wage (both expressed in real terms now), at the level of current employment n_t. Given the assumed linearity, the ratio between the two gaps is constant and given by φ, the slope of the labor supply schedule, as implied by (**??**).

Both the unemployment rate and the average wage markup are endogenous variables. Their determination is influenced by the wage setting framework in place, among other factors. Next I describe two alternative wage setting assumptions and discuss their consequences for the dynamics of wage inflation. The first assumption, based on the existence of an exogenous desired (or natural) wage markup, is the one generally adopted in existing formulations of the NK framework. The second assumption consists of an adaptation to the NK framework of a wage setting setup analyzed in Blanchard and Summers (1986).

Both wage setting assumptions are embedded in the Calvo-style model of staggered wage setting originally proposed in Erceg, Henderson and Levin (2001) and generally adopted by the literature due to its tractability. In that model only a constant fraction of worker-types (or the unions representing them), drawn randomly from the population, are able to reset their nominal wage in any given period. Under that assumption the evolution of the average (log) nominal wage is described by the difference equation

$$w_t = \theta_w w_{t-1} + (1 - \theta_w) w_t^* \tag{4}$$

where θ_w is the fraction of worker-types that keep their wage unchanged, and w_t^* is the newly set wage in period t. The fact that the wage remains unchanged for several periods makes the implied optimal wage setting decision to be forward-looking. In particular, when setting the wage w_t^*, unions take into account the current and future demand for their work services, which is given by:

$$n_{t+k|t} = -\epsilon_{w,t+k}(w_t^* - w_{t+k}) + n_{t+k} \tag{5}$$

for $k = 1, 2, 3, ...$where $n_{t+k|t}$ denotes period $t + k$ demand for labor whose wage has been reset for the last time in period t, and where $\epsilon_{w,t+k} > 1$ is the (possibly stochastic) wage elasticity of labor demand effective in that period.

3.1.1 The Case of an Exogenous Natural Wage Markup

This is the standard case considered in the literature. When resetting the wage, each union seeks to maximize the utility of the representative household, to which all union members (employed or unemployed) belong. This gives rise to a (log-linearized) wage setting rule of the form:

$$w_t^* = (1 - \beta\theta_w) \sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ \mu_{w,t+k}^n + \underline{w}_{t+k|t} \right\} \tag{6}$$

where $\underline{w}_{t+k|t} \equiv c_{t+k} + \varphi n_{t+k|t} + \xi$ is the relevant reservation wage in $t+k$ for a union that has reset its wage for the last time in period t, and $\mu_{w,t}^n \equiv \log \frac{\epsilon_{w,t}}{\epsilon_{w,t}-1}$ is the *natural* wage markup in period t, i.e. the wage markup that any union (acting independently) would choose in that period if wages were fully flexible, given a labor demand schedule with an exogenous, time-varying wage elasticity $\epsilon_{w,t}$.

A particular case of the model above, found in numerous examples in the literature, corresponds to that of a constant natural wage markup, i.e. $\mu_{w,t}^n = \mu_w^n$ for all t.[8] In the estimated DSGE model of Smets and Wouters (2003, 2007), on the other hand, $\mu_{w,t}^n$ is allowed to follow a stationary $AR(1)$ process, and shown to be an important source of fluctuations of key macro variables at business cycle frequencies.

Combining (4) and (6) (after some algebra) yields the wage inflation equation:

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} - \lambda_w(\mu_{w,t} - \mu_{w,t}^n) \tag{7}$$

where $\pi_t^w \equiv w_t - w_{t-1}$ and $\lambda_w \equiv \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$. The previous equation can in turn be combined with (3) to obtain the New Keynesian Wage Phillips

[8] See, e.g. Erceg, Henderson and Levin (2001).

Curve (NKPC):

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} - \lambda_w \varphi(u_t - u_t^n) \tag{8}$$

where

$$u_t^n \equiv \frac{\mu_{w,t}^n}{\varphi} \tag{9}$$

can be thought of as a *natural* rate of unemployment, defined as the rate of unemployment that would prevail in period t if wages were fully flexible (and, hence, the wage markup was given by $\mu_{w,t}^n$).[9]

3.1.2 An Insider-Outsider Model of Wage-Setting

In their seminal 1986 paper, Blanchard and Summers propose a theory of unemployment that emphasizes membership considerations in wage setting as an explanation for the high persistence in European unemployment. The basic assumption underlying their theory, closely related to the insider-outsider models of Lindbeck-Snower and others,[10] is described in the words of Blanchard and Summers as follows:

> "...there is a fundamental asymmetry in the wage-setting process between insiders who are employed and outsiders who want jobs. Outsiders are disenfranchised and wages are set with a view to ensuring the jobs of insiders. Shocks that lead to reduced employment change the number of insiders and thereby change the subsequent equilibrium wage rate, given rise to hysteresis..."

[9] In contrast with the original Phillips curve (Phillips (1958)), which involved a static empirical relation between wage inflation and unemployment, (8) is a forward looking relation derived from first principles, with coefficients that are a function of structural parameters. In Galí (2011), I showed how an extension of (8) allowing for wage indexation to past price inflation and assuming a constant natural rate fits postwar U.S. data surprisingly well.

[10] See Lindbeck and Snower (1988) for a survey of those models.

Here I use a version of the Blanchard-Summers model consistent with the Calvo wage setting formalism, and hence one that can be readily embedded in the New Keynesian model.[11] I assume that unions resetting the wage in period t choose the latter so that, in expectation, average employment (over the duration of the wage) of the labor type they represent equates the union's current membership, which in turn is assumed to correspond to employment at the end of the previous period. Formally, the wage $w_t^*(j)$ for a labor type j that can readjust its wage in period t is set so that the following condition is satisfied:

$$(1-\beta\theta_w)\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left\{n_{t+k}(j)\right\} = n_{t-1}(j)$$

As shown in the Appendix the previous assumption, combined with the sequence of labor demand schedules

$$n_{t+k}(j) = -\epsilon_w(w_t^* - w_{t+k}) + n_{t+k}$$

for $k = 0, 1, 2, ...$implies that the average newly set wage, w_t^*, will be given by:

$$w_t^* = -\frac{1}{\epsilon_w}n_{t-1} + (1-\beta\theta_w)\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left\{w_{t+k} + \frac{1}{\epsilon_w}n_{t+k}\right\} \qquad (10)$$

where, for simplicity, I now assume a constant wage elasticity of labor demand, ϵ_w. Thus the newly set wage is increasing in current and expected future average wage and aggregate employment, for higher values of those variables raise the current and expected future demand for the labor provided by the workers/unions currently setting the wage. On the other hand, a high level of employment in the previous period calls for the need to moderate wages in order to preserve the employment status of unions' members.

[11] See Galí (2015b) for a detailed derivation and analysis of its implications.

Combining (10) with (4) yields, after some algebra, a modified version of the New Keynesian Wage Phillips curve:

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} + \lambda_n \Delta n_t \tag{11}$$

where $\lambda_n \equiv \frac{1-\theta_w}{\theta_w \epsilon_w}$.

Note that wage inflation no longer depends on the gap between the unemployment rate and its natural counterpart, but on the *change* in (log) employment. As shown below, that feature, when embedded in the full-fledged New Keynesian model generates a unit root in both employment and the unemployment rate.

Note that under the assumed wage setting arrangement, the relation between the average wage markup and the unemployment rate (3) is still valid. The wage markup (together with unemployment) evolves endogenously in response to any shock, above and beyond the fluctuations associated with wage stickiness. With some abuse of language, I define the natural rate of unemployment as the one that would prevail in the absence of nominal wage rigidities *and* membership effects. In that case, that natural rate is constant and given by

$$u^n \equiv \frac{1}{\varphi} \log \frac{\epsilon_w}{\epsilon_w - 1}$$

3.2 Closing the Model

The remaining blocks of the model are standard. Their formal description, as well as the derivation of the relevant equilibrium conditions, can be found in Galí (2015, chapter 6). I assume the existence of a continuum of differentiate goods, each produced by a monopolistic competitor, with a production function:

$$Y_t(i) = A_t N_t(i)^{1-\alpha} \tag{12}$$

where $Y_t(i)$ denotes the output of good i, A_t is an exogenous technology parameter common to all firms, and $N_t(i)$ is a CES function of the quantities of the different types of labor services employed by firm i, whose elasticity of substitution is given by $\epsilon_{w,t}$. Cost minimization by firms gives rise to the labor demand schedule (5) introduced above.

Price-setting is staggered à la Calvo, with a constant fraction θ_p of firms that keep prices unchanged. Aggregation of price-setting decisions, gives rise to a New Keynesian Phillips curve of the form

$$\pi_t^p = \beta E_t\{\pi_{t+1}^p\} + \varkappa_p \widetilde{y}_t + \lambda_p \widetilde{\omega}_t$$

where $\widetilde{y}_t \equiv y_t - y_t^n$ and $\widetilde{\omega}_t \equiv \omega_t - \omega_t^n$ denote the output and wage gaps, with the natural output and natural wage, y_t^n and ω_t^n, defined as the values of the respective variables that would prevail in equilibrium if prices and wages were flexible *and* unions had a constant desired wage markup $\mu_w^n \equiv \log \frac{\epsilon_w}{\epsilon_w - 1}$.

Equilibrium in the goods market, together with the household's intertemporal optimality condition gives rise to a version of the so called dynamic IS equation:

$$\widetilde{y}_t = E_t\{\widetilde{y}_{t+1}\} - (i_t - E_t\{\pi_{t+1}^p\} - r_t^n) \tag{13}$$

where the natural interest rate r_t^n is defined as the real rate prevailing in an equilibrium with flexible wages *and* flexible prices. Like the natural output and the natural wage, is a function of the exogenous real shocks.

Finally, monetary policy needs to be specified. I assume an interest rate rule of the form:

$$\widehat{i}_t = \phi_i \widehat{i}_{t-1} + (1-\phi_i)[\phi_\pi(\pi_t^p - \pi_t^*) + \phi_y \Delta y_t]$$

where $\widehat{i}_t \equiv i_t - (\rho + \pi_t^*)$ and π_t^* is the price inflation target, which is assumed to follow an exogenous process.[12]

The impulse responses and simulations reported above are based on a (rather conventional) calibration of the model's parameter values, which for the most part follows that in Galí (2015a). A brief description of that calibration can be found in the Appendix.

4 Interpreting the Unit Root in Unemployment Through the Lens of the New Keynesian Model

Next I examine the possible sources of a unit root in the unemployment rate through the lens of the New Keynesian model described above. In a nutshell, there are three possible sources of a unit root in unemployment consistent with the model above:

- A unit root in the exogenous natural wage markup $\mu_{w,t}^n$. Given (9), that assumption implies a unit root in the natural rate of unemployment u_t^n and, as a result, in the unemployment rate itself, since deviations of the latter from its natural rate counterpart are stationary. Below I refer to this possibility as the *natural rate hypothesis*.

[12] Of course, during the post-1999 period π_t^* should probably be modeled as a constant, in a way consistent with Smets (2010).

- A unit root in the central bank's inflation target π_t^*. Ceteris paribus, a permanent change in that target eventually leads to a commensurate change in price and wage inflation, as well as in the unemployment rate, given the existence of a long run tradeoff, as implied by (8). I label that potential explanation for the unit root in unemployment the *long run tradeoff hypothesis*.

- The presence of wage setting rules motivated by the desire to maximize insiders' wages, while preserving their current employed status, as in the Blanchard-Summers' model of hysteresis. The unit root in unemployment emerges in this case independently of the nature and properties of the exogenous driving forces, even if the latter consist of transitory demand shocks. Following Blanchard and Summers, I refer to this potential source of the unit root in unemployment as the *hysteresis hypothesis*.

Note that the first two hypothesis are associated with a wage setting model with an exogenous natural wage markup, while the third one is a distinct feature of the insider-outsider model of wage setting. From a different perspective, and if we consider the decomposition

$$u_t = u_t^n + (u_t - u_t^n)$$

we see that under the first hypothesis the unemployment rate inherits the unit root in the natural rate u_t^n, while the unemployment gap remains stationary. By contrast, under the second and third hypotheses, the unit root in unemployment is associated with an identical property for the unemployment gap $u_t - u_t^n$, while the natural rate remains constant (or stationary).

Next I discuss each of the hypotheses, illustrate them by means of some simulations, and discuss their consistency with the empirical evidence.

4.1 The Natural Rate Hypothesis

Under the natural rate hypothesis, the wage setting framework is assumed to involve an exogenous, time-varying natural wage markup $\{\mu_{w,t}^n\}$. Fluctuations in the latter reflect variations in workers' bargaining power, and drive the variations over time in the natural rate of unemployment, which is given by

$$u_t^n \equiv \frac{\mu_{w,t}^n}{\varphi}$$

In that environment, and given a constant inflation target, the model's equilibrium implies a stationary unemployment *gap,* $u_t - u_t^n$, independently of the source(s) of economic fluctuations and their persistence. Accordingly, the unemployment rate will display a unit root if and only if the natural wage markup, $\mu_{w,t}^n$, and, hence, the natural rate of unemployment u_t^n, have a unit root themselves.

Note that if we take the model at face value, any permanent change in the natural wage markup must result from a corresponding change (of opposite sign) in the wage elasticity of labor demand $\epsilon_{w,t}$. More generally, it seems reasonable that any exogenous factors of a structural or institutional nature that imply a permanent change in the bargaining power of wage setters would have a similar effect (e.g. a change in firing costs, unemployment benefits, or in the composition of the labor force).

Variations in the natural unemployment rate of this sort are presumably the ones that authors like Gordon (1997) or Staiger, Stock and Watson (1997) have sought to uncover in their efforts to estimate the NAIRU and its changes over time.

Next I analyze the model's predictions regarding the effects of shocks to the natural wage markup under the assumption of a random walk process for that variable (and, hence, for the natural rate of unemployment):

$$\mu_{w,t}^{n} = \mu_{w,t-1}^{n} + \varepsilon_t^w$$

I calibrate the standard deviation of ε_t^w so that the standard deviation of the innovations in the long run component of unemployment generated by the model matches its empirical counterpart. I estimate the latter using a multivariate Beveridge-Nelson decomposition, with the unemployment rate, price inflation, and wage inflation included in the information set. The resulting estimate is 0.45 percent, which given (9) and a baseline setting $\varphi = 5$ implies a standard deviation for ε_t^w of 2.25 percent.[13]

Figure 7 displays the dynamic responses to a one standard deviation (positive) innovation in the natural wage markup based on a calibrated version of the New Keynesian model described above. In response to that shock the unemployment rate raises on impact, and then keeps increasing until it reaches a new permanently higher plateau, close to half a percentage point above its initial level. The response of output is, qualitatively, the mirror image to the unemployment response. Wage and price inflation (reported in annualized terms, here and in all subsequent figures) also increase in response to that shock, but their variation seems rather small.[14] Most importantly, however,

[13]Note that the stationarity of the unemployment gap, combined with equation (20) implies that $\sigma(\varepsilon_t^w) = \varphi\sigma(u_t^{BN})$. Given the baseline setting $\varphi = 5$, it follows that $\sigma(\varepsilon_t^w) = 5(0.0048) = 0.024$.

[14]Note that the reason why wage inflation increases is that the unemployment rate does

note that both inflation rates covary positively with the unemployment rate.

4.1.1 Empirical Assessment

To what extent can the unit root in euro are unemployment be viewed as the result of exogenous permanent changes in the natural rate? It should be clear that a proper answer to that question should be based on the analysis of an estimated model with a richer specification to the one considered here. That analysis is beyond the scope of the present paper. Yet, a first assessment can be made by contrasting with the data some of the predictions of the above framework under the null hypothesis that the unit root in unemployment is caused by a unit root in its natural rate.

A number of empirical observations appear to be in conflict with that hypothesis. I'll discuss them in turn.

Note first that under the maintained assumption of a random walk process for the natural wage markup, the hypothesis of an exogenous natural rate implies that we can recover the latter as the "permanent" component in a Beveridge-Nelson decomposition of the unemployment rate, while the unemployment gap will correspond to the "transitory" component of the same decomposition. Under the null examined here, that correspondence holds independently of the exact specification and calibration of any other aspect of the model, including the sources of fluctuations.

Figure 8 displays the natural rate of unemployment and the unemployment gap, constructed as described above, together with the actual unem-

not increase as much as its natural counterpart in the wake of a shock to the latter. In other words, the average wage markup remains persistently below its desired counterpart, leading workers/unions adjusting their wages to raise the latter, thus generating the observed positive response of wage inflation.

ployment rate, all in the same scale. The shaded areas correspond to the CEPR-dated euro area recessions. Note that the amplitude of the fluctuations in the unemployment gap appears quite small relative to the unemployment rate itself. Furthermore, and most importantly, none of the substantial increases experienced by the unemployment rate during the recession episodes seem to be driven by increases in the unemployment gap. In fact, the latter appears to go down during many of the recession episodes. Instead, the bulk of unemployment fluctuations is attributed to exogenous changes in the natural rate itself, with no other disturbances playing a significant role. Such an interpretation of unemployment fluctuations seems to be clearly at odds with conventional accounts of European business cycle episodes.

The empirical relevance of the natural rate hypothesis can also be assessed by comparing its prediction regarding the evolution of wage inflation with actual wage inflation. Note that (8) can be solved forward to yield:

$$\pi_t^w = -\lambda_w \varphi \sum_{k=0}^{\infty} \beta^k E_t\{\widetilde{u}_{t+k}\}$$

where $\widetilde{u}_t \equiv u_t - u_t^n$ is the unemployment gap, obtained as the cyclical component in the Beveridge-Nelson decomposition of $\{u_t\}$, as discussed above. Given that $\{\widetilde{u}_t\}$ is clearly stationary throughout the sample period, it is clear that the previous model has no chance of accounting for the nonstationary behavior of wage inflation in the pre-1994 period. In order to give the model a better chance, and given the evidence reported in section 2, I use a version of (8) that allows for indexation and which implies:[15]

$$\pi_t^w = \gamma \pi_{t-1}^p + (1-\gamma)\pi^* - \lambda_w \varphi \sum_{k=0}^{\infty} \beta^k E_t\{\widetilde{u}_{t+k}\}$$

[15] See Galí (2011b) for a derivation and further discussion.

where $\gamma \in [0,1]$ denotes the weight given to lagged price inflation in the indexation mechanism.

In order to estimate the discounted sum $\sum_{k=0}^{\infty} \beta^k E_t\{\widetilde{u}_{t+k}\}$ I follow the approach in Campbell and Shiller (1987) and use a VAR for $\mathbf{x}_t \equiv [\widetilde{u}_t, \pi_t^w - (\gamma \pi_{t-1}^p + (1-\gamma)\pi^*)]$, given a calibration for γ.[16]

Figure 9a displays actual and predicted wage inflation for the full sample period, and under the assumption of full wage indexation ($\gamma = 1$). Predicted wage inflation tracks actual wage inflation reasonably well, especially over the medium and long term. The correlation between the two series is 0.91. But it should be clear that this is driven by indexation, combined with the fact that wage and price inflation comove strongly at low frequencies. This is made clear by looking at the component of predicted wage inflation associated with current and expected future output gaps, i.e. $-\lambda_w \varphi \sum_{k=0}^{\infty} \beta^k E_t\{\widetilde{u}_{t+k}\}$, which is also shown in the same Figure, and which can be seen to play a negligible role in accounting for the overall correlation. Figure 9b zooms in on the 1999-2014 period, which is characterized by inflation stability and where, as a result, the unemployment gap-related component should in principle play a central role. As the figure makes clear the natural rate model has a difficult time accounting for the evolution of wage inflation. The correlation of the latter with predicted wage inflation is only 0.24, and as low as -0.20 when the indexation components is removed.

[16] See Galí (2011b) for a discussion. Under the null that the model is correct, one can show

$$\sum_{k=0}^{\infty} \beta^k E\{\widetilde{u}_{t+k} | \mathbf{x}_t, \mathbf{x}_{t-1,...}\} = \sum_{k=0}^{\infty} \beta^k E_t\{\widetilde{u}_{t+k}\}$$

thus implying that the use of current and lagged values of $\mathbf{x}_t$ as an information set is not restrictive (under the null).

On the basis of the evidence above, I conclude that exogenous changes in the natural rate are not a plausible dominant source of the unit root in euro area unemployment, at least when examined through the lens of the NK model above.

4.2 The Long Run Tradeoff Hypothesis

Under the *long run tradeoff hypothesis*, the unit root in the unemployment rate is caused by the presence of a unit root in (price and wage) inflation which is in turn inherited from the central bank's inflation target $\{\pi_t^*\}$. More precisely, under that hypothesis the model implies a cointegrating relation between the unemployment rate and wage inflation, with the linear combination $\pi_t^w + \frac{\lambda_w \varphi}{1-\beta} u_t$ being stationary.[17]

The existence of a *long run tradeoff* between wage inflation and unemployment found in the NK model has a simple explanation: the "engine" of wage inflation in the model is the existence of a discrepancy between the average wage markup and its desired (or natural) counterpart. Specifically, positive wage inflation arises when the difference between the average wage markup and its desired level is negative (see (7)). Accordingly, the only way to attain permanently higher wage inflation is to increase that gap or, equivalently, the gap between the unemployment rate and its natural counterpart, as implied by (8).

Thus, under the long run tradeoff hypothesis, the observed permanent changes in the euro area unemployment rate should be interpreted as the

[17] In the case of *partial* indexation to price inflation and labor productivity a similar result holds, with CI vector $[1, -\lambda_w \varphi/(1-\beta)(1-\gamma)]$. With full indexation there is no long run tradeoff.

consequence of permanent changes in inflation. Under the assumed interest rate rule, those would in turn be the result of changes in the central bank's (implicit or explicit) inflation target.

Figure 10 displays the dynamic responses of unemployment, output and wage and price inflation to a 1 percent reduction in the (annualized) inflation target, under the assumption that the latter follows a random walk process:

$$\pi_t^* = \pi_{t-1}^* + \varepsilon_t^*$$

and given the model's baseline calibration. Note that the disinflation generates a large recession in the short run, with an output decrease of nearly 2 percent and a rise of unemployment of 2.5 percentage points in response to the 1 percentage point disinflation. In the short run, both inflation and the unemployment overshoot their long run level. Note, however, that the predicted long run effect on the unemployment rate (and output) of the permanent disinflation is, however small, as is further discussed below.

4.2.1 Empirical Assessment

The long run tradeoff hypothesis seems, at least qualitatively, consistent with the evidence of cointegration between wage inflation and the unemployment rate uncovered above. Figure 11 highlights the existence of that long run relation by plotting the unemployment rate against wage inflation, after changing the sign of the latter. It is clear that cointegration is driven by the comovement between the two variables during the first part of the sample.

The estimated coefficient in a cointegrating regression of the unemployment rate on wage inflation (the latter in quarterly terms) is -2.[18] If one

[18] Using the shorter 1970-1993 period yields an identical estimate.

interprets that empirical relationship as a structural one (in a way consistent with the model), that estimated coefficient implies a permanent increase of 0.5 percentage points in the unemployment rate for every percent (permanent) reduction in annual inflation. That estimate reflects the large (and seemingly permanent) increase in the unemployment rate that took place during the gradual wage disinflation experienced by the euro area from the mid-1970s to the early 1990s.

That cost of disinflation in terms of unemployment is substantially larger than that implied by the model. In the latter the long run increase in the unemployment rate from a permanent reduction in (annualized) inflation of 1 percentage point is given by $\frac{1-\beta}{4\lambda_w \varphi}$, which under my baseline calibration equals 0.13, which is well below the 0.5 estimate. Note that allowing for indexation to past inflation wouldn't make things better, for in that case the long run effect on inflation is given by $\frac{(1-\beta)(1-\gamma)}{4\lambda_w \varphi}$ where, as above, γ denotes the degree of indexation.

Independently of the role that the presence of a long run inflation-unemployment tradeoff effect may have played in accounting for the permanent changes in the unemployment rate in the 1970s and 1980s, it is clear that such a mechanisms cannot have played a significant role in accounting for the unit root in the unemployment rate observed in the post-1994 period, since wage inflation remains highly stable after that date, while the unemployment rate persists in its random walk-like behavior, as Figure 11 makes clear.

To confirm the previous assessment I simulate the paths of wage inflation and the unemployment rate implied by the calibrated model for 1970-2014 period, given a sequence of inflation target shocks consistent with the low frequency movements in wage inflation. Thus, note that under the maintained assumption of a random walk for the inflation target, the following relation can be used to back out the innovations in that process:

$$\varepsilon_t^* = \Delta\pi_t^* = \Delta\pi_t^{BN}$$

where π_t^{BN} is the permanent component of the Beveridge-Nelson decomposition of wage inflation.[19] Note that, by construction, the simulated inflation series will matches the low frequency patterns of the corresponding observed inflation variable. The interest of the exercise lies, however, in the model's predictions regarding the fluctuations in wage inflation and the unemployment rate in response to inflation target shocks, and the extent to which the latter are consistent for the observed properties of those variables at different frequencies.

Figure 12a displays the evolution of wage inflation generated by the model's equilibrium in response to the estimated sequence of inflation-target shocks, together with observed wage inflation (both expressed in year-on-year terms). As expected, the simulated series for wage inflation accounts reasonably well for the medium and long-term variations of its actual counterpart, and up to the early 1990s also for fluctuations at higher frequencies. Starting in the early 1990s, however, simulated wage inflation shows large and persistent fluctuations while actual wage inflation is nearly flat.

Figure 12b displays the fluctuations in the unemployment rate generated by the model in response to the sequence of inflation target shocks. As one could anticipate from the tiny *long run* response of unemployment to a disinflationary shock in the impulse responses described above, the model fails

[19] Alternatively, one could use a corresponding estimate for price inflation.

to generate the secular increase in the unemployment rate that accompanied the gradual disinflation of the 1980s and early 1990s. Furthermore, and most noticeably, variations in the inflation target generate counterfactually large short term fluctuations in the unemployment rate.

To summarize: the low frequency comovement between wage inflation and the unemployment rate over the period 1975-1993 seems *qualitatively* consistent with the long run tradeoff hypothesis, which would attribute the permanent variations in the unemployment rate over that period to permanent changes in the inflation target and, in particular, to the (successful) disinflationary monetary policies. Yet, neither the size of the tradeoff nor the nature of the unemployment rate fluctuations resulting from the sequence of estimated changes in the inflation target can be easily reconciled with that hypothesis, at least through the lens of a conventionally calibrated New Keynesian model.

4.3 The Hysteresis Hypothesis

In the insider-outsider model of wage setting introduced above, shocks of any nature and persistence –even if purely transitory– that have an initial impact effect on employment, will have a permanent effect on that variable, as well as on output and the unemployment rate. The reason is that unions have a narrow objective when setting wages: to choose the highest possible wage consistent with maintaining employment at its most recent level (in expectation). Thus, any change in employment is bound to become permanent, even after the shock that triggered it has faded away. This is the phenomenon Blanchard and Summers (1986) referred to as "hysteresis".

In this scenario, there is no "anchor" value towards which the wage markup converges after any deviation caused by an exogenous disturbance. As a result, and given (3), there is no mechanism that guarantees that unemployment will revert back towards its natural level when it deviates from it.[20] Instead, in the wake of an adverse shock, the economy may "stabilize" at a level of employment and output permanently lower, and with a higher unemployment rate.

The previous phenomenon is illustrated in Figure 13a, which displays the effects of a *transitory* adverse demand shock in the insider-outsider version of the New Keynesian model. Again, the standard deviation of the shock has been calibrated for consistency with the observed volatility of the permanent component of the unemployment rate. Note that a one standard deviation shock leads to a sizeable permanent increase in unemployment and a commensurate decrease in output. That permanent effect is an illustration of the hysteresis property emphasized by Blanchard and Summers (1986). Note also that the impact on wage and price inflation is very small.

4.3.1 Empirical Assessment

A key element behind the model's hysteresis property is wage equation (11), implied by the IO-NK model and which I reproduce here for convenience:

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} + \lambda_n \Delta n_t \tag{14}$$

where $\lambda_n \equiv \frac{1-\theta_w}{\theta_w \epsilon_w}$. A feature of the previous equation, namely, the dependence of wage inflation on employment *growth* –as opposed to employment

[20] Note that the natural rate of unemployment is assumed to be constant here, and given by $u^n \equiv \frac{1}{\varphi} \log \frac{\epsilon_w}{\epsilon_w - 1}$.

or unemployment *levels*– is the source of hysteresis in the model. Next I try to assess the extent to which an equation like (14) is consistent with the observed joint behavior of employment and wage inflation in the euro area.

To begin with one should note that (14) implies a highly implausible positive long run relation between wage inflation and employment *growth*, whichis a very strong form of non-superneutrality. Such a relation is at odds with the lack of evidence of a unit root in Δn_t. Furthermore, a (pseudo) cointegrating regression of Δn_t on π_t^w yields a *negative* estimated coefficient (-0.03), in contrast with the positive one implied by (11), namely $(1-\beta)/\lambda_n$.

The previous counterfactual implication can be overcome through a (standard) modification of the model to incorporate indexation to past inflation between reoptimization periods, as assumed earlier when evaluating the New Keynesian wage Phillips curve under the natural rate hypothesis. In particular, I assume a form of indexation which gives rise to the modified wage inflation equation:

$$\widetilde{\pi}_t^w = \beta E_t\{\widetilde{\pi}_{t+1}^w\} + \lambda_n \Delta n_t \tag{15}$$

where $\widetilde{\pi}_t^w \equiv \pi_t^w - (\gamma \pi_{t-1}^p + (1-\gamma)\pi_{t-1}^*)$.

Next I assess the empirical relevance of (15), by constructing a measure of its predicted wage inflation, given (current and expected) employment growth, and comparing that prediction with actual wage inflation. Thus, note that (15)

$$\pi_t^w = \gamma \pi_{t-1}^p + (1-\gamma)\pi_{t-1}^* + \lambda_n \sum_{k=0}^{\infty} \beta^k E_t\{\Delta n_{t+k}\}$$

I construct a measure of $\sum_{k=0}^{\infty} \beta^k E_t\{\Delta n_{t+k}\}$ based on an estimated VAR for $\mathbf{x}_t \equiv [\Delta n_t, \widetilde{\pi}_t^w]$, given a calibration for γ and the measure of the inflation target π_t^* introduced earlier. Again, under the null of a correct model (and calibration), the wage inflation series thus constructed should correspond to its empirical counterpart.[21]

Figure 14a displays the predicted path of wage inflation (together with its observed counterpart), given my baseline calibration (which implies $\lambda_n = 0.074$) as well as an assumed setting of 0.5 for γ.[22] In addition, the figure displays (under the label "adjusted") the estimated path of $\lambda_n \sum_{k=0}^{\infty} \beta^k E_t\{\Delta n_{t+k}\}$, i.e. predicted wage inflation after removing the "mechanical" effects of indexation. As the figure shows, predicted inflation tracks well the medium and long term variations in actual inflation. The correlation between the two series is 0.94. Note, in particular, that the model can account for the substantial stability of wage inflation in the post-1994 period in the face of a persistent random walk-like behavior of the unemployment rate.

Of course, as it was the case in the natural rate model evaluated above, indexation together with the large low frequency variations in inflation in the first half of sample period is responsible for an important component of the observed correlation. Focusing on a more recent period allows us to control for that phenomenon. Figure 14b, which focuses on the single currency period, suggests that a substantial positive comovement between the predicted and actual series remains even in periods of stable inflation: the correlation for this period is 0.68. Furthermore, and in contrast with the results for the natural rate model, the correlation between wage inflation and the "adjusted" component of predicted wage inflation (i.e. excluding the indexation

[21] See, e.g. Campbell and Shiller (1987). Galí (2011b) for an application to wage inflation.

[22] Results are little affected by the particular choice of γ

term) for the single currency period is now positive and substantial: 0.52.

A closer look at Figure 14b suggests that the previous correlation would be significantly higher if it weren't for the model's failure to account for the relative wage inflation stability during the 1998-1999 episode. As Figure 14b implies, both the decline in inflation and employment call for substantially lower (negative, in fact) wage inflation, which contrasts with a much milder decline in the actual series. The presence of downward nominal wage rigidities, ignored in the model above, could be a candidate explanation for the difference.

Notice also that the model is predicting correctly the current level of wage inflation and its eeming stability. According to the model, wage inflation remains relatively stable as a result of two countervailing forces: on the one hand, current and expected employment growth would call for an increase in wage inflation (see "adjusted" series). On the other hand, lower price inflation is helping contain that pressure, through the indexation mechanism.

Overall I conclude that the wage inflation equation generated by the insider-outsider version of the New Keynesian model is reasonably consistent with the observed patterns of employment and wage inflation.

5 Summary and Concluding Remarks

In the present paper I have tried to offer a preliminary exploration of a phenomenon that has (unfortunately) become a distinctive feature of the European economy, namely, the seeming nonstationarity in its unemployment rate. I have sought to uncover some clues about the nature and sources of that nonstationarity by analyzing the joint behavior of unemployment and wage inflation in the euro area, over the period 1970-2014 and trying to interpret it through the lens of a textbook like New Keynesian model, to which unemployment is incorporated, following the approach in Galí (2011a,b).

In particular, I have put forward three alternative hypothesis regarding the unit root in the euro area unemployment rate: the *natural rate hypothesis*, the *long run tradeoff* hypothesis, and the *hysteresis hypothesis*.

My analysis suggests that exogenous permanent variations in the natural rate are unlikely to be behind the unit root in unemployment. The reason is that the behavior of the unemployment gap implied by that hypothesis is hard to reconcile with the observed patterns of wage inflation.

The long run tradeoff hypothesis could in principle account for the secular rise in unemployment in the 1970s and 1980s as a consequence of the disinflation experienced over that period. However, under any reasonable calibration of the model, it is hard to account for the size of the unemployment decline that accompanied the disinflation.

The hysteresis hypothesis, on the other hand, does not appear to be strongly at odds with any aspect of the data. In particular, it can potentially account for the remarkable stability of wage inflation in the face of persistently nonstationary movements in the unemployment rate over the post-1994 period.

It goes without saying that further research is needed, possibly involving a richer, estimated structural model in order to draw more precise conclusions about the sources of unit root behavior in euro area unemployment. Yet, a number of remarks seem warranted in light of the previous evidence.

Firstly, the low sensitivity of wage inflation (and, by extension, price inflation) to the unemployment rate in the euro area since 1994, uncovered in the estimates above, may have significant implications for the design of monetary policy.

On the one hand, it implies that demand-driven fluctuations in the unemployment rate will have small effects on wage inflation and, consequently, on price inflation as well, with smaller second round effects. This may facilitate the attainment of the ECB's price stability objectives.

On the other hand it should require a stronger focus on unemployment stabilization, since a policy that were to respond only to significant deviations of inflation from target could imply excessive fluctuations in unemployment and economic activity, given the flatness of the Phillips curve. On the other hand, in the presence of cost-push inflationary shocks that generate a tradeoff between unemployment and inflation stabilization, the change in the unemployment rate required to reduce wage inflation by a given amount is likely to be very large.

Furthermore, if the low sensitivity of inflation to the unemployment rate is due to the presence of hysteresis effects, a case for a greater emphasis on unemployment stabilization can be made, as my preliminary findings in a formal analysis of optimal monetary policy under hysteresis show.[23] There are two reasons for this. First, in the absence of a countercyclical policy there is no "anchor" that guarantees that unemployment will revert back to some "natural" level. Accordingly, in the absence of a forceful countercyclical policy, the economy may be stuck with an inefficiently low level of activity for a protracted period. Secondly, and in response to shocks that generate

[23] See Galí (2015b).

a policy tradeoff, any given tightening of monetary policy in response to a deviation from the inflation target would trigger a much larger and persistent increase in the unemployment rate. As a result, the optimal policy is likely to involve a stronger accommodation of inflationary pressures and a greater stability of the unemployment rate than under the labor market environment assumed in the standard New Keynesian model.

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Technical Appendix

The Household Problem

I assume a large number of identical households. Each household has a continuum of members represented by the unit square and indexed by a pair $(j,s) \in [0,1] \times [0,1]$. The first index, $j \in [0,1]$, represents the type of labor service ("occupation") that a given household member is specialized in. The second index, $s \in [0,1]$, determines the disutility from work. The latter is given by χs^{φ} if he is employed and zero otherwise, where $\chi > 0$ and $\varphi > 0$ are exogenous parameters. Full risk sharing within the household is assumed. Given the separability of preferences, this implies the same level of consumption for all household members, independently of their occupation or employment status.

The household's period utility is given by the integral of its members' utilities:

$$\begin{aligned} U(C_t, \{N_t(j)\}; Z_t) &\equiv \left(\log C_t - \int_0^1 \int_0^{\mathcal{N}_t(j)} \chi s^{\varphi} ds dj \right) Z_t \\ &= \left(\log C_t - \chi \int_0^1 \frac{\mathcal{N}_t(j)^{1+\varphi}}{1+\varphi} dj \right) Z_t \end{aligned}$$

where $C_t \equiv \left(\int_0^1 C_t(i)^{1-\frac{1}{\epsilon_p}} di \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}$ is a consumption index, $C_t(i)$ is the quantity consumed of good i, for $i \in [0,1]$, and $\mathcal{N}_t(j) \in [0,1]$ is the fraction of members specialized in occupation j who are employed in period t. The exogenous preference shifter $z_t \equiv \log Z_t$ is assumed to follow an AR(1) process:

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z$$

where $\rho_z \in [0,1]$ and ε_t^z is a white noise process with zero mean and variance σ_z^2.

Each household seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, \{\mathcal{N}_t(j)\}; Z_t)$$

subject to a sequence of flow budget constraints given by

$$\int_0^1 P_t(i)C_t(i)di + Q_t B_t \leq B_{t-1} + \int_0^1 W_t(j)\mathcal{N}_t(j)dj + D_t \tag{16}$$

where $P_t(i)$ is the price of good i, $W_t(j)$ is the nominal wage for type j labor, B_t represents purchases of a nominally riskless one-period discount bond paying one monetary unit, Q_t is the price of that bond, and D_t is a lump-sum component of income (which may include, among other items, dividends from the ownership of firms).[24] Independently of wage setting considerations, the above problem gives rise to some standard optimality conditions: a set of optimal demand schedules for each consumption good and a standard intertemporal optimality condition (or Euler equation). See Woodford (200) or Galí (2015) for a derivation of these and other equilbrium condition unrelated to the labor market. Here I focus my discussion on the definition of unemployment and the assumptions regarding wage setting.

Labor Market Participation and Unemployment

Consider individual (j,s) specialized in occupation j and with disutility of work χs^{φ}. *Using the household welfare as a criterion*, and *taking as given* current labor market conditions that individual will be willing to work (and thus be part of the labor force) in period t if and only if

$$\frac{W_t(j)}{P_t} \geq \chi C_t s^{\varphi}$$

[24]The above sequence of period budget constraints is supplemented with a solvency condition which prevents the household from engaging in Ponzi schemes.

i.e. if and only if the relevant real wage exceeds the disutility from work, where the latter is expressed in terms of consumption by dividing the disutility term χs^{φ} by the household's marginal utility of consumption C_t^{-1}. Thus, the *marginal* supplier of type j labor, denoted by $L_t(j)$, is given by

$$\frac{W_t(j)}{P_t} = \chi C_t L_t(j)^{\varphi} \tag{17}$$

Define the aggregate labor force (or participation rate) as $L_t \equiv \int_0^1 L_t(j)dj$. Taking logs and integrating over j one can derive the following approximate relation:

$$w_t - p_t = c_t + \varphi l_t + \xi \tag{18}$$

where use is made of the first order approximations around the symmetric steady state $w_t \simeq \int_0^1 w_t(j)dj$ and $l_t \simeq \int_0^1 l_t(j)dj$. Equation (18) can be thought of as an aggregate labor supply or participation equation.

Following Galí (2011a,b), I define the unemployment rate u_t as the log difference between the labor force and employment:

$$u_t \equiv l_t - n_t \tag{19}$$

The average wage markup is defined as the gap between the average wage and the reservation wage for the marginal employed worker

$$\mu_{w,t} \equiv w_t - \underline{w}_t$$

where $\underline{w}_t \equiv p_t + c_t + \varphi n_t + \xi$. Combining those two definitions with (18) yields a simple linear relation between the wage markup and the unemployment rate

$$\mu_{w,t} = \varphi u_t \tag{20}$$

Wage Setting in the Insider-Outsider Model

As discussed in the main text, in the insider-outsider model a union resetting the wage for occupation j chooses a wage such that the following condition is satisfied:

$$(1-\beta\theta_w)\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left\{n_{t+k}(j)\right\} = n_{t-1}(j) \tag{21}$$

On the other hand, the demand for labor of type j resetting the wage in period t is given by

$$n_{t+k}(j) = -\epsilon_w(w_t^* - w_{t+k}) + n_{t+k} \tag{22}$$

for $k = 0, 1, 2...$ Substituting (22) into (21) yields the wage setting rule:

$$w_t^* = -\frac{1}{\epsilon_w}n_{t-1} + (1-\beta\theta_w)\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left\{w_{t+k} + \frac{1}{\epsilon_w}n_{t+k}\right\}$$

which can be written, in turn, in recursive form as follows:

$$w_t^* = \beta\theta_w E_t\left\{w_{t+1}^*\right\} + (1-\beta\theta_w)w_t + \frac{1}{\epsilon_w}\Delta n_t$$

The latter can be combined with the equation describing the evolution of the average wage under Calvo staggered price setting, i.e.

$$w_t = \theta_w w_{t-1} + (1-\theta_w)w_t^*$$

to yield (after some algebra), the following New Keynesian Phillips curve for the insider-outsider economy:

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} + \lambda_n \Delta n_t$$

where $\lambda_n \equiv \frac{1-\theta_w}{\theta_w \epsilon_w}$.

Calibration

The simulations in the paper are based on a calibration of the NK model similar to that used in Galí (2015). Thus, I assume $\beta = 0.99$, which implies a steady state real (annualized) return on financial assets of about 4 percent. I also assume $\sigma = 1$ (log utility) and $\varphi = 5$ (which implies a Frisch elasticity of labor supply of 0.2), $\alpha = 1/4$, and $\epsilon_p = 9$ (implying $\mathcal{M}_p = 1.125$, i.e., a steady state markup of a 12.5 percent). When relevant, I set $\epsilon_w = 4.5$, a value consistent with an average unemployment rate of 5 percent, roughly the mean unemployment rate in the postwar U.S. economy. I also assume $\theta_p = \theta_w = 3/4$, which impliy an average price and wage durations of four quarters, consistent with much of the empirical evidence.[25] As to the interest rate rule coefficients, I assume $\phi_\pi = 1.5$, $\phi_y = 0.5$, and $\phi_i = 0.9$. That calibration (nearly) corresponds to the one proposed in Orphanides (2006) and Smets (2010) as a good approximation to ECB policy.

[25] See, in particular, the estimates in Galí, Gertler and López-Salido (2001) and Sbordone (2002), based on aggregate data and the discussion of the micro evidence in chapter 1.

Table 1. ADF Unit Root Tests

Euro area		*United States*	
1 lag	4 lags	1 lag	4 lags
−2.03	−1.91	−3.39*	−3.35*

Note: t-statistics of Augmented Dickey-Fuller tests (with intercept) for the null of a unit root in the unemployment rate. Sample period 1970Q1-2014Q4. Asterisks denote significance at the 5 percent level. Critical values (adjusted for sample size) for the null of a unit root are −2.57 (10%) and −2.87 (5%).

Table 2. Estimated Reduced Form Wage Equations

	1970Q1-2014Q4		*1970Q1-1992Q4*		*1993Q1-2014Q4*	
u_t	-0.36^{**} (0.018)	-0.20^{**} (0.023)	-0.29^{**} (0.029)	-0.22^{**} (0.034)	-0.06^{**} (0.018)	-0.06^{**} (0.019)
$\pi_{t-1}^{(4)}$		0.74^{**} (0.008)		0.53^{**} (0.111)		0.11 (0.131)
R^2	0.73	0.82	0.58	0.68	0.09	0.09
DW	1.16	1.84	1.62	2.17	2.58	2.61

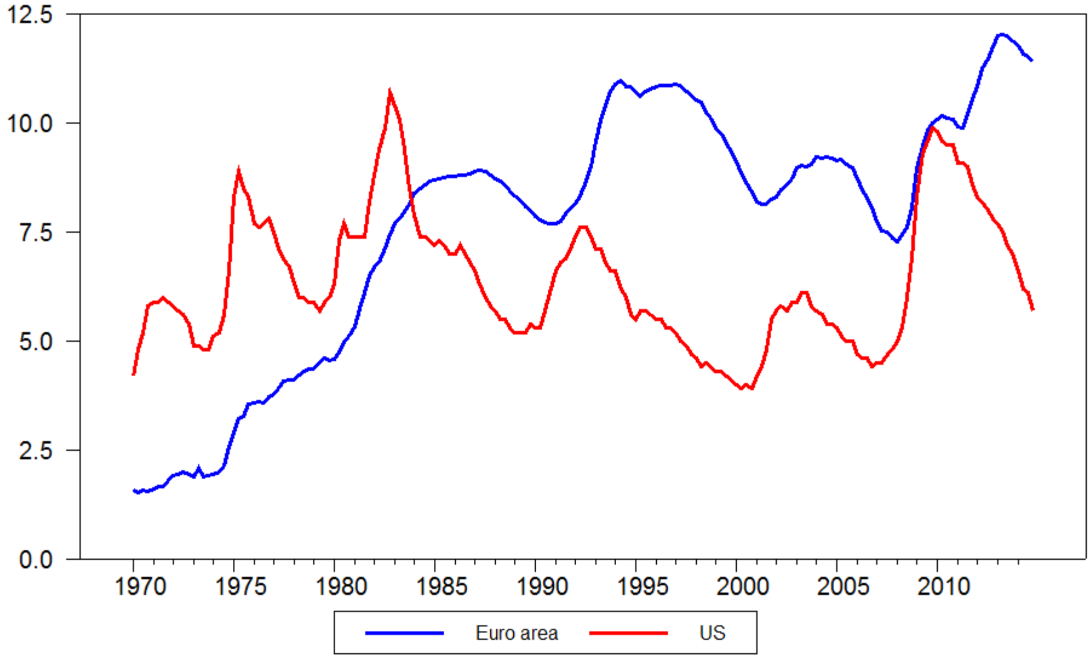

Figure 1. Unemployment Rate: Euro Area vs. United States

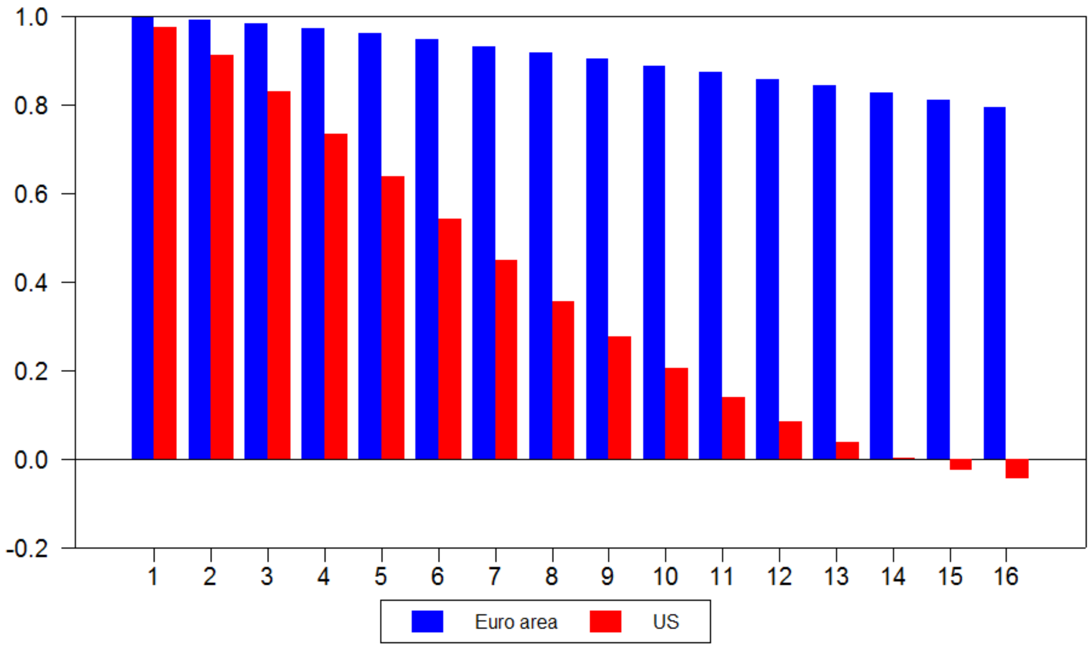

Figure 2. Unemployment Rates: Autocorrelations

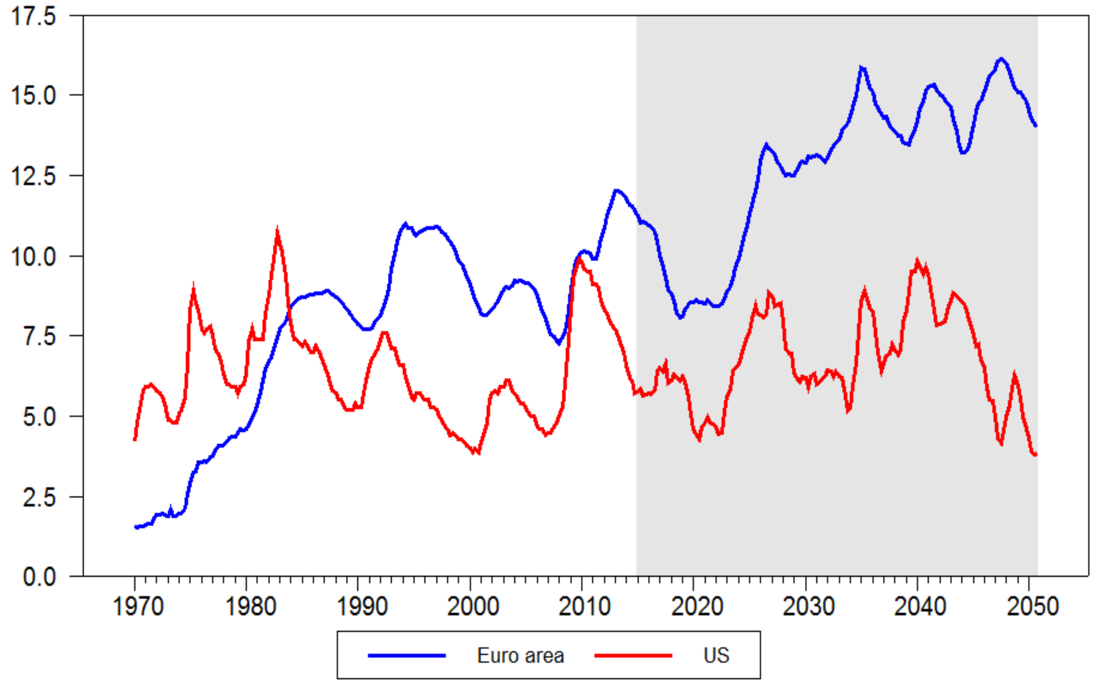

Figure 3a. Unemployment Rate: Simulated Path I

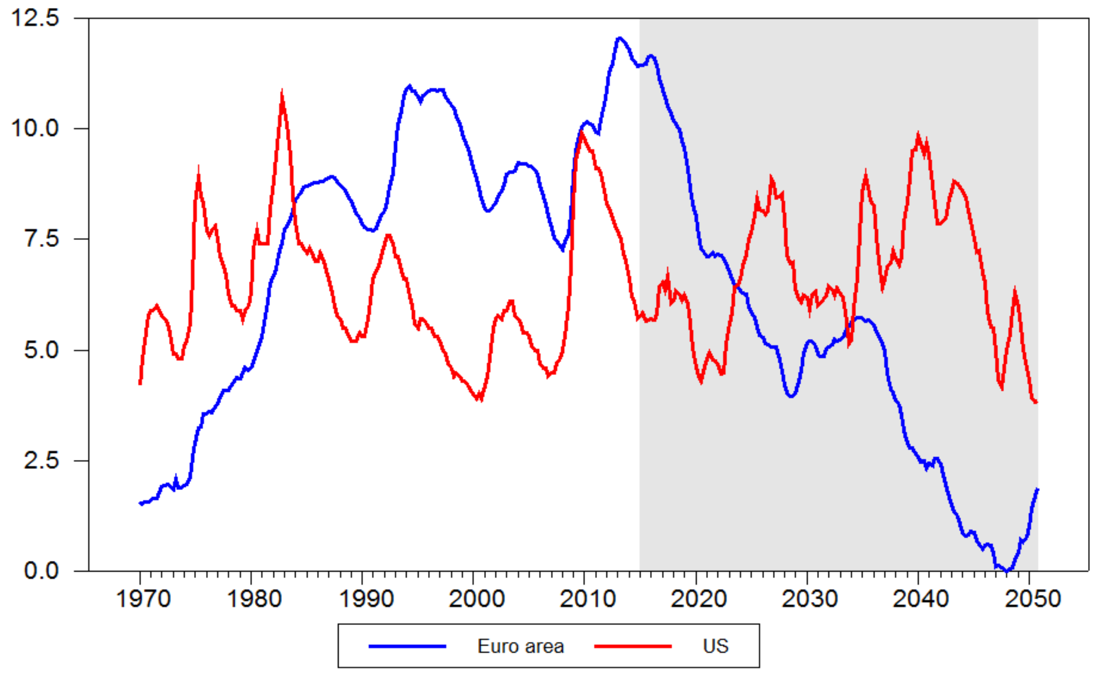

Figure 3b. Unemployment Rate: Simulated Path II

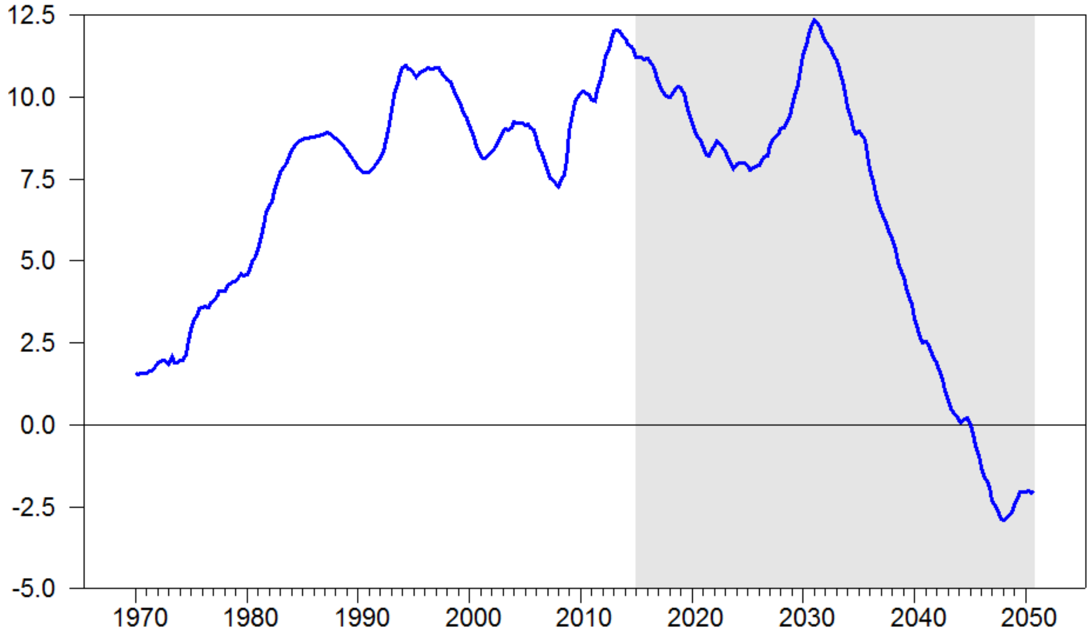

Figure 3c. Unemployment Rate: Simulated Path III

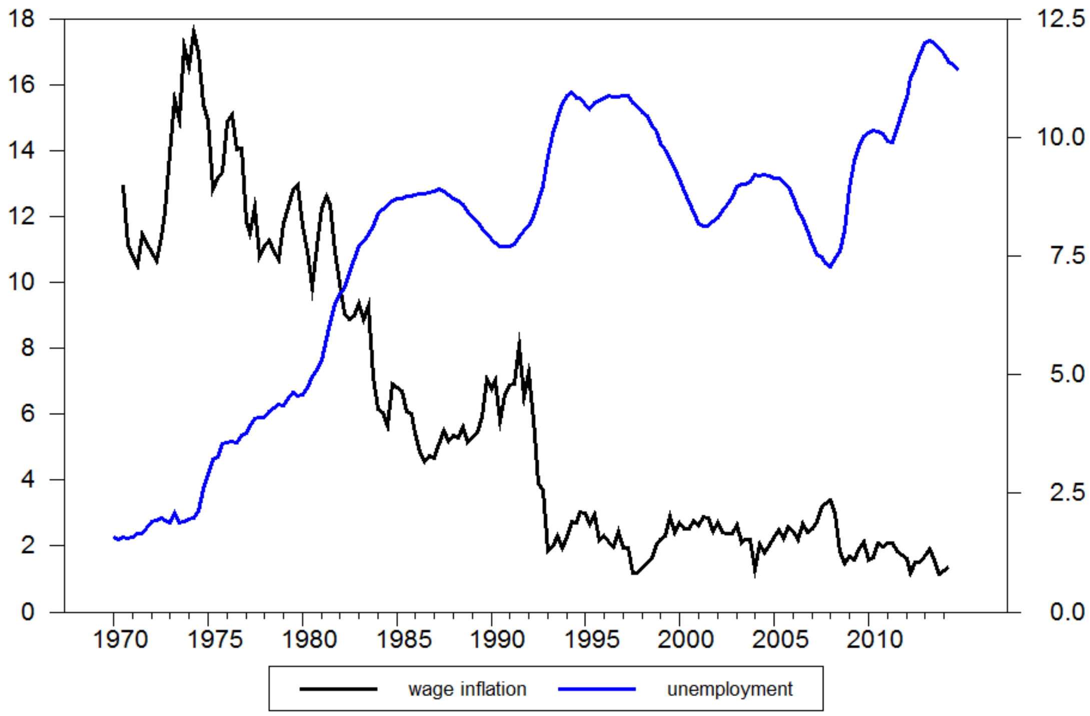

Figure 4. Unemployment and Wage Inflation in the Euro Area

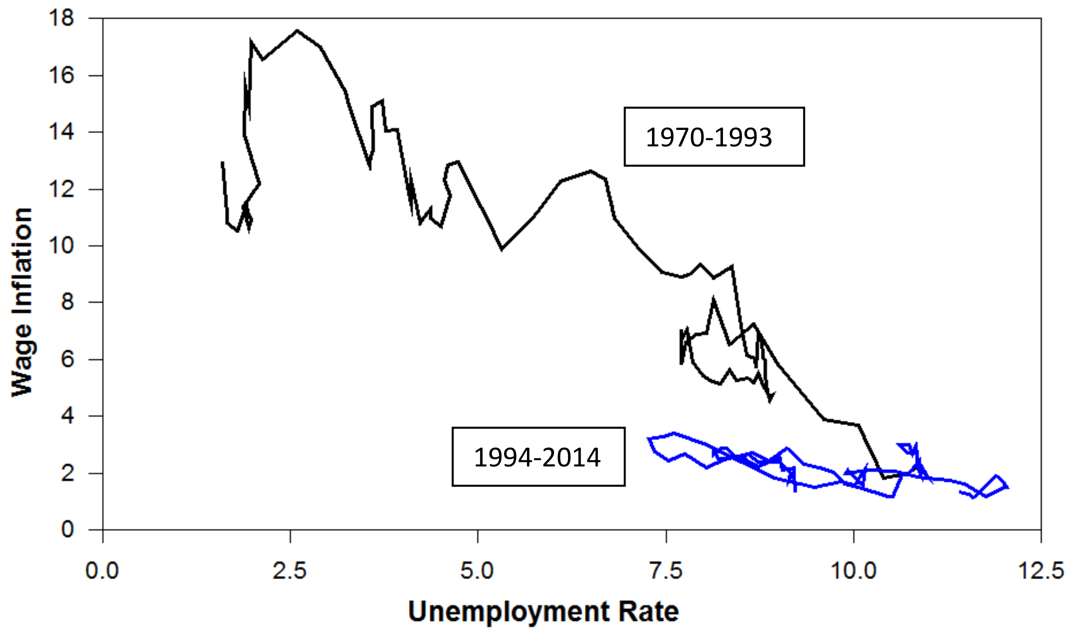

Figure 5a. The Euro Area Wage Phillips Curve (1970-2014)

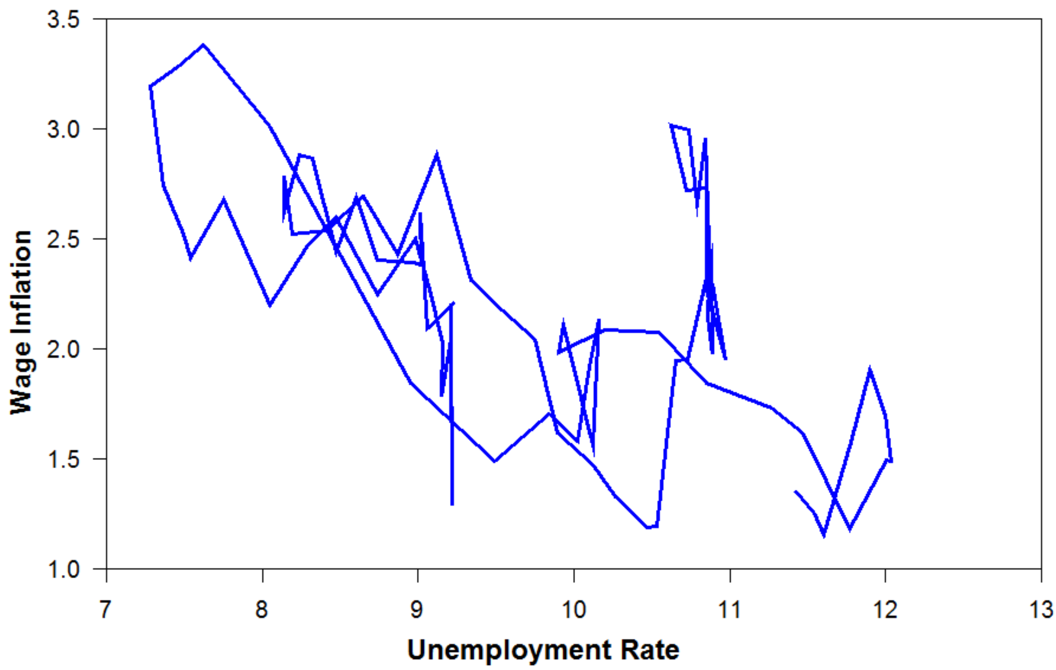

Figure 5b. The Euro Area wage Phillips curve (1994-2014)

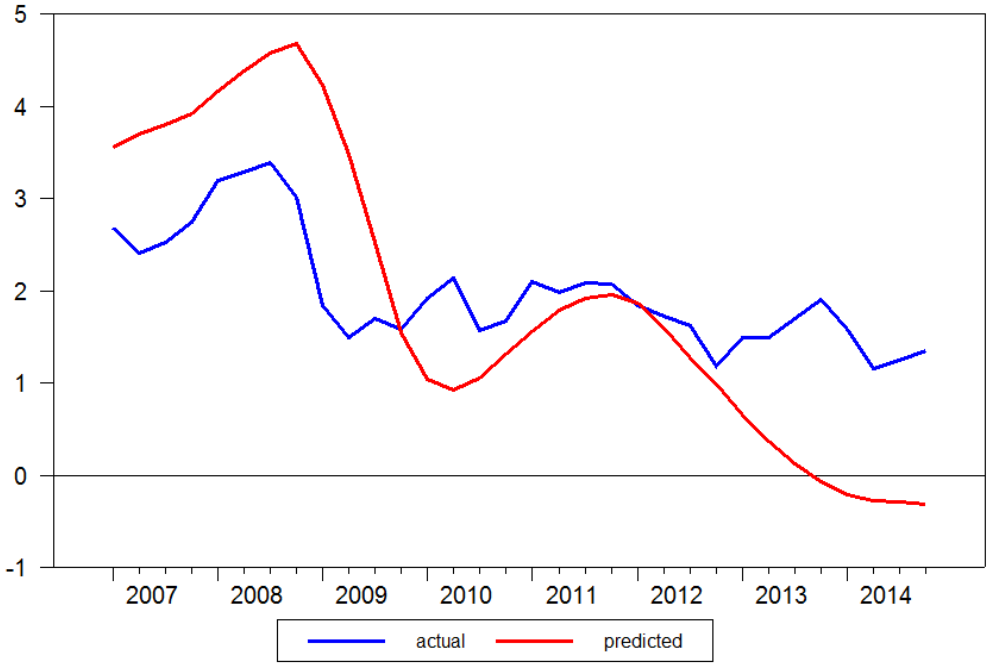

Figure 5c. Wage Inflation in the Euro Area: Actual vs. Predicted

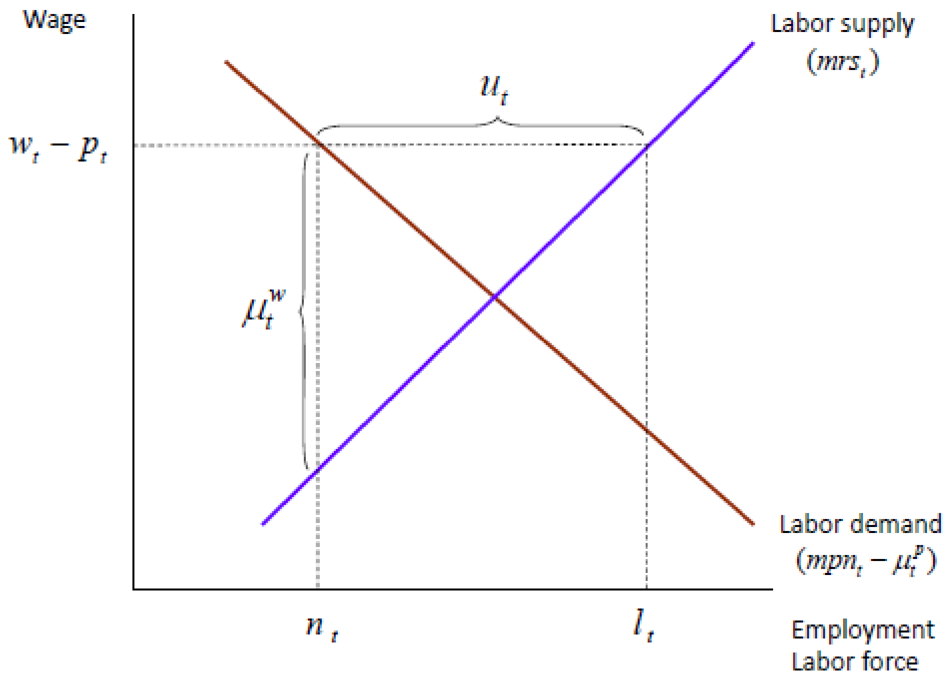

Figure 6. The Wage Markup and the Unemployment Rate

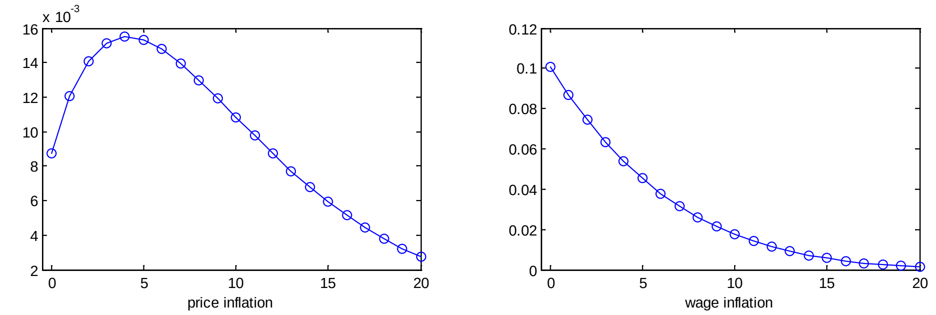

Figure 7. The Effects of a Permanent Wage Markup Shock

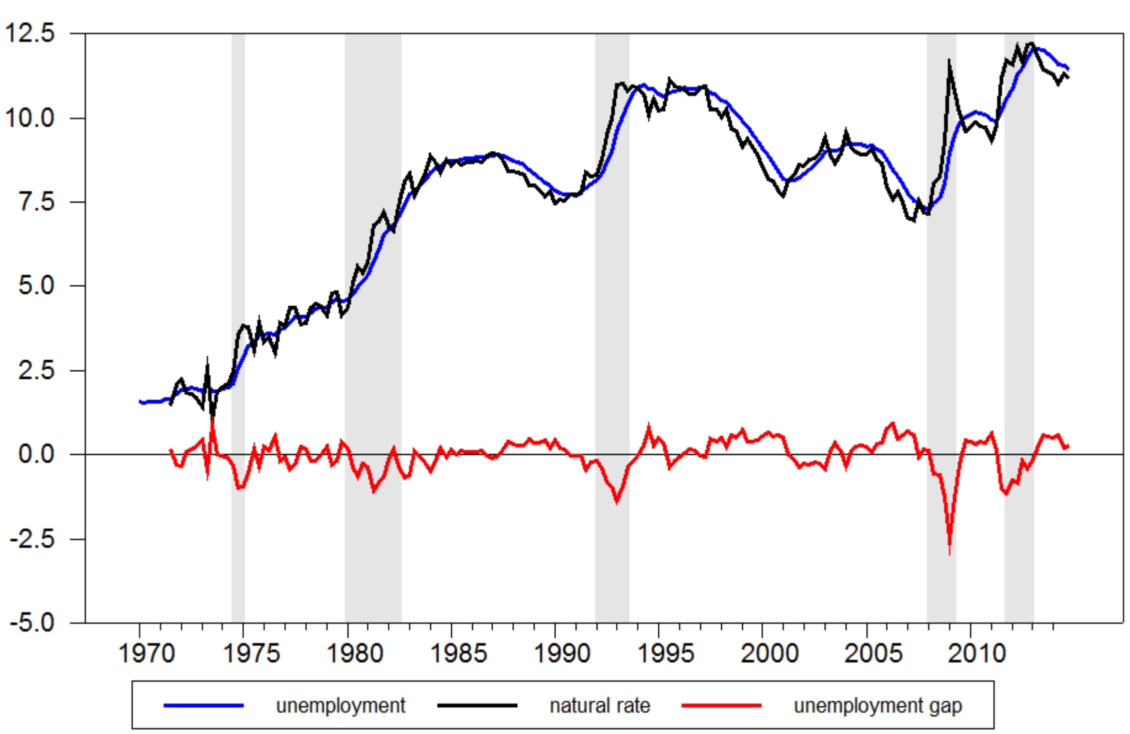

Figure 8. The Natural Rate Hypothesis

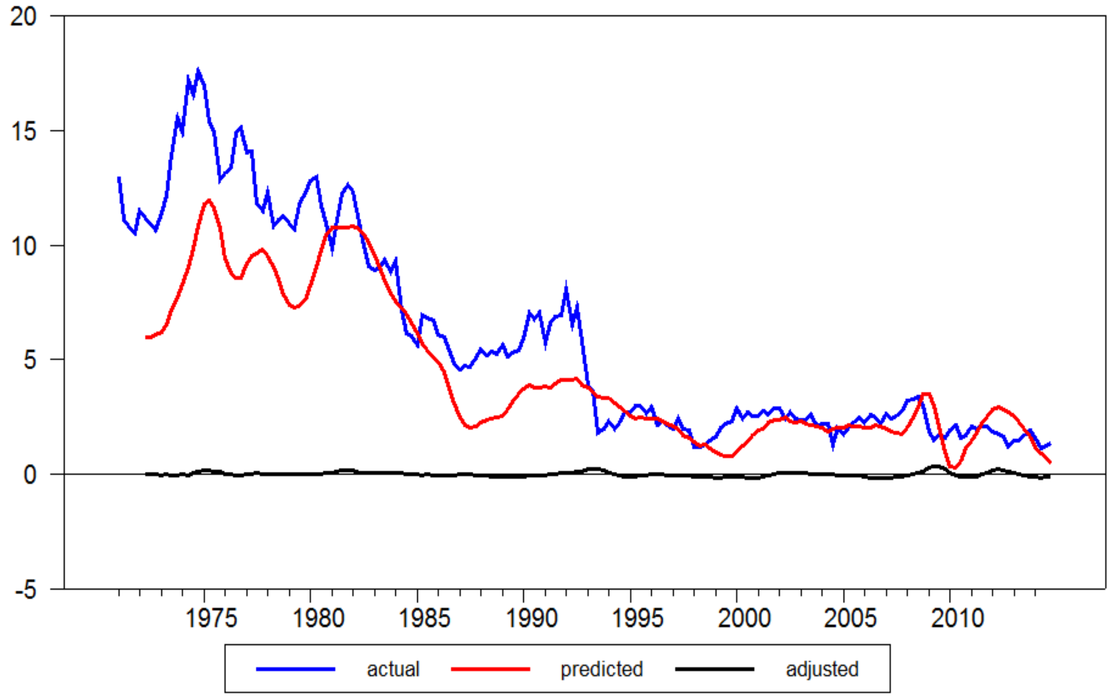

Figure 9a. Wage Inflation under the Natural Rate Hypothesis (1970-2014)

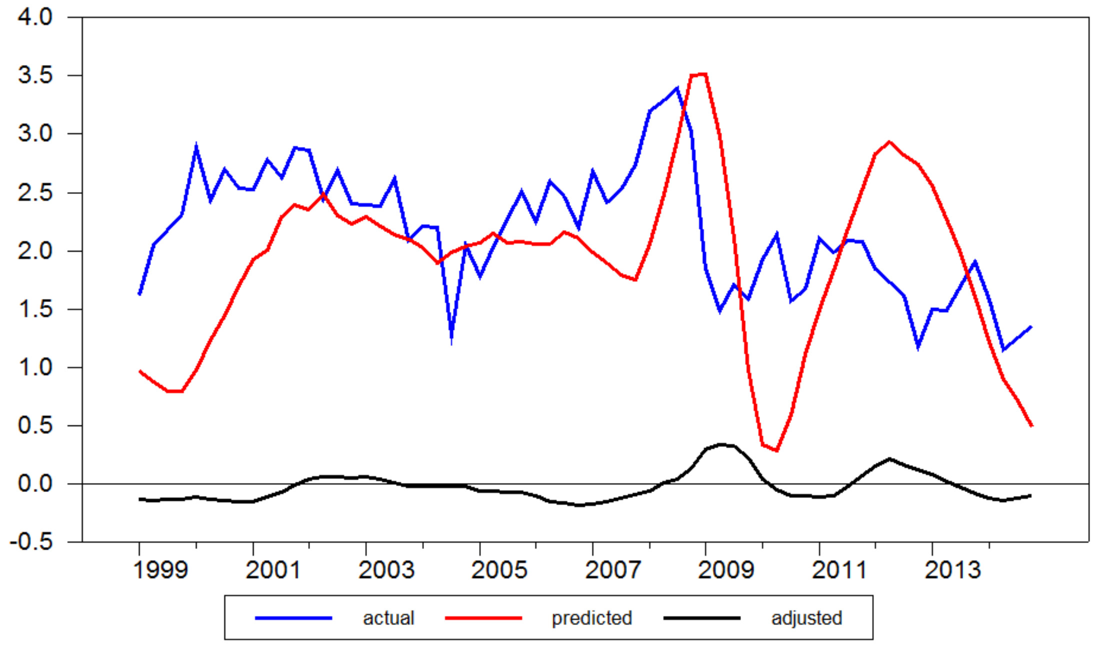

Figure 9b. Wage Inflation under the Natural Rate Hypothesis (1999-2014)

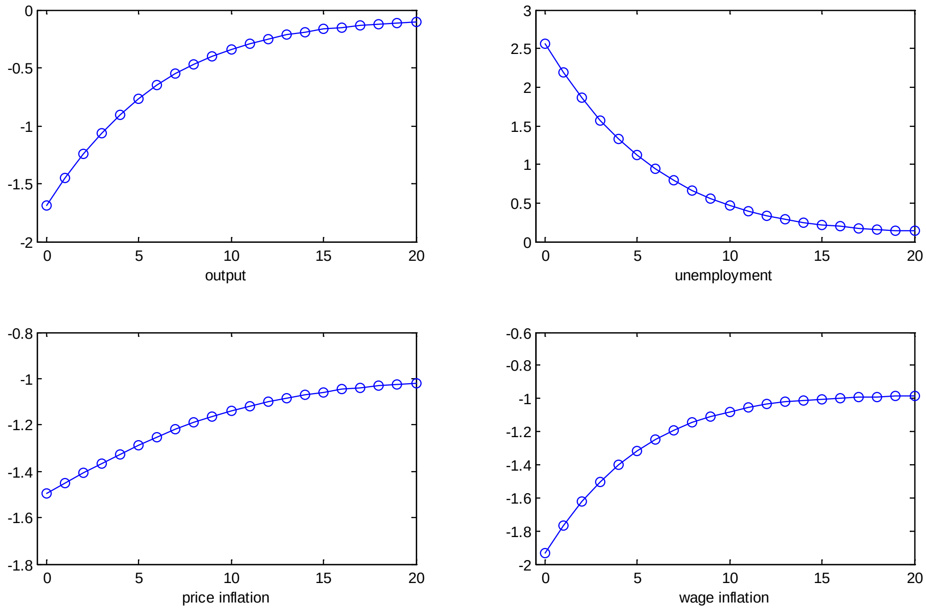

Figure 10. The Effects of a Permanent Inflation Target Shock

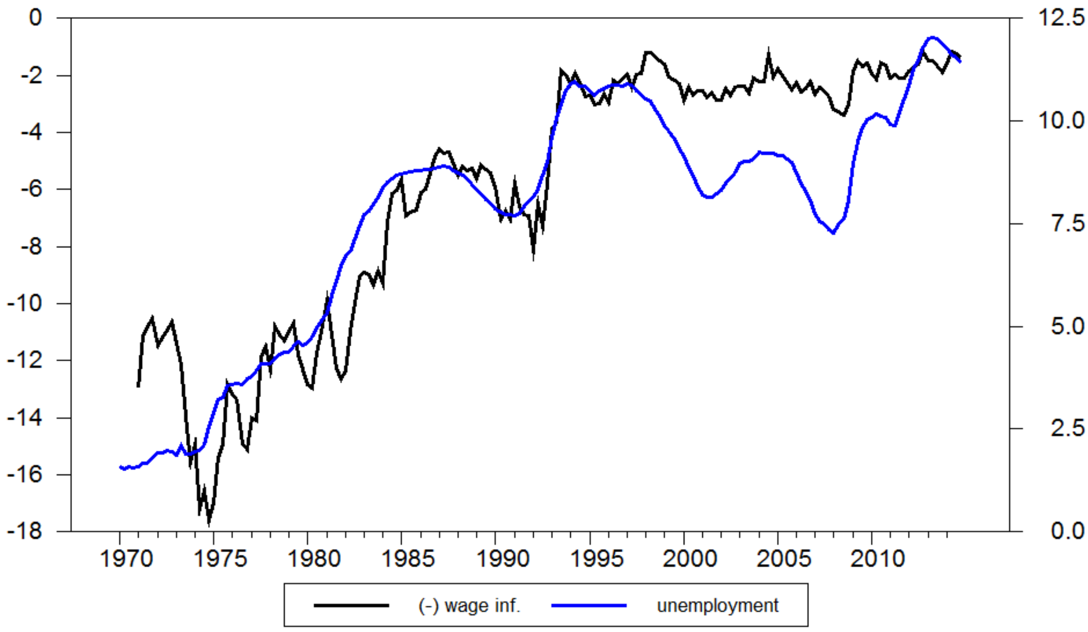

Figure 11. A Long Run Tradeoff Between Inflation and Unemployment?

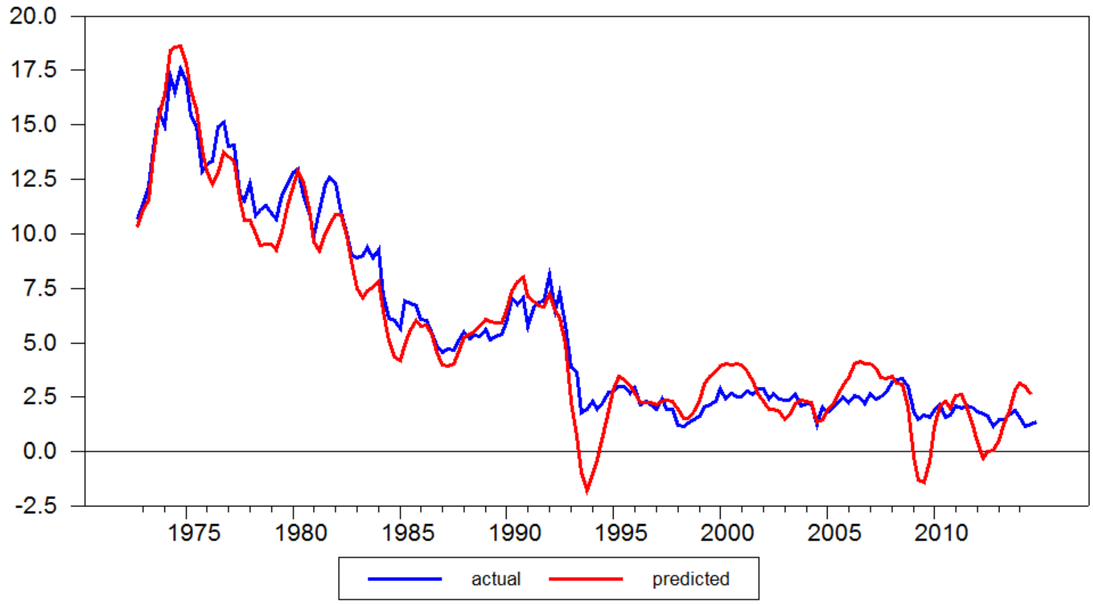

Figure 12a. Wage Inflation and the Long Run Tradeoff Hypothesis

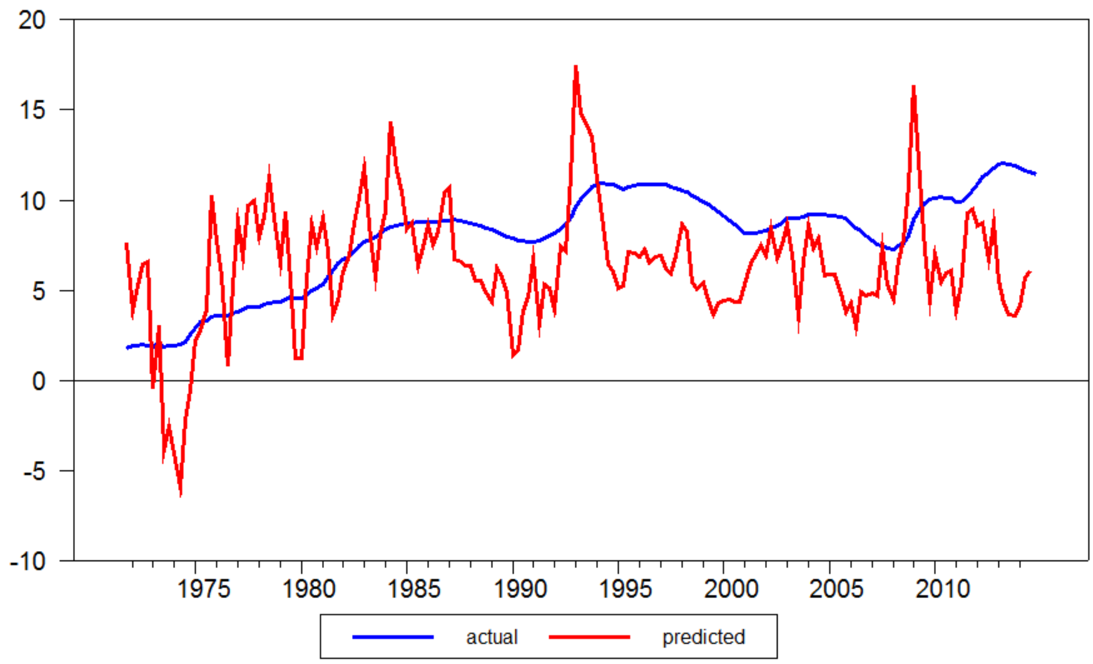

Figure 12b. Unemployment and the Long Run Tradeoff Hypothesis

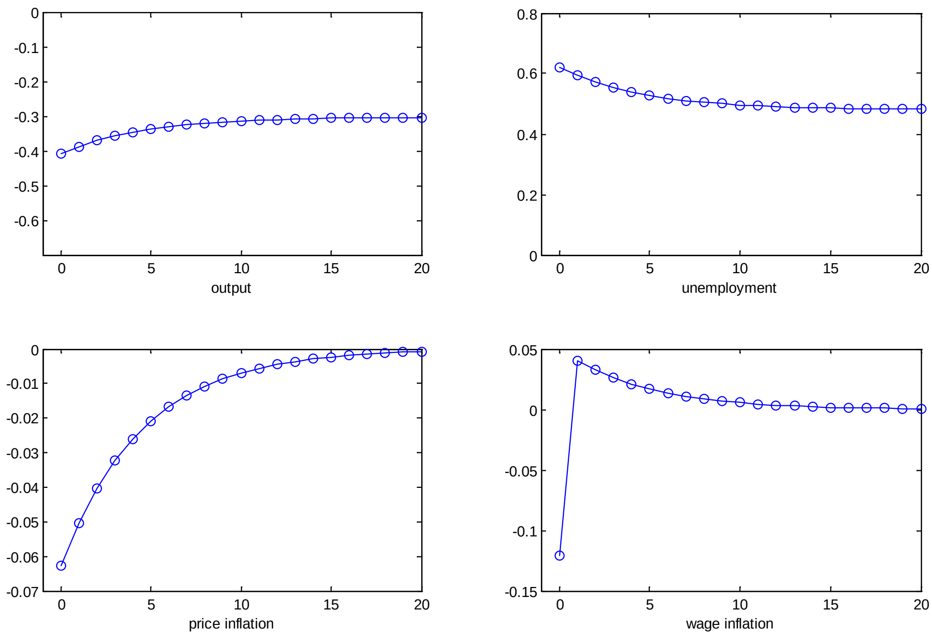

Figure 13. The Effects of a Demand Shock in the Insider-Outsider Model

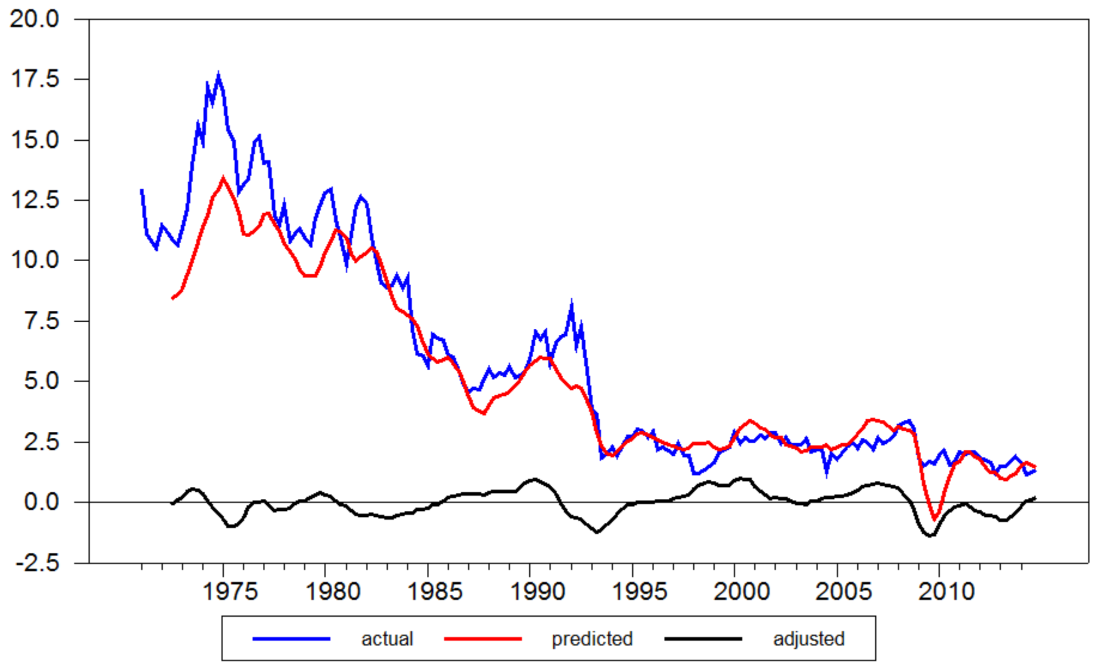

Figure 14a. Wage Inflation under the Hysteresis Hypothesis (1970-2014)

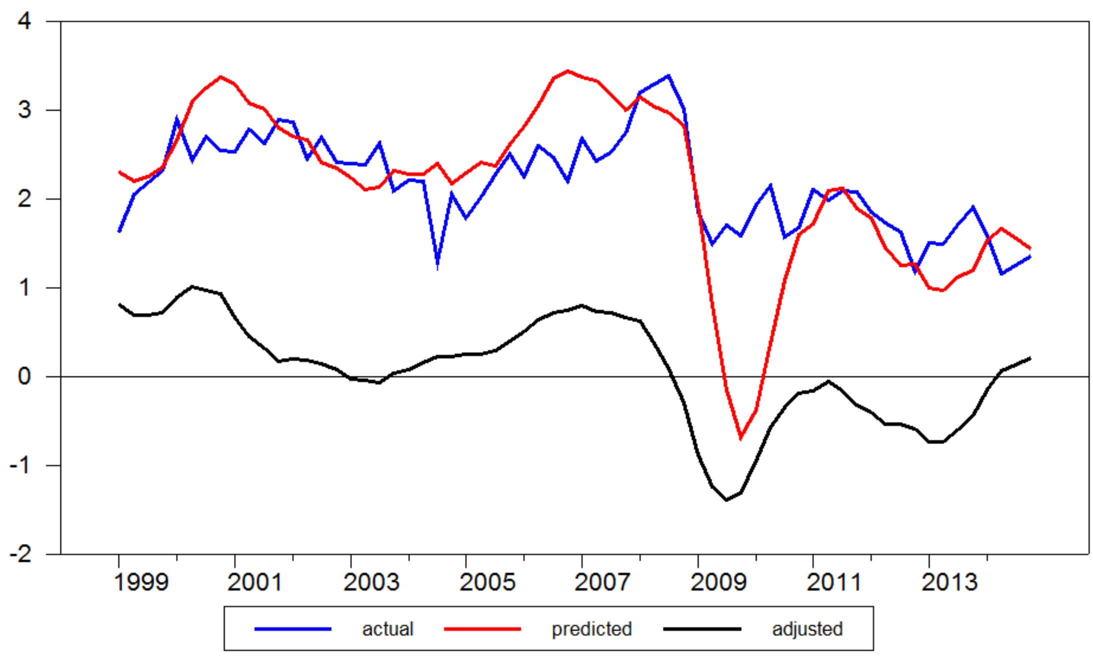

Figure 14b. Wage Inflation under the Hysteresis Hypothesis (1999-2014)