Revisiting the hysteresis hypothesis: An ARIMAX approach*

Robert Calvert Jump[†] Engelbert Stockhammer[‡]

June 23, 2023

Abstract

The 2008 financial crisis saw a resurgence of interest in the hysteresis hypothesis, which was subsequently reflected in policy responses to the Covid-19 and cost-of-living crises. In this paper, we present new evidence in favour of the hysteresis hypothesis for Germany, France, and the United Kingdom, using a dataset that spans 1960 – 2019. Our model is based on the popular unobserved components approach to estimating the degree of hysteresis, which is generalised to permit a reduced form Phillips curve that takes the form of an ARIMAX model. Our results are robust to ARCH effects and varying the sample span. They support contemporary warnings of the risk of scarring effects following the Covid-19 crisis, longstanding Post Keynesian models of hysteresis, and the recent resurgence of mainstream interest in hysteresis.

Keywords: Unemployment, Hysteresis, NAIRU, Phillips Curve.

JEL Codes: E24, E60, E61.

*We gratefully acknowledge funding from the Österreichisches Bundesministerium für Arbeit, Soziales und Konsumentenschutz. The paper has benefited from the excellent research assistance of Victoria Fattinger and Benedikt Gohmann, and the advice of Johannes Pfeifer, Christophe Planas and Gerdien Meijerink. We would also like to thank seminar participants at the University of the West of England and the 2018 OFCE conference for useful comments. Any remaining errors are the responsibility of the authors.

[†]Institute of Political Economy, Governance, Finance and Accountability, University of Greenwich, Old Royal Naval College, Park Row, London SE10 9LS. Email: r.g.calvertjump@greenwich.ac.uk.

[‡]Department of European and International Studies, King's College London, Strand, London, WC2R 2LS. Email: engelbert.stockhammer@kcl.ac.uk.

1 Introduction

The 2008 financial crisis saw a resurgence of interest in the hysteresis hypothesis. Reflecting on the British response to the crisis, the governor of the Bank of England observed that,

> . . . to the extent appropriate under our mandates, the monetary policy response has represented a race against long-term (or hysteretic) unemployment. As Janet Yellen remarked, "the risk that continued high unemployment could eventually lead to more-persistent structural problems underscores the case for maintaining a highly accommodative stance of monetary policy." (Carney 2014).

In the same year, the governor of the European Central Bank argued that demand side policies are justified as they, "help insure against the risk that a weak economy is contributing to hysteresis effects" (Draghi 2014). This outlook was subsequently reflected in policy responses to the Covid-19 crisis, including the Biden administration's American Rescue Plan. Defending the $1.9 trillion package against accusations that it would lead to inflation, the Treasury Secretary Janet Yellen has argued that,

> Inflation has been very low for over a decade, and you know it's a risk, but it's a risk that the Federal Reserve and others have tools to address . . . The greater risk is of scarring the people, having this pandemic take a permanent lifelong toll on their lives and livelihoods. (Quine 2021).

Economic support packages have also been implemented by many countries in response to the 2022 energy crisis, which (at the time of writing) is continuing into 2023 (see e.g., Jurkovic, 2023, for a comparison of the UK and EU responses).

This 'return of hysteresis' is reflected in the re-emergence of theoretical work on the subject since 2008, both in the Post Keynesian and New Keynesian literatures. Hysteresis was incorporated into Post Keynesian alternatives to the non-accelerating inflation rate of unemployment in Stockhammer (2008), and Post Keynesian equivalents to the textbook three equation model (e.g., Lavoie, 2009). The policy implications of this type of model are discussed particularly clearly in Michl and Oliver (2019). Similar extensions to New Keynesian models can be found in Kienzler and Schmid (2014), Engler and Tervala (2018), Tervala (2021), and Calvert Jump and Levine (2021).

These theoretical models are yet to be estimated empirically. However, there is a literature using unobserved components models to examine the hysteresis hypothesis that stretches back to Jaeger and Parkinson (1994). This literature is summarised in table 1, which lists the relevant papers along with the models they estimate. All of the models use similar specifications for the natural (low frequency) and cyclical (high frequency) components of the unemployment rate, and are estimated using the Kalman filter. They tend to find evidence in favour of the hysteresis hypothesis, particularly for European countries, which is consistent with an extensive literature documenting the existence of unit roots in European unemployment rates (Stanley 2004).

In this paper, we present new evidence for the existence of hysteresis in the three most populous European countries: Germany, France, and the United Kingdom. Our empirical strategy is based on an unobserved components model which is structurally similar to those listed in table 1, in which the characterisation of hysteretic unemployment dynamics is similar to the theoretical models discussed above. Our contributions, over and above the existing literature, are follows:

paper	model equations	estimation
Jaeger and Parkinson (1994)	$u_t = n_t + c_t$	max. likelihood
	$\Delta n_t = \alpha c_{t-1} + \epsilon_t$	
	$c_t \sim AR(2)$	
	$d_t = \beta d_{t-1} + \delta \Delta c_t + v_t$	
Assarsson and Jansson (1998)	$u_t = n_t + c_t$	max. likelihood
	$\Delta n_t = \alpha c_{t-1} + \epsilon_t$	
	$c_t \sim AR(p)$	
	$\beta(L)d_t = \delta(L)c_t + m(L)v_t$	
	+ output gap equation	
Logeay and Tober (2006)	$u_t = n_t + c_t$	max. likelihood
	$\Delta^2 \tau_t = \epsilon_t + \Delta v_t$	
	$n_t = \tau_t + \alpha u_{t-1}$	
	$c_t \sim AR(2)$	
	$\theta(L)\pi_t = \beta c_t + \gamma x_t + e_t$	
Di Sanzo and Pérez-Alonso (2011)	$u_t = n_t + c_t$	max. likelihood
	$\Delta n_t = \begin{cases} \alpha_1 c_{t-1} + \epsilon_t & \text{if } q_{t-1} \geq \gamma \\ \alpha_2 c_{t-1} + \epsilon_t & \text{if } q_{t-1} < \gamma \end{cases}$	
	$q_t = u_{t-1} - u_{t-d}$	
	$c_t \sim AR(2)$	
	$\beta(L)d_t = \delta c_t + v_t$	
Mossfeldt and Österholm (2011)	$u_t = n_t + c_t$	max. likelihood
	$\Delta n_t = \alpha c_{t-1} + \epsilon_t$	
	$c_t \sim AR(2)$	
	$\theta(L)\pi_t = \beta(L)c_t + \gamma(L)x_t + e_t$	
	+ output gap equations	
Bechný (2019)	$u_t = n_t + c_t$	Bayesian
	$\Delta n_t = \mu + \alpha c_{t-1} + \epsilon_t$	
	$c_t \sim AR(2)$	
	$\theta(L)w_t = \beta(L)c_t + \gamma(L)x_t + e_t$	
Stockhammer and Calvert Jump (2022)	$u_t = n_t + c_t$	max. likelihood
	$\Delta n_t = \alpha c_{t-1} + \epsilon_t$	
	$c_t \sim AR(2)$	
	$\theta(L)\pi_t = \beta c_{t-1} + \gamma(L)x_t + e_t$	

Table 1: Literature using unobserved components models. u_t denotes unemployment, n_t denotes the natural rate of unemployment, c_t denotes cyclical unemployment, d_t denotes a measure of output growth, π_t denotes price inflation, w_t denotes wage inflation, and x_t denotes a vector of control variables.

1. Unlike the models in table 1, we generalise the specification of the natural (low frequency) component of the unemployment rate to allow for a persistent but stationary natural rate.

2. Using this specification of the natural rate, we derive and estimate a reduced form Phillips curve which does not require any assumptions on the cyclical (high frequency) component of the unemployment rate.

3. As our approach does not require any assumptions on the cyclical component of the unemployment rate, we can examine the robustness of our estimates to both heteroskedasticity and variations in the sample span.

Specifically, our Phillips curve takes the form of an ARIMAX model, i.e., an autoregressive moving average model in the first difference of the inflation rate, with the unemployment rate as an exogenous regressor. The relative ease of estimating this model means that we can examine the robustness of our estimates to autoregressive conditional heteroskedasticity and temporal stability. In turn, this means that our results should be considerably more robust to model misspecification than those in the existing literature.

While the focus of this paper is on labour market dynamics and policy, hysteresis has far reaching implications in other directions. Unemployment hysteresis undermines the demand side – supply side dichotomy that many (if not most) mainstream models are based on. If hysteresis is present, demand shocks will show effects not only in the short run, but also in the long run, so any medium-term macroeconomic equilibrium will not be anchored in a supply-side determined labour market equilibrium. For economic policy, this means that in times of elevated unemployment the inflationary pressures caused by expansionary policies will be temporary, as expansionary policies affect both actual unemployment and the NAIRU. Theoretically, unemployment hysteresis complements Post Keynesian models of induced technological change (e.g., Fazzari et al, 2020). In these models, demand shapes not only short run growth, but also the long run equilibrium, with profound implications for economic policy.

The paper proceeds as follows. We discuss the natural rate and the hysteresis hypothesis in section 2, and our modelling strategy in section 3. Section 4 discusses the estimation strategy and data, and section 5 presents the results. Finally, section 6 compares our results to the wider literature on hysteresis, and section 7 discusses policy implications.

2 Theoretical background

Since the seminal contributions of Phillips (1958) and Samuelson and Solow (1960), most macroeconomists have acknowledged the existence of some kind of trade-off between inflation and unemployment. In particular, in response to aggregate demand shocks like higher interest rates, falls in government expenditure, or financial crises, inflation and unemployment are expected to move in opposite directions. This observation is often formalised using some variation of the expectations augmented Phillips curve,

$$\pi_t = \pi_t^e + \beta(u_t - n_t) + v_t,$$

where π_t denotes the inflation rate, π_t^e denotes the expected inflation rate, u_t denotes the unemployment rate, and v_t denotes a white noise supply shock with $\mathbb{E}[v_t] = 0$. The parameter β, which will usually be negative, determines the extent of the short run trade-off. To make the equation operational, one usually assumes that π_t^e can be approximated by some function of observables, which may or may not be the rational expectations forecast. To arrive at the canonical accelerationist Phillips curve, one assumes that $\pi_t^e = \pi_{t-1}$, which is the rational expectations forecast when inflation follows a random walk. We then have,

$$\Delta\pi_t = \beta(u_t - n_t) + v_t,$$

from which it follows that $\mathbb{E}[\Delta\pi_t | u_t = n_t] = 0$ and $\mathbb{E}[\Delta^2\pi_t | u_t = n_t] = 0$, i.e., the inflation rate is stable when the unemployment rate is equal to n_t. Thus, n_t is the non-accelerating inflation rate of unemployment, or NAIRU.

As observed in Stockhammer (2008), the NAIRU theory is an interesting theoretical object, in that (unlike most parts of macroeconomic theory) it can be given Marxian, Post Keynesian and New Keynesian interpretations. Exactly how one wishes to interpret the NAIRU depends on, among other things, the issue of its exogeneity. The strongest form of the natural rate hypothesis, for example, states that the NAIRU is only affected by the institutional structure of the labour market (e.g., Siebert, 1997). However, this strong form hypothesis was (apparently) falsified by the experience in Europe of the 1980s, in which significant increases in unemployment rates were not accompanied by decelerating prices, as an exogenous NAIRU model would predict. This provoked the development of endogenous NAIRU models, or models of unemployment hysteresis.

Various hysteresis mechanisms were proposed from the 1980s onwards, including but not limited to the insider-outsider mechanisms of Blanchard and Summers (1986, 1987, 1988), the skill-loss mechanism of Pissarides (1992), and the social norm mechanisms of Skott (2005) and Stockhammer (2011). This literature spans the Post Keynesian and New Keynesian literatures, and reflects the basic Keynesian proposition that capitalist economies are stable at (and can converge towards) a wide variety of unemployment rates. In the empirical literature, a commonly used reduced form model is the Hargreaves-Heap (1980) specification,

$$n_t = n_{t-1} + \alpha(u_{t-1} - n_{t-1}),$$

which can be rearranged to yield,

$$n_t = (1-\alpha)n_{t-1} + \alpha u_{t-1},$$

and therefore defines the NAIRU as an exponentially weighted moving average of previous unemployment rates. This specification is used by all of the papers in the existing unobserved components literature listed in table 1, with the single exception of Logeay and Tober (2006). It is also used in the theoretical models discussed in section 1. The unemployment hysteresis extension to the textbook three equation model in Lavoie (2009), for example, uses a Phillips curve of the form,

$$\Delta\pi_t = \beta(u_t - u_{t-1}),$$

which is implied by the 'full hysteresis' parametrisation in which $\alpha = 1$. The model in Michl and Oliver (2019) uses the following equations to define the Phillips curve,

$$\pi_t = \chi\pi^T + (1-\chi)\pi_{t-1} + \beta(y_t - y_t^n),$$

$$y_t^n = (1-\alpha)y_{t-1}^n + \alpha y_{t-1},$$

which – aside from the fact that actual and natural unemployment rates are replaced with the actual and target output rates (y_t and y_t^n) – nests the inflation and natural rate specifications outlined above. In the New Keynesian literature, the model in Kienzler and Schmid (2014) incorporates a specification of potential output that nests the specification in Michl and Oliver (2019), while Galì (2022) directly incorporates the Hargreaves-Heap specification for a natural rate of employment.

3 Baseline model

If we assume that the cyclical component of the unemployment rate is stationary, then the empirical models in table 1 imply that the natural rate and unemployment rate are integrated of order 1. Non-stationarity is not, however, strictly required by either the supply-side natural rate or the hysteresis hypotheses, which simply require that we can conceptually divide the unemployment rate into low frequency and high frequency components. We therefore generalise the Hargreaves-Heap specification for the natural rate to,

$$n_t = \gamma n_{t-1} + \alpha u_{t-1}, \tag{1}$$

which reduces to the Hargreaves-Heap specification when $\gamma = 1 - \alpha$. By combining (1) with the accelerationist Phillips curve,

$$\Delta\pi_t = \beta(u_t - n_t) + v_t, \tag{2}$$

we arrive at the reduced form model,

$$\Delta\pi_t = \gamma\Delta\pi_{t-1} + \beta u_t - \beta(\alpha+\gamma)u_{t-1} + v_t - \gamma v_{t-1}, \tag{3}$$

in which v_t is a white noise supply shock with $\mathbb{E}[v_t] = 0$, as before. Thus, the reduced form Phillips curve is an ARIMAX model in the inflation and unemployment rates, i.e., an autoregressive moving average model in the first difference of the inflation rate, with the unemployment rate as an exogenous regressor.

The reduced form in (3) is a useful specification for two reasons. First, it only requires the estimation of three slope parameters plus a single error variance. As unemployment series with a useful span are only available at annual frequency for most European countries, models with any more than 3 or 4 parameters quickly run into degrees of freedom problems. The United Kingdom, for example, only has quarterly unemployment rate data consistent with the LFS definition after 1992; all quarterly data prior to this are interpolated. As any meaningful study of the natural rate hypothesis has to include the 1970s and 1980s in its sample, we are therefore limited to the use of annual data. And second, the hysteresis parameter α is straightforwardly identified as the model can be parametrised as,

$$\Delta\pi_t = \phi_1\Delta\pi_{t-1} + \phi_2 u_t + \phi_3 u_{t-1} + v_t + \phi_4 v_{t-1}, \tag{4}$$

subject to the linear restriction $\phi_1 = -\phi_4$, which yields a point estimate for $\alpha = -\phi_3/\phi_2 - \phi_1$, a confidence interval for which can be computed using the delta method. Finally, while our specification of the natural rate in (1) does not incorporate a shock to labour market institutions, in practice this long-run supply shock is difficult to identify separately to the short-run supply shock v_t.

4 Estimation and data

The reduced form Phillips curve in (4) is an ARIMAX model, which we estimate in Stata by maximum likelihood using the Kalman filter. One alternative to estimating the reduced form would be to estimate a fully specified unobserved components system,

$$n_t = \gamma n_{t-1} + \alpha u_{t-1},$$

$$\Delta\pi_t = \beta c_t + v_t,$$

$$\varphi(L)c_t = \zeta_t,$$

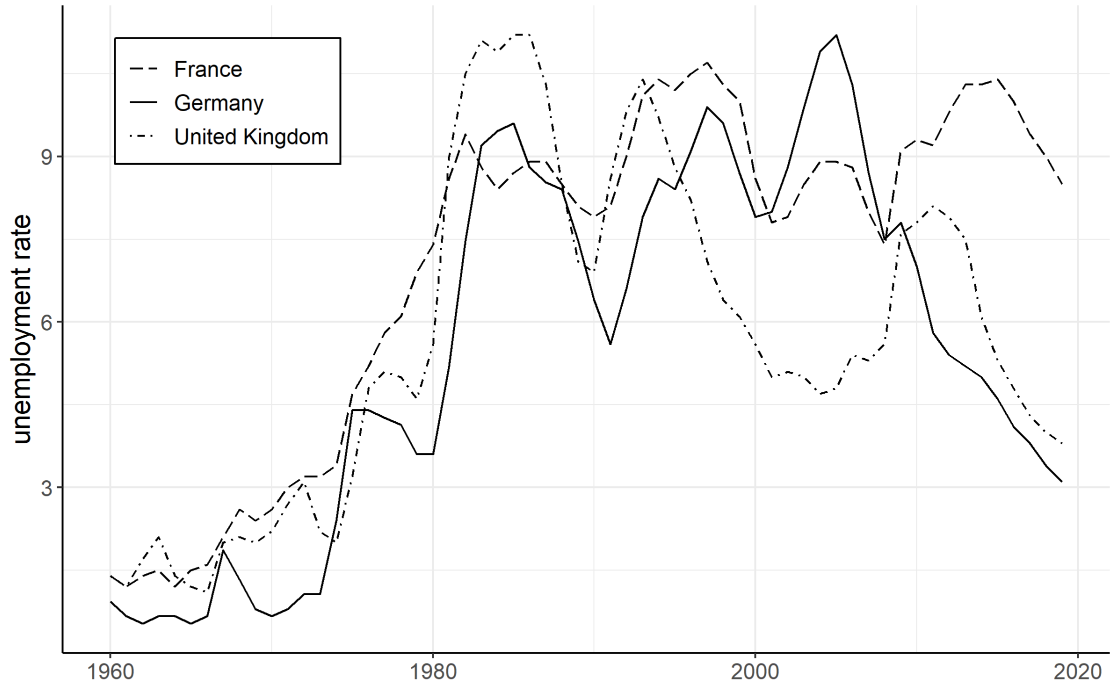
$$u_t = n_t + c_t,$$

also by maximum likelihood using the Kalman filter, which is the approach taken by the existing empirical literature in table 1. However, this requires a specification of the lag polynomial $\varphi(L)$, and at least two more parameters to be estimated. Estimation of the reduced form in (4) is, therefore, not only sufficient to identify the degree of hysteresis, but also avoids the need to specify the high frequency component of unemployment, and mitigates the associated degrees of freedom problem.

An alternative approach would be to estimate one of the theoretical models discussed in sections 1 and 2, again using maximum likelihood or a moment matching routine. However, this would involve an even more highly-specified model than those employed in the empirical literature, and it would not be clear how robust the resulting parameter estimates were to model specification changes. One of the advantages of our approach is that, as we do not have to model the demand-side block of the (implicit) macroeconomic model, our estimates of the hysteresis parameter should be relatively robust to model misspecification.

A reliable source of annual unemployment and inflation data for Germany, France, and the UK is the AMECO database, which is used by the European Commission to estimate its NAIRU models. We use these data, specifically the unemployment rate coded ZUTN, and the consumer price index coded ZCPIN. As the unemployment rate is recorded in percentage points (i.e. 1% unemployment is recorded as "1", rather than "0.01"), we define the inflation rate as $100 \times \Delta P_t/P_{t-1}$, where P_t is the price index at time t. The sample runs from 1960 to 2019 for all countries, aside from the unemployment rate data for Germany which is split between West Germany and Germany (see appendix A). As our sample ends in 2019, we exclude the structural changes posed by furlough and short-work policies during Covid-19, which will require revisiting in the future as more post-pandemic data becomes available.

Figure 1 plots the unemployment and inflation rate data for the three countries. Inflation rates were high in the 1970s, with Germany experiencing a relatively modest increase, and then decreased for all countries during the Great Moderation. In contrast, unemployment rates were relatively low during the 1960s and 1970s, and then increased rapidly in all countries during the 1980s. Unemployment remained elevated in France between the mid-2000s and the eve of the Covid-19 crisis, but fell quite rapidly in the UK and Germany over



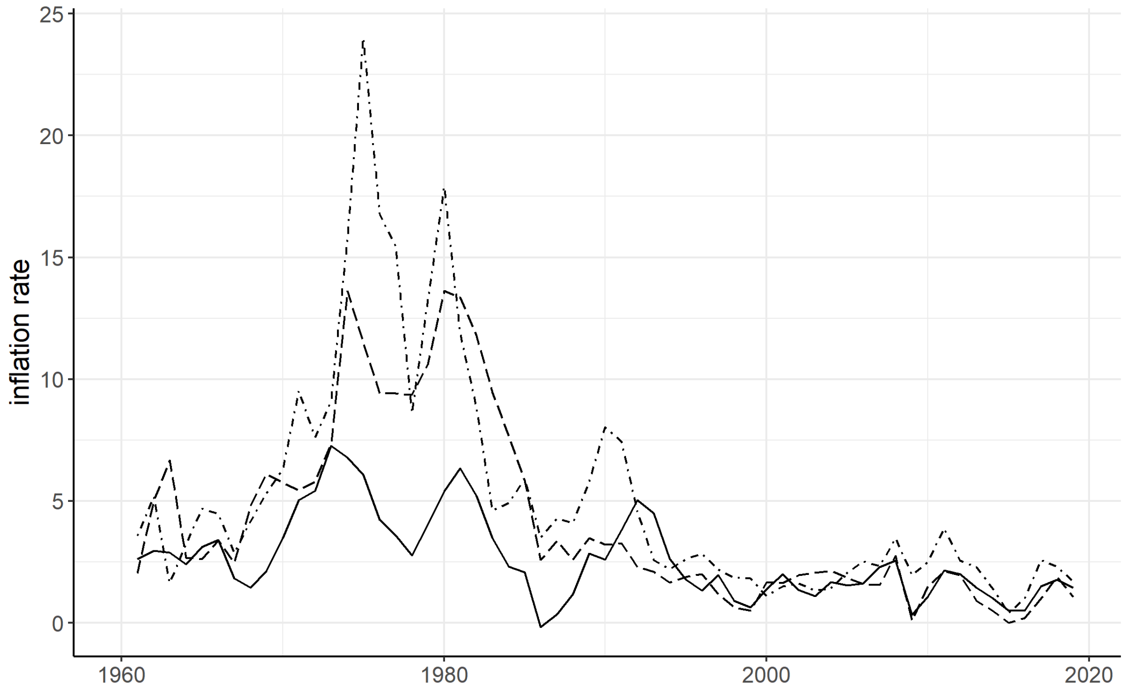


Figure 1: Time series plots of annual unemployment rates (top panel) and inflation rates (bottom panel) for France, Germany, and the UK.

the same time period. Finally, the variance of unemployment in each country appears to be low prior to the 1980s and high after the 1980s, while the opposite appears to be true for inflation. This suggests that we need to control for ARCH effects in (4), which we initially explored using the simple ARCH(1) specification,

$$\mathsf{Var}_t[v_t] = \phi_5 + \phi_6 v_{t-1}^2. \tag{5}$$

However, the estimation of (4) with (5) resulted in very imprecise estimates of ϕ_6, and in some cases estimates which violated the stationarity condition. Instead of presenting unconditional estimates of (4) with (5), therefore, we present robustness plots for our estimates of α as ϕ_6 is varied between 0.1 and 0.9. This is sufficient to examine the robustness of our estimates of the degree of hysteresis to the presence of ARCH effects, without having to estimate the (badly identified) ARCH slope parameter. Note, however, that we do allow ϕ_5 in (5) to be freely estimated.

5 Results

Figure 2 summarises our results for the degree of hysteresis estimated using the ARIMAX model in (4) on the whole sample. The circle markers are the point estimates of α for the baseline specification, i.e., the specification subject to the linear constraint $\phi_1 = -\phi_4$; the triangle markers are the point estimates of α for an alternative specification which is not subject to this linear constraint; and the square markers are the point estimates of α for an alternative specification which excludes the moving average term altogether. The vertical lines span the 90% confidence intervals for each point estimate.

While the estimates of α are clearly rather imprecise, particularly for France and the UK, they indicate economically significant degrees of hysteresis for each of the countries in our sample. In addition, the point estimates are in line with those found in Assarsson and Jansson (1998), Di Sanzo and Pérez-Alonso (2011), and Bechný (2019), who estimate models with a similar structure to our own. The country with the lowest hysteresis parameter in our sample is Germany, which may be driven by its subdued inflationary experience in the 1970s. This is discussed in Issing (2005), who suggests that an early adoption of strict monetary targeting by the Bundesbank, and a fear of inflationary spirals among union wage setters, kept inflation under control during this period.

Table B1 in appendix B presents the full set of estimation results corresponding to figure 2. The full results explain why, at least for Germany and the United Kingdom, excluding the moving average term from the baseline specification in (4) substantially reduces the point estimate for α. This is because both of these countries have relatively high point estimates for γ, indicating significant persistence in the natural rate stemming from sources *other* than hysteresis. Excluding the moving average term, which enters the specification as a result of autonomous persistence in the natural rate, therefore results in an inflated estimate of the degree of hysteresis for Germany and the United Kingdom. For France, on the other hand, the effect of removing the MA term on the point estimate of α is smaller, because the point estimate for γ is considerably lower.

Figure 3 presents recursive point estimates and confidence intervals for α for each country in the sample. Specifically, the x-axes indicate the end of the sample for each point estimate and confidence interval, so the leftmost point estimates and confidence intervals on each plot correspond to a sample spanning 1960 to 2000, while the rightmost point estimates and confidence intervals on each plot correspond to a sample spanning 1960 to 2019. There is a

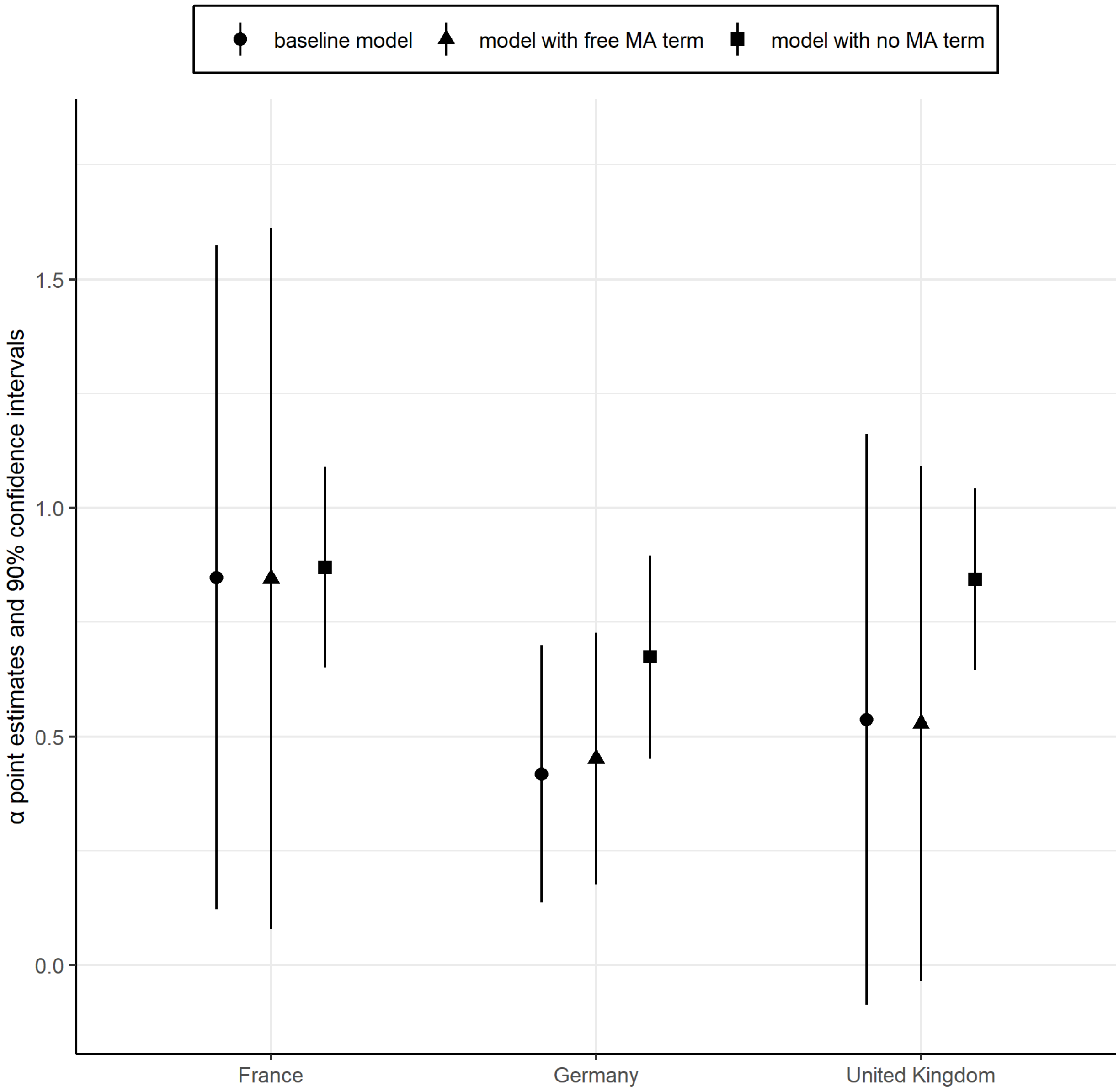


Figure 2: Point estimates and 90% confidence intervals for the degree of hysteresis in (4), for the baseline specification with a constrained moving average coefficient, an alternative specification with an unconstrained moving average coefficient, and an alternative specification with no moving average term.

small amount of parameter instability for France and Germany, in which the point estimate increases slightly once the 2008 financial crisis enters the sample (which is obscured for France by the sizeable confidence intervals prior to 2008), but the qualitative existence of hysteresis is unaffected in both cases. In comparison, both the point estimates and confidence intervals for the degree of hysteresis in the UK are remarkably stable.

As discussed in section 4, apparent time-variation in the volatility of unemployment and inflation in France, Germany and the UK suggests the need to control for ARCH effects in (4). Thus, figure 4 presents point estimates and confidence intervals for α for each country in the sample with the model in (4) augmented with an ARCH(1) error structure. Because the estimation of (4) with an unconstrained ARCH process resulted in very imprecise estimates

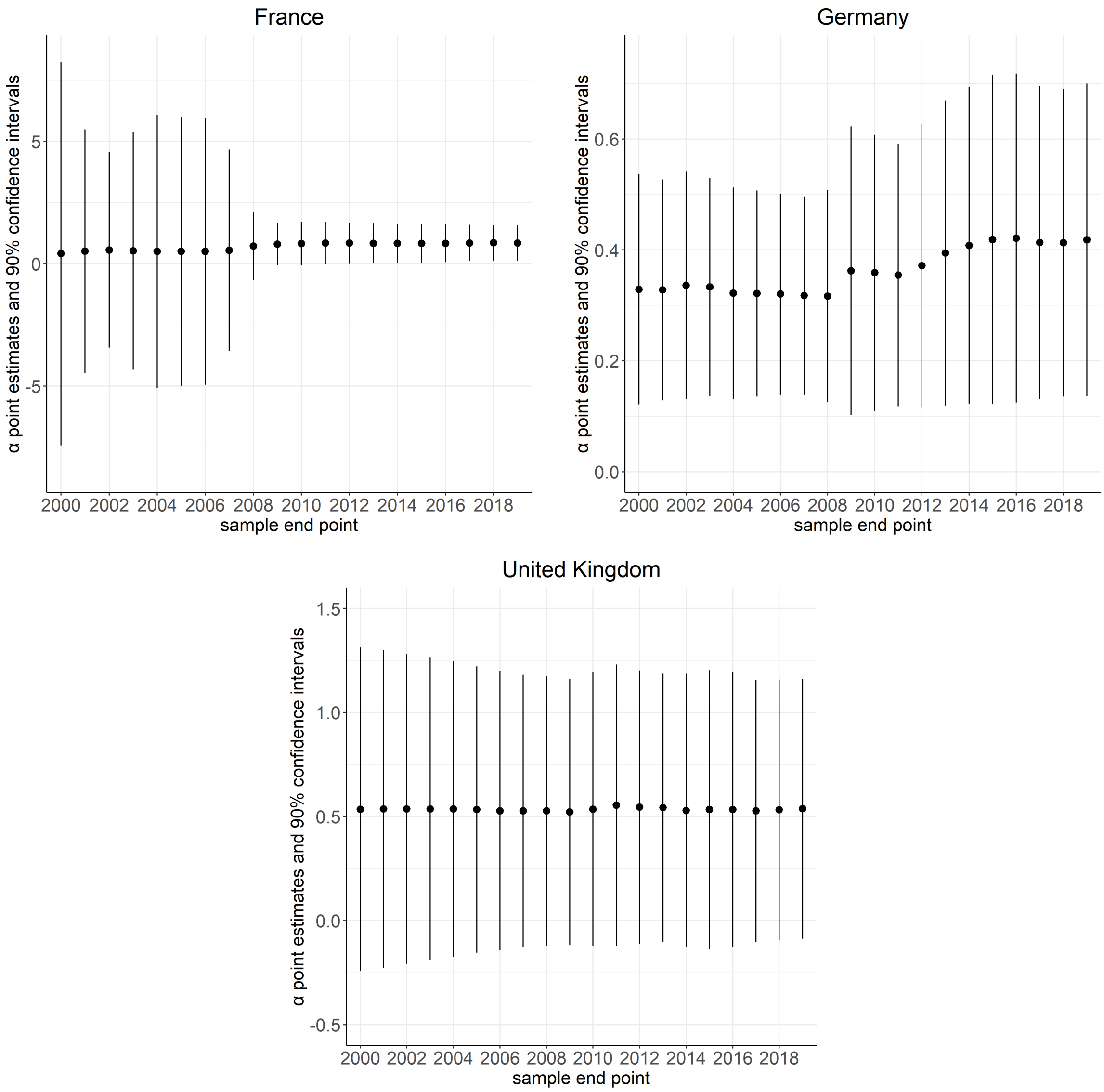


Figure 3: Point estimates and 90% confidence intervals for the degree of hysteresis in (4), estimated on recursively increasing samples.

of the ARCH slope parameter, figure 4 presents the estimates of α conditional on fixed values of the ARCH slope parameter between 0.1 and 0.9. Interestingly, incorporating heteroskedasticity appears to increase the point estimate of α for France, decrease it for the United Kingdom, and leave it unaffected for Germany. It is not clear why this should be the case, although it is worth noting that the qualitative existence of hysteresis is robust to heteroskedasticity in all three countries. The only possible exception to this is the UK, but this is mainly due to problems of imprecision, and one imagines that the confidence intervals for the UK would exclude zero with ten or twenty years' extra observations.

To summarise, our baseline point estimates for the degree of hysteresis are around 0.85 for France, just over 0.4 for Germany, and just over 0.5 for the United Kingdom. In other words, we would expect an increase in the unemployment rate of 1 percentage point (for any reason) to result in a subsequent increase in the natural rate by around 0.85 percentage points for France, just over 0.4 percentage points for Germany, and just over 0.5 percentage points for the United Kingdom, followed by a slow decline. Compared with a non-hysteretic

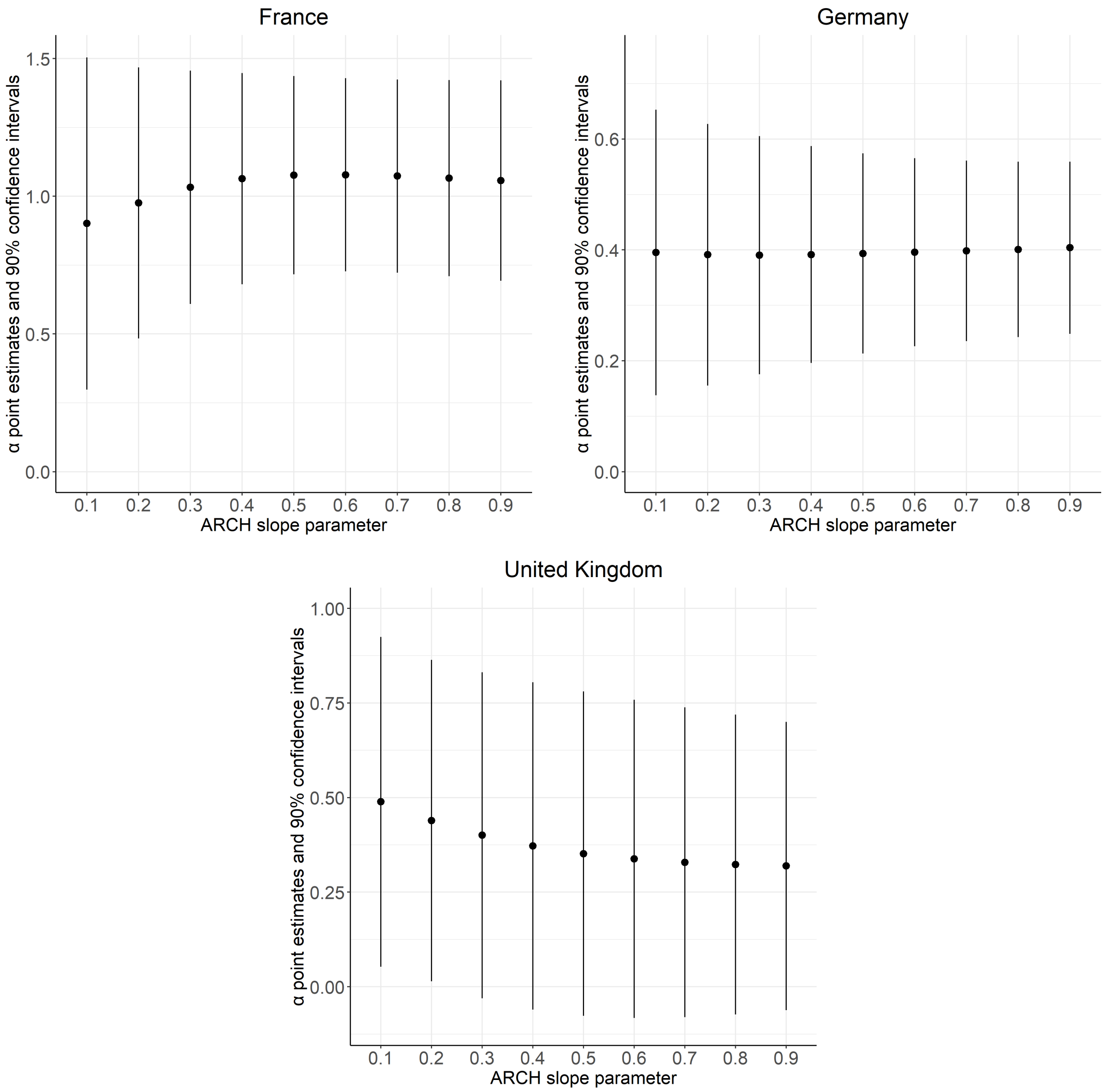


Figure 4: Point estimates and 90% confidence intervals for the degree of hysteresis in (4), estimated conditional on ARCH slope parameters between 0.1 and 0.9. Note that the unconditional variance of the error term is freely estimated.

economy, this dampens the effect of a change in the unemployment rate on inflation. While these estimates are rather imprecise, they are robust to both changes in the sample span and autoregressive conditional heteroskedasticity. These results support contemporary warnings of the risk of scarring effects following the Covid-19 crisis, and the recent resurgence of interest in theoretical models of hysteresis.

6 Relation to the wider empirical literature

The results presented in section 5 contribute to a growing empirical literature on the existence of hysteresis. Traditionally this literature has utilised unit root tests, with the existence of a unit root in the unemployment rate being seen as evidence of hysteresis (see Stanley 2004 for a useful survey). However, as discussed above, the behaviour of unemployment and inflation in Europe during the 1980s makes a constant NAIRU all but impossible, and this is reflected in the time varying NAIRU models used by the European Commission and OECD. As the unemployment rate in these models has a unit root by construction, the unit root approach to hysteresis is of limited utility. Of more interest is the reduced form Phillips curve approach, which is closely related to our approach. Originally introduced in Gordon (1989), this has been applied by Fortin (1991) and Burger and Marinkov (2006). Gordon (1989) does not find evidence of full hysteresis, but finds "traces of hysteresis" in the USA and UK, where prolonged slumps are found to exert very little downward pressure on prices, and Fortin (1991) finds hysteresis effects in Canada after 1972. Burger and Marinkov (2006) applies the approach to South Africa, finding some evidence of hysteresis in output.

An alternative approach to hysteresis is to ignore the reduced form evidence between inflation and unemployment, and directly examine the impact of long term unemployment on wages or future job prospects. Arulampalam et al (2000), for example, use the British Household Panel Survey to demonstrate that British individuals' past employment states directly affect their future labour market fortunes, "perhaps because of depreciation of human capital, or because employers use an individual's previous labour market history as a screening mechanism." Elsby et al (2015) provide a useful discussion of this issue in the context of the Beveridge curve, and Mathy (2018) examines duration effects in the US Beveridge curve during the Great Depression. Of particular interest are Kroft et al (2013) and Farber et al (2016), which examine the existence of duration dependence by sending fictitious job applications to US employers, and Eriksson and Rooth (2014), who do the same for Swedish employers. Kroft et al (2013) find that the probability of receiving an interview decreases with the length of an applicant's unemployment spell, and suggest that this is due to employer screening. Eriksson and Rooth (2014) find that past spells of unemployment are irrelevant to the probability of receiving an interview, but contemporary unemployment spells lower the probability of receiving an interview by twenty percent for low and medium skilled jobs. Farber et al (2016), in contrast, find that there is no relationship between callback rates and the duration of unemployment for college educated females. A very recent paper in this line of research is Farber et al (2019), who find that lower callback rates are mainly a function of long term unemployment rather than short term unemployment.

It is also possible to examine the reduced form relationship between inflation and unemployment and duration effects simultaneously. Llaudes (2005) and Rusticelli (2014) estimate versions of the OECD NAIRU model that incorporate measures of long term unemployment as explanatory variables in the Phillips curve and NAIRU equations. Llaudes (2005) concludes that, "the incidence of long-term unemployment is key to understanding the true pressures on prices", with high long term unemployment having little effect on inflation according to his estimates (ibid.: 20). Rusticelli (2014) finds similar results for Greece, Ireland, Italy, Portugal, and Spain, but finds statistically insignificant effects for Germany, France, and the UK. Her results do not rule out hysteresis effects in Germany, France, and the UK, but suggest that the methodology applied in the present paper - i.e. incorporating actual unemployment in the NAIRU equation - may be capturing the effects of a different hysteresis mechanism.

Finally, it is possible to examine hysteresis effects using VAR models, as in the recent paper by Rodriguez-Gil (2017), and cross-country panel regressions, as in Baccaro and Rei (2007), Stockhammer and Klär (2011), and Stockhammer et al (2014). These papers control for labour market institutions including employment protection, social security levels, union density, and so on, and find an important independent role of capital accumulation and real interest rates in driving medium run unemployment rates. Rodriguez-Gil (2017) finds evidence of various hysteresis channels alongside orthodox institutional mechanisms, particularly the generosity of unemployment benefits, in the UK and the Netherlands.

To summarise, the existing literature does not unequivocally support the hysteresis hypothesis, and where it does, it is not always evaluated against the natural rate hypothesis as defined in the present paper. Nevertheless, it is fair to interpret the literature as broadly supportive of the existence of hysteresis. Of particular importance are the experimental papers on the existence of duration effects in the job market, including Kroft et al (2013) and Eriksson and Rooth (2014), which find direct evidence for the microeconomic mechanisms underpinning the type of aggregate relationship explored in the present paper and the wider macroeconomic literature. Our results lend support to the existing literature, and are consistent with the existing evidence in favour of the hysteresis hypothesis.

7 Concluding remarks

In this paper, we have presented new evidence in favour of the hysteresis hypothesis for Germany, France, and the United Kingdom, using a dataset of unemployment and inflation rates that spans 1960 – 2019. By assuming that the inflation rate responds to the difference between the unemployment rate and its natural (low frequency) component, our estimates imply that an increase in the unemployment rate of 1 percentage point results in a subsequent increase in the natural rate by around 0.85 percentage points for France, just over 0.4 percentage points for Germany, and just over 0.5 percentage points for the United Kingdom. Compared with a non-hysteretic economy, this dampens the effect of a change in the unemployment rate on inflation, and increases the persistence of unemployment following aggregate demand shocks.

Our results are robust to changes in the sample span and the incorporation of autoregressive conditional heteroskedasticity. Moreover, they support growing empirical and theoretical literatures on the existence of hysteresis, particularly in Europe. Actual unemployment rates and estimated NAIRUs across Europe remain high, suggesting the existence of substantial welfare losses across the continent. If these welfare losses are the result of hysteresis rather than sub-optimal institutions, they should be straightforward to remedy by a continent-wide fiscal policy expansion. This is, in fact, the central policy implication of Michl and Oliver (2019), to which our paper can be seen as an empirical complement.

Increasingly, the empirical literature on unemployment dynamics supports an active role for aggregate demand management policy. In fact, in a forecasting exercise completed just prior to the Covid-19 crisis by the European Commission, the Director General of Economic and Financial Affairs observed that,

> Using available fiscal space actively would allow Member States not only to provide a fiscal stimulus amid the sharp slowdown in manufacturing that threatens to spill over to the labour market, but also to refresh and modernise the public capital stock, thereby boosting potential growth . . . This window of opportunity should be used now. (European Commission 2019: xi).

That window of opportunity was not used in 2019, but the Covid-19 and cost-of-living crises have subsequently provided a significant *moral* stimulus to the creation and maintenance of full employment. It remains to be seen whether the European Union's recent budget, as well as its 'NextGenerationEU' recovery plan, will be sufficient to reduce unemployment on a sustained basis. The results presented in this paper, and the wider literature on hysteresis, suggest that sustained reductions are at least possible, and that expansionary policy ought to be maintained until they are achieved.

References

Arulampalam, W., Booth, A., and Taylor, M. 2000. Unemployment persistence. *Oxford Economic Papers*, 52.1, 24-50.

Assarsson, B., and Jansson, P. 1998. Unemployment persistence: The case of Sweden. *Applied Economics Letters*, 5.1, 25-29.

Baccaro, L., and Rei, D. 2007. Institutional determinants of unemployment in OECD countries: Does the regulatory view hold water? *International Organization*, 61.3, 527-569.

Bechný, J. 2019. Unemployment hysteresis in the Czech Republic *Prague Economic Papers*, 28.5 (forthcoming).

Blanchard, O. J., and Summers, L. H. 1986. Hysteresis and the European unemployment problem. *NBER Macroeconomics Annual*, 1, 15-78.

Blanchard, O. J., and Summers, L. H. 1987. Hysteresis in unemployment. *European Economic Review*, 31.1-2, 288-295.

Blanchard, O. J., and Summers, L. H. 1988. Beyond the natural rate hypothesis. *The American Economic Review*, 78.2, 182-187.

Burger, P., and Marinkov, M. 2006. The South African Phillips curve: How applicable is the Gordon model? *South African Journal of Economics*, 74.2, 172-189.

Calvert Jump, R. and Levine, P. 2021. Hysteresis in the New Keynesian three equation model (No. 0821). School of Economics, University of Surrey.

Calvert Jump and Stockhammer (2022).

Carney, M. 2014. Inclusive capitalism - creating a sense of the systemic. https://www.bis.org/review/r140528b.pdf. Speech by Mr Mark Carney, Governor of the Bank of England and Chairman of the Financial Stability Board, at the Conference on Inclusive Capitalism, London, 27th May 2014.

Di Sanzo, S., and Perez-Alonso, A. 2011. Unemployment and hysteresis: A nonlinear unobserved components approach. *Studies in Nonlinear Dynamics & Econometrics*, https://doi.org/10.2202/1558-3708.1806.

Draghi, M. 2014. Unemployment in the euro area. https://www.ecb.europa.eu/press/key/date/2014/html/sp140822.en.html. Speech by Mario Draghi, President of the ECB, Annual central bank symposium in Jackson Hole, 22 August 2014.

Elsby, M., Michaels, R., and Ratner, D. 2015. The Beveridge Curve: A Survey. *Journal of Economic Literature*, 53.3, 571-630.

Engler, P., and Tervala, J. 2018. Hysteresis and fiscal policy. *Journal of Economic Dynamics and Control*, 93, 39-53.

Erikson, S., and Rooth, D. 2014. Do employers use unemployment as a sorting criterion when hiring? Evidence from a field experiment. *American Economic Review*, 104.3, 1014-1039.

European Commission. 2019. European Economic Forecast Autumn 2019. *European Commission Institutional Paper 115.*

Farber, H., Herbst, C., Silverman, D., and von Wachter, T. 2019. Whom Do Employers Want? The Role of Recent Employment and Unemployment Status and Age. *Journal of Labor Economics*, 37.2, 323-349.

Farber, H., Silverman, D., and von Wachter, T. 2016. Determinants of Callbacks to Job Applications: An Audit Study. *American Economic Review: Papers and Proceedings*, 106.5, 314-318.

Fazzari, S., P. Ferri. and A. Variato. 2020. Demand-led growth and accommodating supply. *Cambridge Journal of Economics*, 44.3, 583–605

Fortin, P. 1991. The Phillips curve, macroeconomic policy, and the welfare of Canadians. *The Canadian Journal of Economics / Revue Canadienne d'Economique*, 24.4, 774-803.

Galí, J. 2022. Insider–outsider labor markets, hysteresis, and monetary policy. *Journal of Money, Credit and Banking* 54.S1, 53-88.

Gordon, R. 1989. Hysteresis in history: Was there ever a Phillips curve? *The American Economic Review: Papers and Proceedings*, 79.2, 220-225.

Hargreaves-Heap, S. 1980. Choosing the wrong natural rate: Accelerating inflation or decelerating employment and growth? *The Economic Journal*, 90.359, 611-620.

Issing, O. 2005. Why did the great inflation not happen in Germany? *Federal Reserve Bank of St. Louis Review*, 87.2 Part 2, 329-335.

Jaeger, A., and Parkinson, M. 1994. Some evidence on hysteresis in unemployment rates. *European Economic Review*, 38.2, 329-342.

Jurkovic, P. 2023. Explainer: Energy price support schemes. UK in a changing Europe blog, `https://ukandeu.ac.uk/explainers/energy-price-support-schemes/`.

Kienzler, D. and Schmid, K. 2014. Monetary policy and hysteresis in potential output. *Scottish Journal of Political Economy*, 61.4, 371-396.

Kroft, K., Lange, F., and Notowidigdo, M. 2013. Duration dependence and labor market conditions: Evidence from a field experiment. *The Quarterly Journal of Economics*, 128.3, 1123-1167.

Lavoie, M. 2009. Taming the new consensus: Hysteresis and some other post keynesian amendments. In *Macroeconomic theory and macroeconomic pedagogy*, Fontana and Setterfield (eds.) 191-213.

Llaudes, R. 2005. The Phillips curve and long-term unemployment. European Central Bank Working Paper 441.

Logeay, C., and Tober, S. 2006. Hysteresis and the NAIRU in the Euro Area. *Scottish Journal of Political Economy*, 53.4, 409-429.

Mathy, G. 2018. Hysteresis and persistent long-term unemployment: The American Beveridge Curve of the Great Depression and World War II. *Cliometrica*, 12, 127-152.

Michl, T. and Oliver, K. 2019. Combating hysteresis with output targeting. *Review of Keynesian Economics*, 7.1, 6-27.

Mossfeldt, M. and Österholm, P. 2011. The persistent labour-market effects of the financial crisis. *Applied Economics Letters*, 18.7, 637-642.

Phillips, A. W. 1958. The relation between unemployment and the rate of change of money wage rates in the United Kingdom, 1861-1957. *Economica*, 25.100, 283-299.

Pissarides, C. 1992. Loss of skill during unemployment and the persistence of employment shocks. *The Quarterly Journal of Economics*, 107.4, 1371-1391.

Quine, O. 2021. Janet Yellen Warns on Cutting Stimulus as Democrats Plan Vast Jobs, Infrastructure Package. *Newsweek*, 02/19/21, https://www.newsweek.com/janet-yellen-president-biden-defend-stimulus-bill-second-package-1570449.

Rodriguez-Gil, A. 2017. Hysteresis and labour market institutions. Evidence from the UK and the Netherlands. *Empirical Economics*, https://doi.org/10.1007/s00181-017-1338-y.

Rusticelli, E. 2014. Rescuing the Phillips curve. *OECD Journal: Economic Studies*, 2014.1, 109-127.

Samuelson, P. A., and Solow, R. M. 1960. Analytical aspects of anti-inflation policy. *The American Economic Review*, 50.2, 177-194.

Siebert, H. 1997. Labor Market Rigidities: At the Root of Unemployment in Europe. *Journal of Economic Perspectives*, 11.3, 37-54.

Skott, P. 2005. Fairness as a source of hysteresis in employment and relative wages. *Journal of Economic Behavior & Organization*, 57.3, 305-331.

Stanley, T. D. 2004. Does unemployment hysteresis falsify the natural rate hypothesis? A meta-regression analysis. *Journal of Economic Surveys*, 18.4, 589-612.

Stockhammer, E. 2008. Is the NAIRU theory a monetarist, new Keynesian, post Keynesian or a Marxist theory? *Metroeconomica*, 59.3, 479-510.

Stockhammer, E. 2011. Wage norms, capital accumulation, and unemployment: A post-Keynesian view. *Oxford Review of Economic Policy*, 27.2, 295-311.

Stockhammer, E., and Klär, E. 2011. Capital accumulation, labour market institutions and unemployment in the medium run. *Cambridge Journal of Economics*, 35.2, 437-457.

Stockhammer, E. and Calvert Jump, R. 2022. An Estimation of Unemployment Hysteresis. Post Keynesian Economic Society Working Paper (PKWP2221).

Stockhammer, E., Guschanski, A., and Köhler, K. 2014. Unemployment, capital accumulation and labour market institutions in the Great Recession. *European Journal of Economics and Economic Policies: Intervention*, 11.2, 182-194.

Tervala, J. 2021. Hysteresis and the welfare costs of recessions. *Economic Modelling*, 95, 136-144.

A Data preparation for Germany

A number of the AMECO series for Germany begin after re-unification, with West German data provided prior to this. To create unified series for Germany, therefore, the German data has to be back-cast. Suppose a West German series $\{x_t\}$ runs from $t = t_0$ to $t = t_m$, and an equivalent German series $\{y_t\}$ runs from $t = t_m$ to $t = t_n$. Denote by δ_t the West German series growth rate from $t-1$ to t, i.e.,

$$\delta_t = \frac{x_t - x_{t-1}}{x_{t-1}}. \tag{A.1}$$

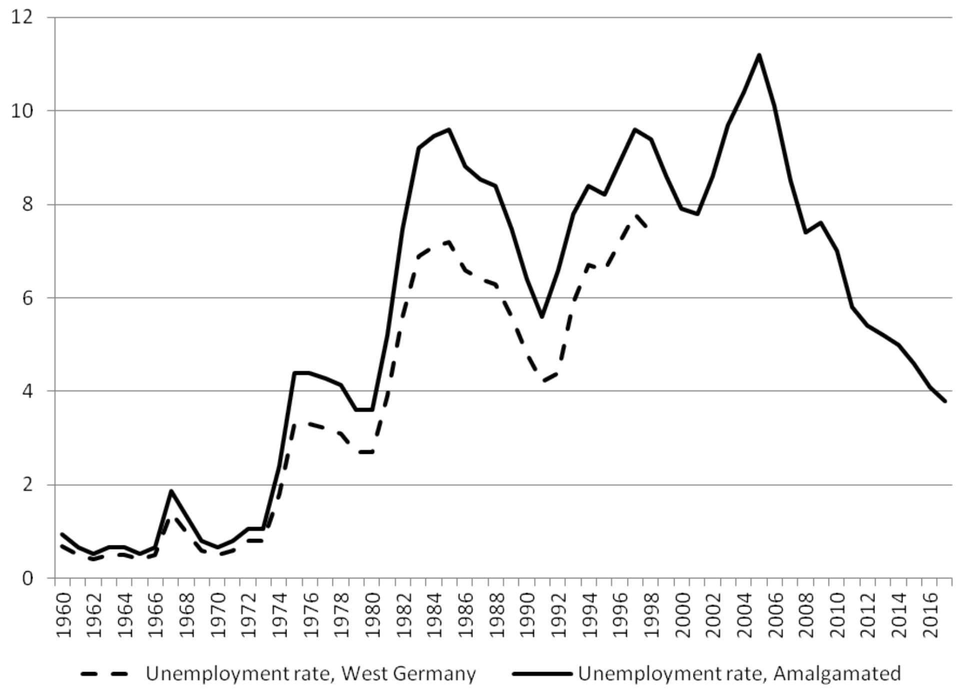
Prior to t_m - when German data is not observable but δ_t is observable - we assume that the following relation holds:

$$y_t = (1 + \delta_t)y_{t-1}. \tag{A.2}$$

Prior to t_m, we can therefore back-cast the German series by recursively calculating,

$$y_{t-1} = \frac{y_t}{1 + \delta_t}. \tag{A.3}$$

This is a fairly common approach to back-casting, and is used (for example) by the Bank of England in its "millennium of macroeconomic data" dataset. A comparison of the amalgamated unemployment rate used in the present paper with the corresponding West German series is shown below:



B Full results table

	Germany			France			United Kingdom		
	Baseline	Free MA term	No MA term	Baseline	Free MA term	No MA term	Baseline	Free MA term	No MA term
ϕ_1	0.569	0.533	0.296	0.111	0.122	0.097	0.436	0.444	0.109
	(0.001)	(0.002)	(0.027)	(0.802)	(0.799)	(0.388)	(0.308)	(0.254)	(0.366)
ϕ_2	-0.345	-0.397	-0.416	-0.358	-0.429	-0.443	-0.845	-0.759	-1.011
	(0.016)	(0.008)	(0.015)	(0.409)	(0.338)	(0.316)	(0.010)	(0.120)	(0.081)
ϕ_3	0.341	0.391	0.404	0.343	0.415	0.428	0.822	0.738	0.963
	(0.016)	(0.009)	(0.019)	(0.440)	(0.366)	(0.347)	(0.015)	(0.126)	(0.113)
ϕ_4	-0.569	-0.375		-0.111	-0.033		-0.436	-0.515	
	(0.001)	(0.090)		(0.802)	(0.950)		(0.308)	(0.218)	
γ	0.569	0.533	0.296	0.111	0.122	0.097	0.436	0.444	0.109
	(0.001)	(0.002)	(0.027)	(0.802)	(0.799)	(0.388)	(0.308)	(0.254)	(0.366)
β	-0.345	-0.397	-0.416	-0.358	-0.429	-0.443	-0.845	-0.759	-1.011
	(0.016)	(0.008)	(0.015)	(0.409)	(0.338)	(0.316)	(0.010)	(0.120)	(0.081)
α	0.418	0.451	0.674	0.847	0.845	0.870	0.537	0.528	0.844
	(0.015)	(0.007)	(0.000)	(0.055)	(0.070)	(0.000)	(0.157)	(0.123)	(0.000)

Table B1: Parameter estimates for the model in (4), for the baseline specification with a constrained moving average coefficient, an alternative specification with an unconstrained moving average coefficient, and an alternative specification with no moving average term, for each country estimated on the full sample. P-values are in parentheses.