Structural Change and Hysteresis Effects on the Labour Market

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Paper draft
(26.05.2026)

Abstract

This paper examines the relationship between hysteresis and the intensity of structural change. We investigate whether cyclical unemployment has become more structural and to which extent structural change leads to a higher entrenchment of unemployment. The idea behind stronger hysteresis effects during times of rapid structural change is that work experience and human capital devalue more quickly since there are faster changes in qualification requirements. We use an unobserved components model, which breaks down the unemployment rate into a structural and a cyclical component. Hysteresis is modelled as a delayed spillover effect from cyclical unemployment to structural unemployment. In addition, this effect is interacted with a measure of structural change. The results show significant hysteresis effects for Germany and the UK, while they were less significant for France. After a period of recession, around 11% of the cyclical unemployment of the previous period became entrenched in Germany and around 8% in the UK. However, these values varied depending on the strength of structural change, which had a positive and significant influence on hysteresis effects. The results make it clear that, specifically for Germany, the current risk of unemployment becoming entrenched must be taken seriously.

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1. Introduction

The implementation of the so-called "Hartz reforms" marked the beginning of a long-lasting upturn in the German labour market, which led to a significant reduction in the unemployment rate. This positive trend remained largely stable even during the global financial crisis. However, the coronavirus pandemic and the resulting recession marked a turning point in this development. Although the rise in unemployment during the pandemic was relatively moderate, mainly due to the use of short-time work (**?**), the subsequent energy crisis posed serious challenges for the German economy and the previously robust labour market (**?**). A slight increase in unemployment is emerging, and a closer look also reveals that the proportion of long-term unemployed has risen compared to before the pandemic (**?**).

In addition to coping with the aftermath of the crisis, the labour market is also facing other fundamental developments, above all climate change and digitalisation. According to forecasts, the structural change driven by these developments will lead to strong dynamics in the labour market (**?**). **?** expect e-mobility in the automotive sector to have negative effects on skilled workers and, in the longer term, on all skill levels. In their Economy 4.0 analysis, **?** predict that the middle skill level in particular will undergo significant changes. At the same time, the structural shift towards the service sector will continue, mainly due to a decline in the manufacturing industry (**?**), although this will have varying degrees of impact on regional labour markets (**?**). Against the backdrop of these developments and the pandemic, **?** speak of a "transformative recession," a term that still aptly describes the current situation. For the labour market, this situation carries the risk of hysteresis effects.

Hysteresis refers to the long-lasting effect of temporary events. In relation to the labour market, this means that cyclical unemployment becomes permanent. There are a number of possible causes for hysteresis. For example, work experience loses value during prolonged unemployment, and the willingness to search for work decreases. However, increased collectively agreed wages can also represent barriers to entry.

Nevertheless, there is no consensus on the significance of hysteresis effects in relation to unemployment. **?** conclude that these play a minor role and that institutional conditions and productivity shocks are more important for structural unemployment. **?** also find no evidence of hysteresis in European OECD countries when structural breaks are taken into account in the analysis. In contrast, **?**, **?**, and **?** show that hysteresis effects can have a significant impact on structural unemployment, although these effects vary greatly from country to country. To our knowledge, however, there is as yet no study that explicitly examines the relationship between hysteresis and the intensity of structural change.

Against this background, the following paper deals not only with the question of whether cyclical unemployment has become more structural, but above all with the extent to which structural change influences hysteresis effects. The idea behind this is that more pronounced structural change devalues work experience and human capital more quickly, as it leads to changes in qualification requirements. Although this paper focuses on the labour market in Germany, the labour markets in France and the United Kingdom are also considered. This is because, on the one hand, the crises and transformations

mentioned at the outset are global in nature and, on the other hand, hysteresis has been regarded primarily as a European phenomenon since the beginning of the discussion (**?**).

Two different approaches have become established in the literature to clarify the question of hysteresis. The first applies unit root tests to the unemployment time series (e.g., **?**, **?**, **?**). The second method, which is also used in this paper, breaks down unemployment into a cyclical and a structural component (e.g., **?**, **?**, **?**). The latter has the advantage of being able to distinguish between temporary and permanent shocks, which makes it possible to determine precisely whether changes in the structural unemployment rate are caused by cyclical influences (hysteresis) or structural shocks (**?**). This paper comes to two main conclusions: First, hysteresis effects can be demonstrated, with these being particularly relevant in Germany and the United Kingdom. For example, after a recessionary period, around 11% of the cyclical unemployment of the previous period in Germany and around 8% in Great Britain become entrenched. Second, the strength of structural change had a positive influence on hysteresis effects. This correlation was initially evident at the country level and was subsequently corroborated by a panel estimation.

In order to shed light on the research question, the paper is structured as follows: The next chapter discusses the theoretical background of hysteresis effects in connection with the NAIRU and structural change. The following chapter outlines the model used, the estimation procedure, and the data basis. The fourth chapter presents the results for each country and for a panel approach. Finally, the most important findings are summarized and recommendations for action are derived from them.

2. Theoretical background

The first section of this chapter briefly explains the concept of exogenous NAIRU. Building on this, the second part discusses various mechanisms that lead to hysteresis effects and relates them to human capital and structural change.

2.1. NAIRU

The *non-accelerating inflation rate of unemployment* (NAIRU) is a central concept in macroeconomic theory that describes the relationship between inflation and unemployment. This concept states that there is a certain rate of unemployment at which inflation remains stable.

However, the NAIRU was preceded by the hypothesis of the natural rate of unemployment (NRU), which gained prominence through Milton Friedman's (1968) essay on the role of monetary policy. According to this hypothesis, for a given real wage, there is also a certain unemployment rate in long-term equilibrium. This natural unemployment arises from market imperfections such as mobility or information costs. Expansionary monetary policy can reduce unemployment below the natural rate, but the price for this is ever-increasing inflation. Thus, unemployment must correspond to the NRU in long-term equilibrium.

The concept of the NAIRU arose from the natural unemployment rate, with two differences in the theoretical basis usually being cited. First, the NRU is a long-term equilibrium concept, whereas the NAIRU is the unemployment rate that is compatible with stable inflation in the short to medium term (**?**). Second, the NRU is often associated with frictional or voluntary unemployment, while the NAIRU is associated with involuntary unemployment (**??**). Apart from this, both theories are largely identical and are therefore often used synonymously (**?**).

The NAIRU concept assumes that there is an inverse relationship between inflation and unemployment (see Phillips curve). A low unemployment rate leads to rising wages and prices, as workers are in a strong bargaining position and demand for goods increases. In contrast, when unemployment is high, workers have little bargaining power and companies try to stimulate demand by lowering prices.

Mathematically, this inverse relationship between unemployment and inflation is often expressed as follows:

$$\Pi = \Pi_{-1} - a(U - U^*) + v, \tag{1}$$

where Π is the current inflation rate, Π_{-1} is the inflation rate of the previous period, U is the current unemployment rate, U^* is the NAIRU, and v are exogenous supply shocks. Here, the inflation rate is modeled as a random walk. Thus, inflation expectations correspond to inflation in the previous period. For the inflation rate to be stable in this model, unemployment must correspond to the NAIRU. In the short term, the classic dichotomy does not apply in this concept, because monetary policy has an impact on unemployment and thus on the real sphere.

In this basic concept, the level of the NAIRU is determined solely by the supply side and is therefore exogenous. While it was initially assumed that the NAIRU was constant, or that shifts were always attributable to changes in labour market structures, a less restrictive version prevailed over time (**?**). According to this, fundamental economic factors can also influence the level. In this context, **?** provides several explanations for a shift in the NAIRU. Among other things, changes in interest rates, productivity, or the production process can move the NAIRU to a new equilibrium.

2.2. Hysteresis

However, the concept of the NAIRU described above has been increasingly questioned since the 1980s. The starting point for this was the high and rising unemployment in many Western European countries since the 1970s, which could only be explained to a limited extent by the exogenous NAIRU. **?** were the first to attribute rising unemployment to hysteresis effects.

Hysteresis in the labour market describes the consolidation of cyclical unemployment into structural unemployment. Thus, current cyclical unemployment has an impact on the future structural unemployment rate. The basic NAIRU concept, which describes the inverse relationship between unemployment and inflation, remains valid despite hysteresis effects (**?**). However, the exogeneity of the NAIRU is no longer given in hysteresis

theory. This is because it is no longer exclusively dependent on supply factors, but can be influenced in the long term by demand shocks.

Over time, various causes of hysteresis effects have been identified. While the focus was initially on labour market mechanisms, goods market mechanisms have also been examined more recently. Two causes are explained in more detail below.[1]

The mechanism already used by **?** and still widely used today (e.g., **??**) is based on the insider-outsider model. This theory was significantly influenced by the work of **??**. According to this theory, there are two groups: on the one hand, the "insiders," i.e., the employed, and on the other hand, the "outsiders," i.e., the unemployed. The central idea of this model is that insiders have bargaining power. This market power of insiders is attributed to various causes: First, companies face costs for training and termination when they replace employees. Second, unions try to negotiate the highest possible collective bargaining wages on behalf of employees, and third, there are social norms that limit wage undercutting by outsiders. Especially when the number of outsiders increases due to a demand shock, this market power can become a barrier to entry for the unemployed, as wages can only be adjusted downwards to a limited extent. As a result, unemployment becomes entrenched after a demand shock.

Another cause of hysteresis is the duration of unemployment. **?** argue that an increase in unemployment is also accompanied by an increase in the number of long-term unemployed. As the duration of unemployment increases, these individuals lose human capital because their work experience becomes devalued, or they lose motivation to continue looking for a job. Regardless of whether they stop looking for work or become unattractive to employers, the long-term unemployed become irrelevant to the wage formation process. As a result, these individuals no longer exert pressure to lower real wages, which perpetuates unemployment.

For the research question, it is primarily this second mechanism, the link between unemployment and the devaluation of human capital, that is important. **?** extend a *search-and-matching model* to include the loss of human capital and analyze the role of monetary policy in relation to hysteresis. According to their analysis, several equilibria are possible in the model due to the devaluation of work experience. **?** argues that the link between human capital and the entrenchment of unemployment depends on the level of the unemployment rate. In his model, he therefore distinguishes between phases of full employment, in which the exogenous NAIRU prevails, and phases of high unemployment, in which hysteresis occurs. These hysteresis effects can lead to a new equilibrium, but one that is unstable.

But even independently of hysteresis, there is a wide range of literature on the relationship between unemployment and human capital. In his influential work, **?** shows that a temporary shock can lead to long-term unemployment if work experience is lost. The reason for this is that the supply of jobs decreases when the human capital of job seekers declines. In their model, **?** distinguish between two types of human capital: individual and job- or industry-specific. In their view, it is primarily the loss of the latter that is responsible for long-term unemployment. However, **?** found that individual skills also

[1] **?** provide a detailed overview of various mechanisms of action.

decline with the duration of unemployment. To this end, they evaluated Swedish test results from *the International Adult Literacy Survey*, which measures reading ability and the ability to handle printed information. However, industry-specific human capital and work experience are of particular interest in the context of structural change and human capital.

In general, structural change can be divided into three different types: firstly, the production structure, secondly, the sectoral structure, and thirdly, the regional structure (**?**). Against this background, **?** conclude in their analysis of length of stay that changes in the production structure devalue the accumulated human capital of those affected, causing them to remain unemployed for longer. **?**, on the other hand, divides human capital into three types in his analysis: general, industry-specific, and company-specific. He shows that the subsequent wages of laid-off workers depend heavily on whether they return to their former industry. He thus concludes that industry-specific human capital is of immense importance. **?** also concludes that this type of human capital is significantly more important than firm-specific human capital. Although these two studies do not directly address the entrenchment of unemployment, but rather the influence of human capital on wages, they allow us to draw an important conclusion: if industry-specific work experience is so crucial, then unemployed people who previously worked in an industry affected by structural change are particularly vulnerable to a sharp decline in the value of their human capital.

With the connection between structural change and human capital, all the elements are now in place to derive the research hypothesis: if structural change leads to a more rapid devaluation of the human capital or work experience of the unemployed, and the loss of human capital is a mechanism for hysteresis effects, then structural change should also have an influence on hysteresis.

3. Methodology

In the first section, the model is first established before the estimation method used is explained in a second step. Finally, the data basis is discussed and, in particular, the development of the unemployment rate in the three countries is outlined.

3.1. Model

To clarify the research questions, an *unobserved components model* (UC model) is estimated. Such a model was first used by **?** in connection with hysteresis. Among others, **?** and **?** have expanded this model, with the latter forming the starting point for this work.

Here, unemployment is broken down into a cyclical and a permanent component. The permanent component corresponds to the NAIRU, which can be influenced by cyclical unemployment and is therefore not exogenous (hysteresis). The model is described by the following three equations:

$$u_t = \tau_t + c_t \tag{2}$$

$$\tau_t = \tau_{t-1} + \mu + \Delta k S_{t-1} c_{t-1} + \gamma S_{t-1} c_{t-1} x_{t-1} + \eta_t \tag{3}$$

$$c_t = \sum_{i=1}^{p} \phi_i c_{t-i} + \alpha S_t - \alpha(1 - S_t) r + \varepsilon_t \tag{4}$$

Equation (2) first decomposes the unemployment rate into two unobserved components, trend τ_t and cycle c_t. The trend equation (3) is a random walk with drift μ. Cyclical unemployment (4) is a stationary autoregressive process of order p. The roots of the lag polynomial $\phi(L) = 1 - \phi_1 L - \cdots - \phi_p L^p$ are all outside the unit circle and thus the process is stationary. The lag length p was determined using information criteria (AIC and BIC) and is $p = 2$ for all three countries.

Furthermore, the cyclical component is influenced by the recession indicator S_t. This indicator is a dummy variable and is intended to reflect the economic cycle, whereby recessions are usually accompanied by higher unemployment. The constant r indicates the ratio of recessive to non-recessive periods. This ensures that the unconditional mean of the stationary process is 0.

Hysteresis effects are incorporated into the trend equation through the interaction of delayed cyclical unemployment with the delayed recession indicator. Thus, the coefficient Δk estimates the proportion of cyclical unemployment that persists after a recessionary period. The reason for this is that hysteresis is usually seen as a long-lasting effect following a recessionary shock. **?** were able to show that job requirements change primarily during recessions. This approach is consistent with the second hysteresis mechanism, the devaluation of work experience. The relationship between structural change and the entrenchment of cyclical unemployment is represented by an interaction between hysteresis and the structural change measure x_{t-1}. Thus, the coefficient γ describes the extent to which the strength of structural change influences hysteresis effects.

For Germany and France, an additional dummy variable was added to account for a structural break in the drift parameter μ. For Germany, this break was set exogenously to April 2005 to take into account the different institutional labour market conditions in connection with labour market reforms. For France, this structural break occurred in April 1997, whereby it was determined endogenously by maximizing the likelihood function. This is because, unlike Germany, there were no comparable labour market reforms in France that coincided with the peak in the unemployment rate and would therefore justify an exogenous specification.

3.2. Estimation method

The estimation is carried out using a Bayesian approach. For this purpose, the UC model described above is converted into a *state space representation* (see Appendix A). For the estimation, samples of the a posteriori distribution of the model parameters are generated using *Gibbs sampling*. *Gibbs sampling* is a Markov chain Monte Carlo (MCMC) method developed by **?** and modified many times since then.[2] This method is particularly

[2] **?**, for example, provide a good introduction to *Gibbs sampling*.

helpful when the joint distribution of a random vector is difficult to determine, but the conditional distributions of the individual variables are easy to determine.

Specifically, the estimation method is based on the application-oriented book by **?** and the code by **?**. The samples are generated in "blocks." This means that first, the unobserved states are drawn given the remaining parameters and the available data. The simulation smoother from **?** is used for this. Then, the parameters of each equation are generated given the remaining parameters, the simulated states, and the data.

A total of 40,000 samples were generated, although only the last 30,000 are relevant for the estimation results, and only every fifth sample was considered in order to reduce autocorrelation. To ensure the convergence of the Markov chain, two criteria were used. The trace plots show a random dispersion of values around a stable mean value, with no discernible trends or systematic changes (see Appendix B for Germany). If the Markov chain is divided into the first and last thirds, a Gelman-Rubin statistic of well below 1.1 is obtained for all model parameters. Both indicators point to the convergence of the Markov chain.

Table 1: A-priori information

Parameter	**Distribution**	**Mean**	**Standard error**
AR(1) coefficient (ϕ_1)	Normal	0.75	0.25
AR(2) coefficient (ϕ_2)	Normal	0	0.25
Recession (α)	Normal	0	0.1
Cycle variance (σ_ε^2)	Inverse gamma	0.023	0.003
Drift (μ)	Normal	0	0.1
Hysteresis (Δk)	Normal	0	0.2
Hysteresis & structural change (γ)	Normal	0	30
Trend variance (σ_η^2)	Inverse gamma	0.023	0.003

The initial state was set to the trend τ_t on the first observation of the unemployment time series and the cycle c_t to 0. The a priori distributions of the parameters used are independent of each other and largely uninformative. Table 1 summarizes the a priori information, and these are presented graphically in Appendix C. An inverse gamma distribution was assumed for the variance of the error terms, while a normal distribution was used for the remaining parameters. The choice of distributions is explained in detail below:

- Cycle parameters: Analogous to **?**, a mean value of 0.75 is specified for the first AR parameter and a mean value of 0 for the second lag, both of which have an a priori variance of $(0.25)^2$. A mean of 0 and a standard error of 0.1 were used for the recession coefficient.

- Trend parameters: For all trend parameters, the mean value of the normal distribution is specified as 0. However, the prior variances differ greatly in some cases. A very large standard error of 30 is used for the interaction of structural change

and hysteresis, as the structural change measure is scaled very small. The standard error of the drift parameter was set to 0.1 and that of the hysteresis coefficient to 0.2. This choice took into account the magnitudes of the estimation results of **?**.

- Error terms: The specification of the variances of the shocks follows the approach of **?** and **?**. Here, the inverse gamma distribution is determined using the shape parameter $r_0 = v_0 T$ and the scale parameter $s_0 = v_0 T \sigma_0^2$. The prior strength v_0 was set to 0.1, and the prior expectation σ_0^2 was set to 0.15 for both the trend and the cycle.

3.3. Data

The observation period for all three countries ranges from January 1960 to February 2020, thus ending before the start of the coronavirus pandemic in Europe. The monthly unemployment rates are taken from various data sources:

- Germany: Statistics from the Federal Employment Agency
- United Kingdom: Bank of England, from February 2017 by the Office for National Statistics
- France: Centre for Prospective Studies and International Information, from January 1983 by the OECD

Since the definition of unemployment differs in these data sources, it is difficult to compare the absolute values of the unemployment rate between countries. Figure 1 shows the development of the unemployment time series. Especially in the first half of the observation period, the three unemployment rates show a very similar trend. Initially, the unemployment rate was low in all three countries, with crises usually resulting in only a short-term increase. For example, the stabilisation crisis of 1966/67 in Germany led to a sharp rise in the rate, before it quickly returned to its original level.

However, a significant increase in unemployment rates began in the 1970s as a result of the two oil crises. It is striking that the unemployment rate recovered only very slowly after each crisis, leading to a step-like pattern. This pattern can also be observed in the recessions of the early 1990s. Both hysteresis effects and institutional conditions are cited as causes for this long-term increase in the unemployment rate. In particular, matching efficiency, employment protection, unemployment benefits, and the influence of trade unions are considered key factors (**???**).

From the mid-1990s onwards, however, the trends in the unemployment time series diverged. The United Kingdom was the first to experience a long-term and continuous recovery in unemployment. **?** describes this phase of the labour market as "a European success story," as the rate fell to one of the lowest in Europe within ten years. France also saw a long-term decline, but not until the turn of the millennium. In Germany, on the other hand, unemployment peaked in 2005 before a strong and sustained recovery set in. This decline is largely attributed to the comprehensive labour market reforms in Germany (**?**).

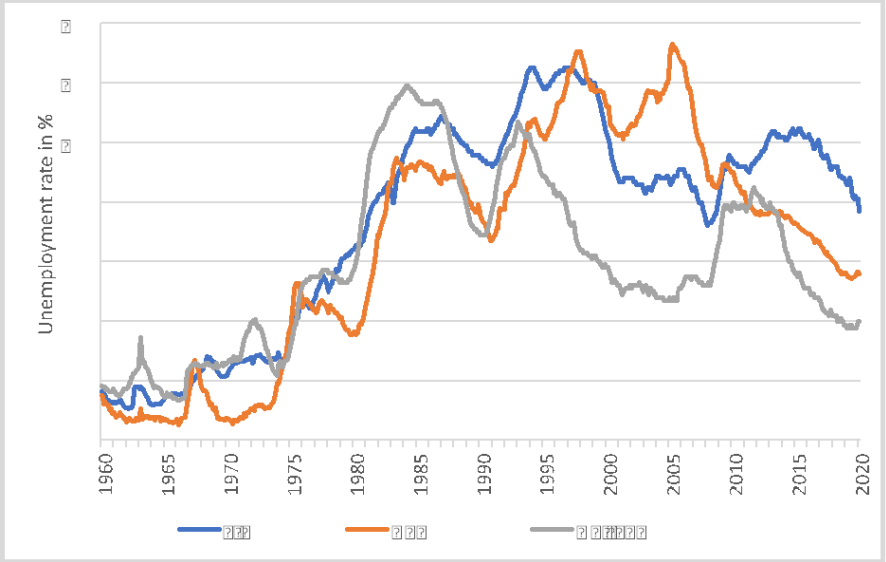


Figure 1: Development of unemployment rates

However, the global financial crisis brought the decline in France and the UK to a halt, as unemployment rose sharply as a result. Ultimately, it took more than five years in the UK and until the end of the observation period in France for the rate to return to its pre-crisis level. In Germany, on the other hand, the financial crisis had little impact on the positive trend: there was only a comparatively small and short-term increase before unemployment began to fall again steadily. One key explanation for the resilience of the German labour market during the financial crisis is the instrument of short time working (**??**).

The course of the observed unemployment time series, and particularly the long-term increase from the mid-1970s onwards, already points to possible hysteresis effects. The delayed recovery phase in France and the United Kingdom after the global financial crisis also suggests this. However, the estimation results in the fourth chapter provide more insight into this.

The exogenous recession indicator of the Federal Reserve Bank of St. Louis is used as the data basis for the recessions. This indicator is a monthly dummy variable and represents an interpretation of the economic cycles. The underlying economic cycle for all three countries is based on the *OECD Composite Leading Indicators*. During a recession, the indicator takes the value 1, while during an expansionary phase it takes the value 0. The interpretation used is based on the trough method. Here, a recession begins with the period after the peak and ends with the trough of a cycle.

Figure 2 shows an example of the recession indicator for Germany. It is striking that, compared to many other economic indicators, a relatively high number of periods are classified as recessions (see, for example, **?** or **?**). This is particularly true of the 2000s, when more than half of the periods were classified as recessions. This circumstance should

be considered when interpreting the later estimation results.

The intensity of structural change is determined based on sectoral change. Instead of the traditional classification into primary, secondary, and tertiary sectors, a more detailed subdivision into ten economic sectors is used. Changes in the employment structure serve as the basis for calculating an annual measure of structural change. Various statistics that record employees by economic sector were used as data sources. For Germany, the data up to 1991 comes from the GGDC and thereafter from the Federal Statistical Office. For both France and the United Kingdom, the data up to 1994 also comes from the GGDC and thereafter from the EU KLEMS project. In order to take into account the change in the data basis and the reunification of Germany, the GGDC data was adjusted using a correction factor. This factor is based on the ratio of employees in a sector in the original and new data sources in the year of the change. Since the data sources use two different coding systems for the sectors, these were merged in accordance with the transfer logic in Appendix D.

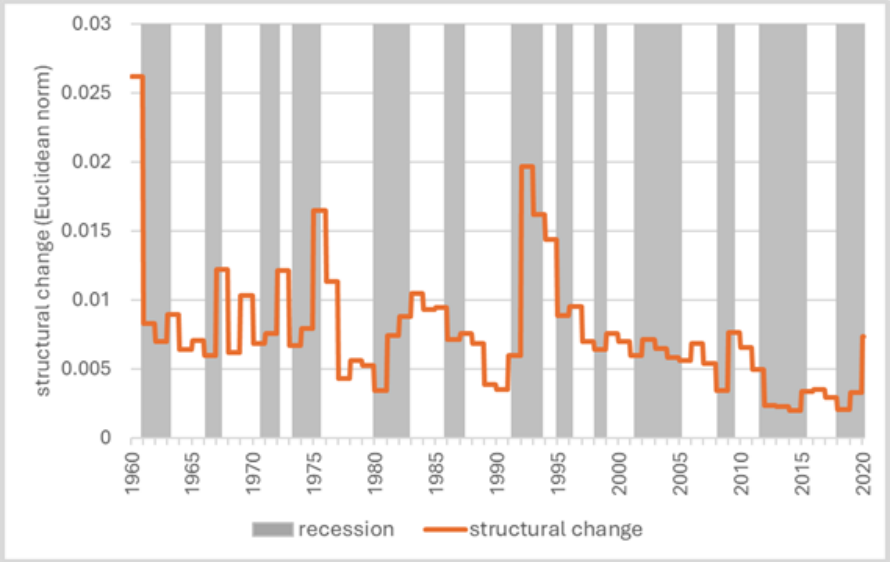


Figure 2: Recession and the extent of structural change in Germany

Specifically, the structural change measure was formed using the Euclidean norm. Formula (5) represents this calculation:

$$x_t = \sqrt{(\Delta shemp_{1,t})^2 + \ldots + (\Delta shemp_{10,t})^2} \tag{5}$$

Here, $\Delta shemp_{i,t}$ denotes the change in the share of employees in a sector i in the total number of employees between two periods. A higher measure of change thus reflects a greater change in the employment structure and therefore represents a greater sectoral structural change.

Figure 2 illustrates the resulting structural change measure for Germany. The scale is very small, with values between 0.002 and 0.027 and an arithmetic mean of 0.008.

Several notable features can be observed: First, structural change declined slightly over the decades. This could be partly due to the fact that the general shift towards a service-based society has slowed down. Second, reunification led to a significant increase in structural change, with the new federal states in particular facing major structural change. Third, there is an increase in 2020, which points to the transformations mentioned at the beginning.

4. Results

4.1. Germany

First, we consider the estimation results of the UC model for Germany. Table 2 summarizes the posterior distribution of the parameters, and Figure 3 shows the decomposition of the unemployment rate into trend and cycle. Cyclical unemployment fluctuates between approximately -1% and 2% over time, rising during recessions and falling during expansions. The stabilisation crisis, the oil crises, and the dot-com crisis are particularly evident in the cycle. The recession coefficient also reflects this behaviour, as it is positive and significant.

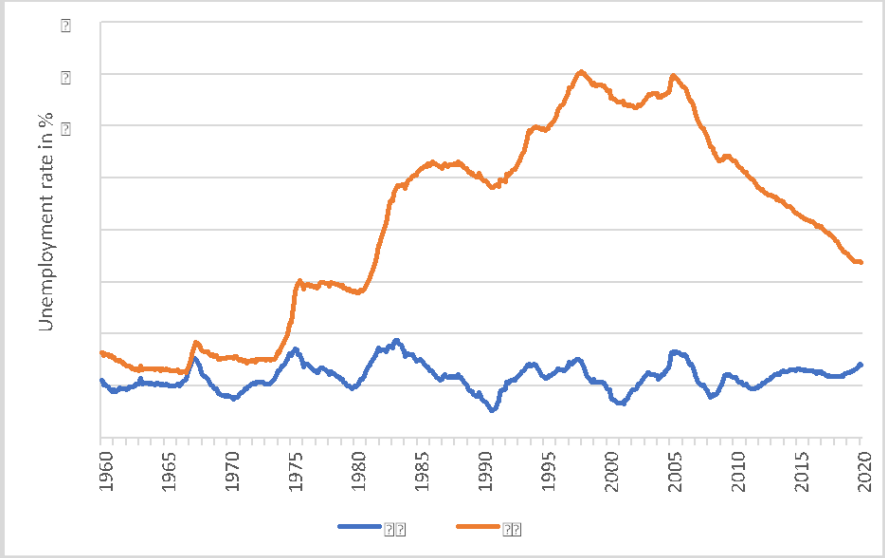


Figure 3: Trend and cycle in Germany

The rise in unemployment prior to the labour market reforms can be attributed to the increasing trend component. However, although the drift parameter is positive, it is not significant and is negligible. Rather, hysteresis effects have contributed to the continuous increase. On the one hand, this can already be assumed from the trend, as the pronounced staircase pattern indicates a consolidation of unemployment following a recession. On the other hand, the hysteresis coefficients also confirm this suspicion.

Although the pure hysteresis coefficient is relatively low at 0.02 and is not significant in itself, the interaction of hysteresis and the structural change measure with 11.5 is of a relevant magnitude and is also highly likely to be greater than 0.[3] In order to determine the overall hysteresis effect, both the hysteresis coefficient Δk and the interaction with the structural change measure x_t must be considered together. On average, approximately 11% of the cyclical unemployment of the previous period becomes entrenched after a period of recession. This value fluctuates between 4% and 32% depending on the intensity of structural change. This result suggests that hysteresis effects are significantly stronger when structural change occurs more rapidly, which is consistent with the research hypothesis.

Table 2: Estimation results for Germany (for a graphical representation of the a posteriori distribution, see Appendix C)

Parameter	**Mean**	**Median**	**90% HPD**	**Likelihood (x<0)**
AR(1) coefficient (ϕ_1)	1.1328	1.1368	[0.975; 1.277]	0.000
AR(2) coefficient (ϕ_2)	-0.1452	-0.1472	[-0.284; 0.003]	0.946
Recession (α)	0.0252	0.0256	[0.010; 0.040]	0.002
Drift (μ)	0.0016	0.0019	[-0.015; 0.018]	0.430
Drift (μ) after reforms	-0.0469	-0.0460	[-0.071; -0.026]	1.000
Hysteresis (Δk)	0.0205	0.0037	[-0.065; 0.161]	0.476
Hysteresis & structural change (γ)	11.4944	11.1186	[3.068; 21.479]	0.015

Following the labour market reforms, a very different picture of the trend component emerges. It falls steadily and extremely evenly until the start of the coronavirus pandemic. The drift parameter is negative and highly significant for this period and represents the dominant factor for this downturn. Although the cycle is mostly positive during this period, the hysteresis effects are not sufficient to counteract this decline significantly. The global financial crisis also had only a minimal impact on the trend, which is consistent with the development of long-term unemployment. This is because the number of long-term unemployed did not increase as a result of the crisis. One reason for this is the increase in matching efficiency, particularly among the long-term unemployed (see **?**). It is also striking that the cycle remains positive after the global financial crisis. This is due, among other things, to the recession indicator used, which interprets a particularly large number of periods in this period as recessive phases.

Overall, the results for Germany show that hysteresis effects played a significant role in the development of structural unemployment. Particularly in times of major structural change, a considerable proportion of cyclical unemployment became entrenched. At the same time, the contrasting developments before and after the labour market reforms illustrate that institutional factors also played a decisive role in this context.

[3]The median even suggests that the pure hysteresis coefficient is completely negligible. This is also reflected in the slightly right-skewed a posteriori distribution of the coefficient (see Appendix C).

4.2. United Kingdom

The results for the United Kingdom are evaluated in the same way as for Germany. Figure 4 shows the breakdown into permanent and cyclical unemployment, and Table 3 summarizes the estimation results. Cyclical unemployment fluctuates over time between approximately +/- 2%, rising during recessions and falling during expansions. The recession coefficient is significant and almost identical in magnitude to that in Germany. However, apart from the greater range, the cycle is also more irregular and sluggish than in Germany. There are longer phases of increase or decrease, which means that the cycle returns to zero less frequently.

Counterintuitively, the drift parameter is negative, but it is insignificant and negligible. In contrast, hysteresis effects play a significant role in the development of the trend. Similar to Germany, the pure hysteresis coefficient is low and not significant in itself. However, the interaction with the structural change measure is strongly positive and significant. Looking at both hysteresis coefficients together, on average approximately 8% of cyclical unemployment becomes entrenched after a period of recession. Depending on the strength of structural change, this figure fluctuates between 4% and 17%.[4]

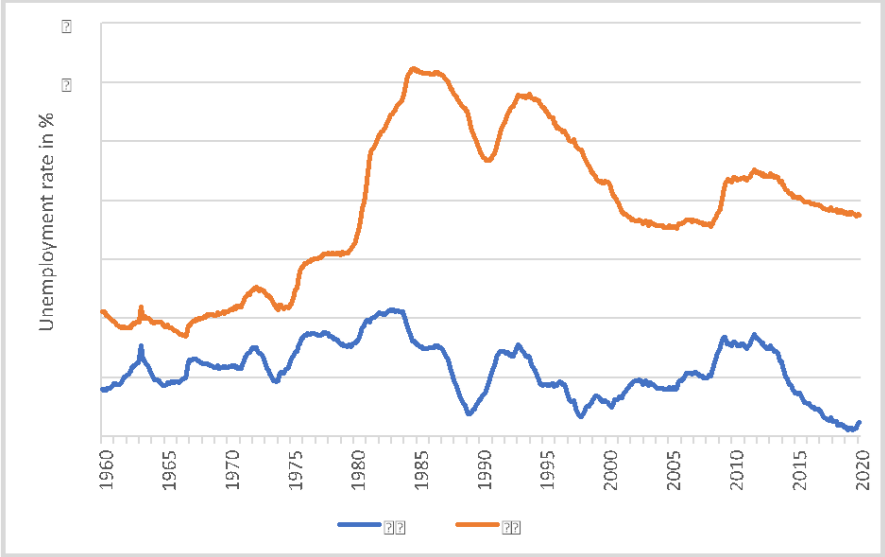


Figure 4: Trend and cycle in the United Kingdom

Looking at the trend in the context of these results, several episodes can be identified. The sharp rise in unemployment from the mid-1970s onwards is reflected primarily in the trend component and is driven largely by hysteresis effects. Firstly, the rate of structural change was comparatively high during this period, which is consistent with increasing deindustrialisation. Secondly, cyclical unemployment peaked at due to the recessions associated with the oil crises. Taken together, this not only led to an entrenchment of

[4]The structural change measure for the United Kingdom has a range of 0.003 to 0.018 and an arithmetic mean of 0.009.

a high proportion of the cycle, but also, in absolute terms, to particularly pronounced hysteresis effects during this phase.

In contrast, during the long-term decline in unemployment from the mid-1990s onwards, cyclical unemployment was significantly lower and mostly in negative territory. As a result, there was no entrenchment of unemployment; on the contrary, hysteresis contributed to the downward trend. However, changes in the institutional framework are usually cited as the main cause of this decline.

? attribute the sharp decline in the trend to, among other things, the declining proportion of workers in trade unions. **?** also sees the declining influence of trade unions and, beyond that, the reform of monetary policy as the main causes of the continuous decline in unemployment in the United Kingdom.

Table 3: Estimation results for the United Kingdom

Parameter	**Mean**	**Median**	**90% HPD**	**Likelihood (x<0)**
AR(1) coefficient (ϕ_1)	1.2463	1.2439	[1.125; 1.375]	0.000
AR(2) coefficient (ϕ_2)	-0.2502	-0.2479	[-0.378; -0.130]	0.999
Recession (α)	0.0227	0.0222	[0.007; 0.039]	0.005
Drift (μ)	-0.0008	-0.0008	[-0.013; 0.012]	0.548
Hysteresis (Δk)	0.0114	0.0093	[-0.040; 0.069]	0.382
Hysteresis & structural change (γ)	8.7460	8.2991	[2.260; 16.536]	0.012

Finally, looking at the period since the global financial crisis, we can see a sharp rise in the trend, which is also partly attributable to hysteresis effects. Only towards the end of the observation period does the trend component decline slightly again. This pattern coincides with the development of the proportion of long-term unemployed in the United Kingdom. **?** attributes this increase in long-term unemployment following the financial crisis primarily to an increase in people giving up looking for work (inactivity), which underscores the hysteresis effect. In contrast, cyclical unemployment falls to its lowest level at the end of the time series, which is in line with the strong economic growth rates following the financial crisis.

4.3. France

Figure 5 shows the breakdown of permanent and cyclical unemployment in France, while Table 4 summarizes the estimation results of the UC model. Cyclical unemployment fluctuates between approximately -1.5% and 2% during the observation period. It is striking that, although the cycle shows minor fluctuations, it is still more sluggish overall than in the United Kingdom. More specifically, cyclical unemployment in France goes through two long-term cycles and shows significantly fewer peaks than, for example, cyclical unemployment in Germany. It remains negative until the mid-1970s and then remains positive for almost 25 years. Before the global financial crisis, it fell to its lowest point but then rose again and remained positive until the end of the observation period. This sluggishness is also underlined by the recession coefficient. Although it is positive

and significant, it is lower than in the other two countries, which means that it generates less momentum in the cycle.

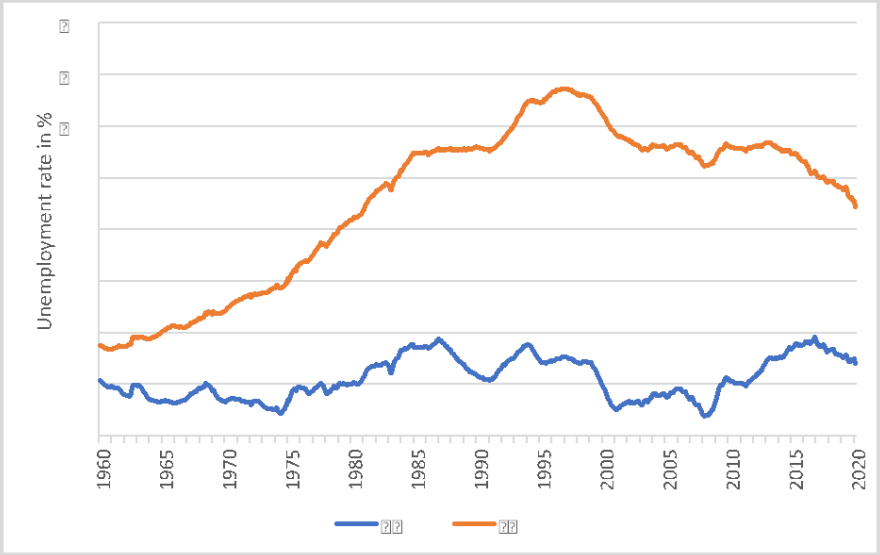


Figure 5: Trend and cycle in France

The trend component is also extremely sluggish and shows only very slight fluctuations. This behaviour is particularly pronounced in the first half of the time series, as the trend component rises continuously until the structural break at the end of the 1990s. Unlike in Germany and the UK, however, this increase can be attributed primarily to the drift parameter. This increases permanent unemployment by approximately 0.23 percentage points per year. This increase in the trend is consistent with the findings of **?**, who estimates the course of the time-varying NAIRU in connection with the Phillips curve. He cites shifts in the demographic composition of the working population and changes in tax burdens and social security contributions as the causes of the two plateaus at the end of the 1980s and from the mid-1990s onwards.

Table 4: Estimation results for France

Parameter	**Mean**	**Median**	**90% HPD**	**Probability (x<0)**
AR(1) coefficient (ϕ_1)	1.1938	1.1950	[1.068; 1.316]	0.000
AR(2) coefficient (ϕ_2)	-0.1996	-0.2012	[-0.322; -0.073]	0.997
Recession (α)	0.0167	0.0175	[0.002; 0.028]	0.035
Drift (μ)	0.0192	0.0201	[0.004; 0.031]	0.029
Drift (μ) after structural break	-0.0165	-0.0156	[-0.035; -0.002]	0.967
Hysteresis (Δk)	-0.0188	-0.0220	[-0.062; 0.038]	0.802
Hysteresis & structural change (γ)	3.4178	3.4546	[-1.982; 8.250]	0.107

The decline in unemployment after the structural break is also primarily reflected in the trend component and the negative drift parameter. The trend in the 21st century is almost identical to the development of the long-term unemployment rate in France (**?**). It is also striking that the global financial crisis caused only a slight increase in the trend, while a long-term increase in cyclical unemployment set in. **?** also come to this conclusion, although this is related to the comparatively weak growth of the French economy after the financial crisis.

Hysteresis effects, on the other hand, play a minor role in the development of the trend in France. The pure hysteresis coefficient is even slightly negative, although it hardly differs from 0. The parameter for the interaction with the structural change measure is positive, but relatively small and statistically insignificant. Nevertheless, when both coefficients are considered together, the hysteresis effect is only 1% for average structural change and is therefore negligible. Depending on the strength of structural change, this value fluctuates between -1% and 4%.[5] Based on these results, the overall conclusion is that unemployment in France was hardly driven by hysteresis.

4.4. Panel estimation

Building on the country estimates, a panel variant is performed in the final step. In general, panel approaches to the study of hysteresis effects have a long tradition, although these are mostly panel unit root tests (e.g., **?**, **?**, **?**). For this study, panel estimation offers the advantage of being able to use a larger number of observations for the cross-country relationship between hysteresis and structural change. This provides a more precise estimate for common parameters and thus also better statistical significance. Despite the long unemployment time series, it should be noted that the structural change measure only varies annually and is only relevant for the estimate during recessions.

Table 5: Hysteresis coefficients of the panel estimation

Parameter	**Mean**	**Median**	**90% HPD**	**Probability (x<0)**
Hysteresis (Δk) for Germany	0.0394	0.0277	[-0.031; 0.148]	0.253
Hysteresis (Δk) for Great Britain	0.0514	0.0447	[-0.014; 0.137]	0.110
Hysteresis (Δk) for France	-0.0211	-0.0275	[-0.072; 0.053]	0.791
Hysteresis & structural change (γ)	7.0163	6.7621	[2.837; 12.111]	0.002

The aim is to estimate only the parameter for the interaction between structural change and hysteresis for all three countries together. The remaining parameters remain country specific. In principle, the same estimation method is used as in Chapter 3, including the a priori information. For the panel approach, the three-time series are pooled together. Several measures are taken to avoid distortions in the transition between the individual time series. First, two additional periods are inserted between the series, which assume

[5] The structural change measure for France has a range of 0.002 to 0.017 and an arithmetic mean of 0.008.

the initial value of the new series. This ensures that the autoregressive process does not rely on the cycle of the previous country. Second, a high error variance is specified for these artificial periods in the UC model. Third, an impulse dummy is inserted into the observation equation for each of these additional periods in order to neutralize them for the estimation. Table 5 summarizes the estimation results for the hysteresis effects.[6] None of the country-specific hysteresis effects is significant on its own. For Germany and the UK, this coefficient is larger than in the individual estimates, while for France it is more negative. These differences are not surprising given the common interaction coefficient. With a value of 7, this parameter is significantly larger than in the estimate for France, which means that the more negative hysteresis coefficient Δk compensates for this difference. The same effect occurs in Germany and the United Kingdom, as the interaction coefficient is larger in the country estimates. Overall, the hysteresis effect averages just under 10% in Germany, which is almost identical to the previous estimate. In the United Kingdom, this value is approximately 11% and for France just under 4%, meaning that the hysteresis effect in these two countries is slightly stronger than before.

Figure 6 shows the a priori and a posteriori distribution of the joint interaction parameter. The samples are evenly distributed around the mean, and the resulting distribution differs significantly from the a priori distribution. The probability that this parameter is greater than 0 is over 99%. Thus, this group-specific coefficient has high statistical significance and confirms the results of the previous estimates: the strength of structural change has a positive and significant influence on hysteresis effects. Overall, stronger hysteresis effects are observed for Germany and the United Kingdom.

[6] The remaining country-specific parameter estimates for this panel approach can be found in Appendix E. Apart from the AR coefficients, which are smaller in magnitude in this estimate, the parameters are very similar to the country estimates.

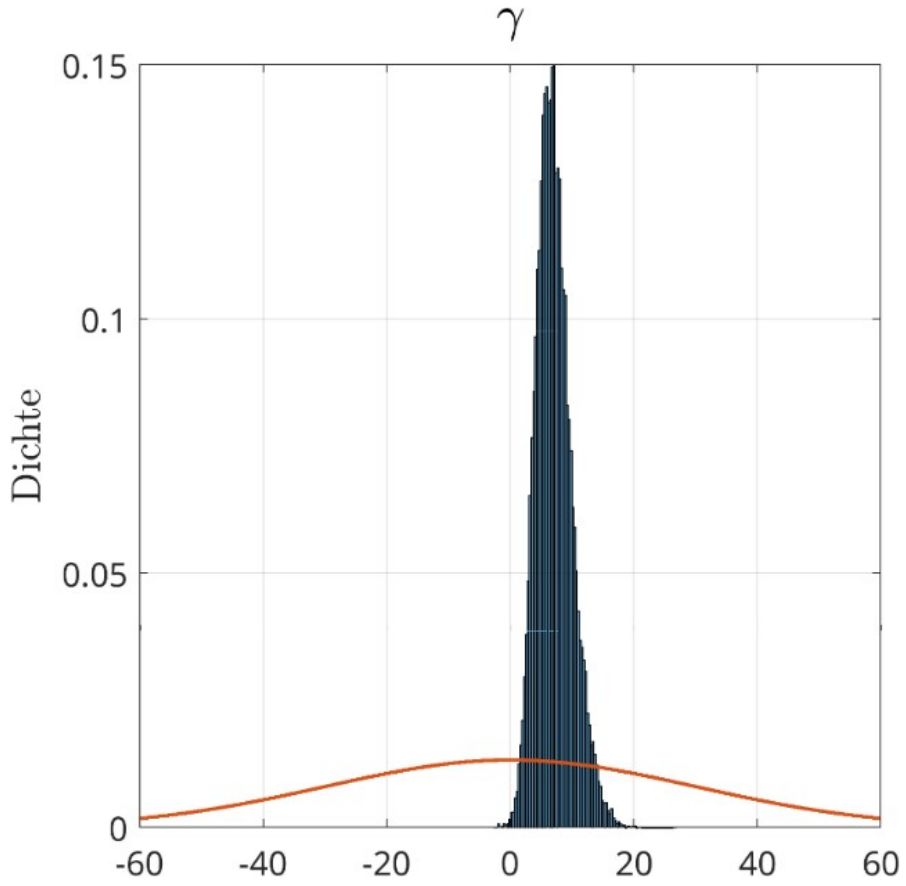


Figure 6: A priori and a posteriori distribution of the joint interaction coefficient

5. Summary

This study examined the extent to which hysteresis effects occurred in the labour markets in Germany, the United Kingdom, and France and whether these were related to the intensity of structural change. A UC model was used for the analysis, which breaks down the unemployment rate into a structural and a cyclical component. Hysteresis was modeled as a delayed spillover effect from cyclical unemployment to structural unemployment. In addition, this effect was interacted with a measure of structural change.

First, the model was estimated separately for all three countries. Significant hysteresis effects were found for Germany and the United Kingdom, while they were less significant for France. After a period of recession, around 11% of the cyclical unemployment of the previous period became entrenched in Germany and around 8% in the United Kingdom. However, these values varied depending on the strength of structural change, which had a positive and significant influence on hysteresis effects. A subsequent panel estimation confirmed this positive correlation between structural change and hysteresis. At the same time, developments following labour market reforms in Germany in particular made it

clear that institutional factors also play a decisive role during structural unemployment. Labour market policy measures can therefore make a significant contribution to reducing the entrenchment of unemployment and achieving long-term positive effects on the labour market.

However, the results make it clear that, specifically for Germany, the current risk of unemployment becoming entrenched must be taken seriously. Firstly, significant structural change is expected in the near future (especially climate transformation and digitalisation). Secondly, Germany is currently in recession and thirdly, unemployment is rising slightly. Based on this work, the combination of these three factors represents the perfect starting point for hysteresis effects. Concrete measures to preventively counteract this, would include, for example, expanding support for further training and retraining measures to prevent the devaluation of work experience (**?**). Financial start-up assistance for unemployed people who take up employment could also prevent unemployment from becoming entrenched (**?**).

Finally, it should be noted that this study explicitly deals with the relationship between hysteresis and sectoral structural change. It would therefore be logical to analyze the influence of changes in the production structure or regional change in further studies in order to obtain a more comprehensive picture. Particularly against the backdrop of increasing mismatch unemployment at certain skill levels (**?**), it would be interesting to investigate the extent to which shifts in skill requirements promote hysteresis effects. Thus, there remains much room for future studies in this research area.

A. Appendix A: State space representation

Note: Since the optimal lag length is identical for all three countries, the lag length $p = 2$ is used in the following representation.

The measurement equation combines the two unobserved components τ_t and c_t to form the unemployment rate u_t.

$$u_t = \underbrace{g}_{(1\times3)}\underbrace{z_t}_{(3\times1)} \text{ with } g = \begin{pmatrix}1 & 1 & 0\end{pmatrix}$$

$$z_t = \begin{pmatrix}\tau_t \\ c_t \\ c_{t-1}\end{pmatrix}$$

The transition equation models the dynamics of the unobserved time series.

$$\underbrace{z_t}_{(3\times1)} = \underbrace{d_t}_{(3\times1)} + \underbrace{H_t}_{(3\times3)}\underbrace{z_{t-1}}_{(3\times1)} + \underbrace{e_t}_{(3\times1)}$$

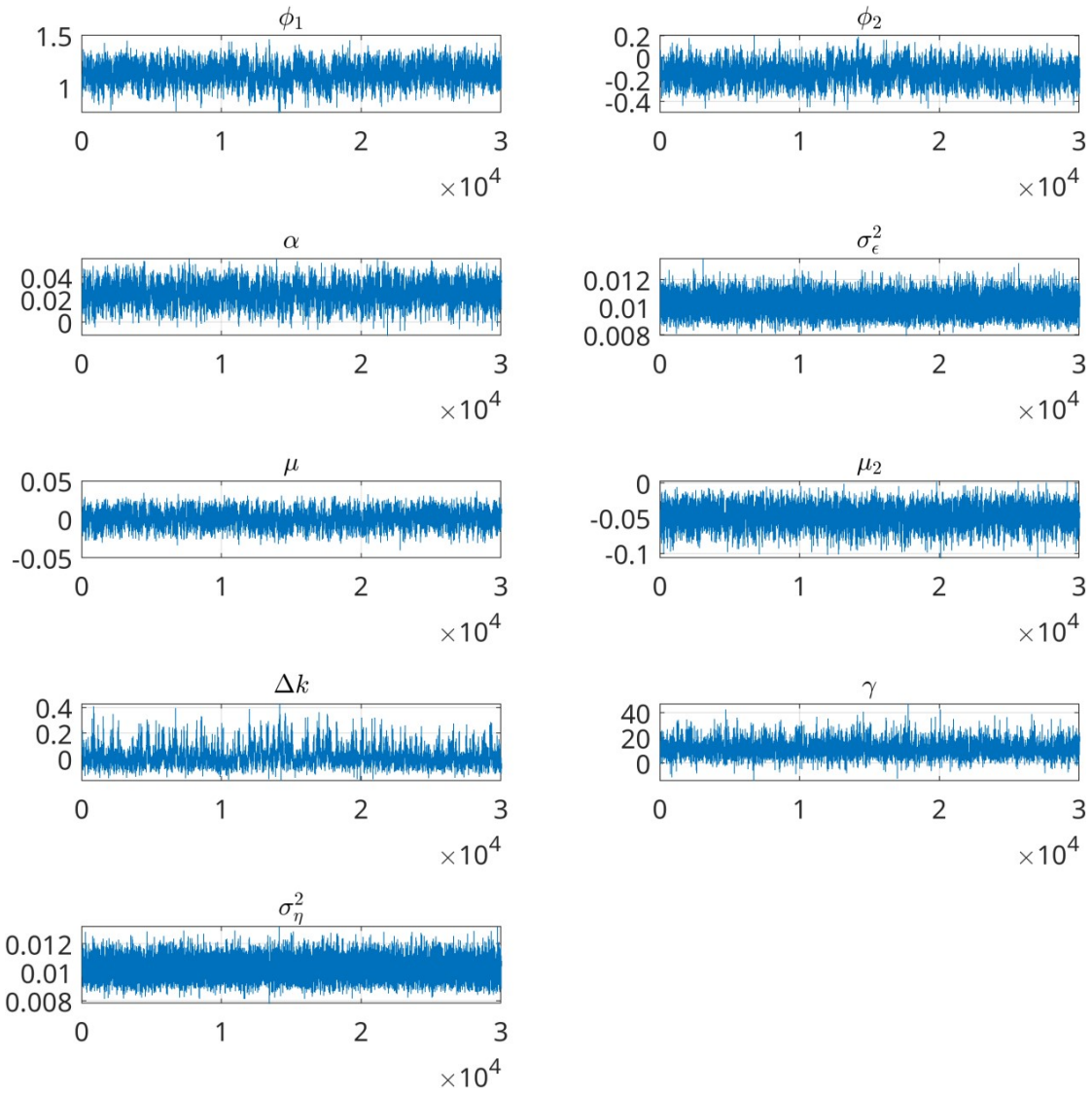
The vector d_t contains the drift parameter and the recession indicator. The matrix H_t contains the pure hysteresis effect, the interaction of structural change and hysteresis, and the autoregressive part of the trend and cycle.

$$d_t = \begin{pmatrix}\mu \\ \alpha S_t - \alpha(1-S_t)r \\ 0\end{pmatrix} \quad H_t = \begin{pmatrix}1 & \Delta k S_{t-1} + \gamma S_{t-1} x_{t-1} & 0 \\ 0 & \phi_1 & \phi_2 \\ 0 & 1 & 0\end{pmatrix}$$

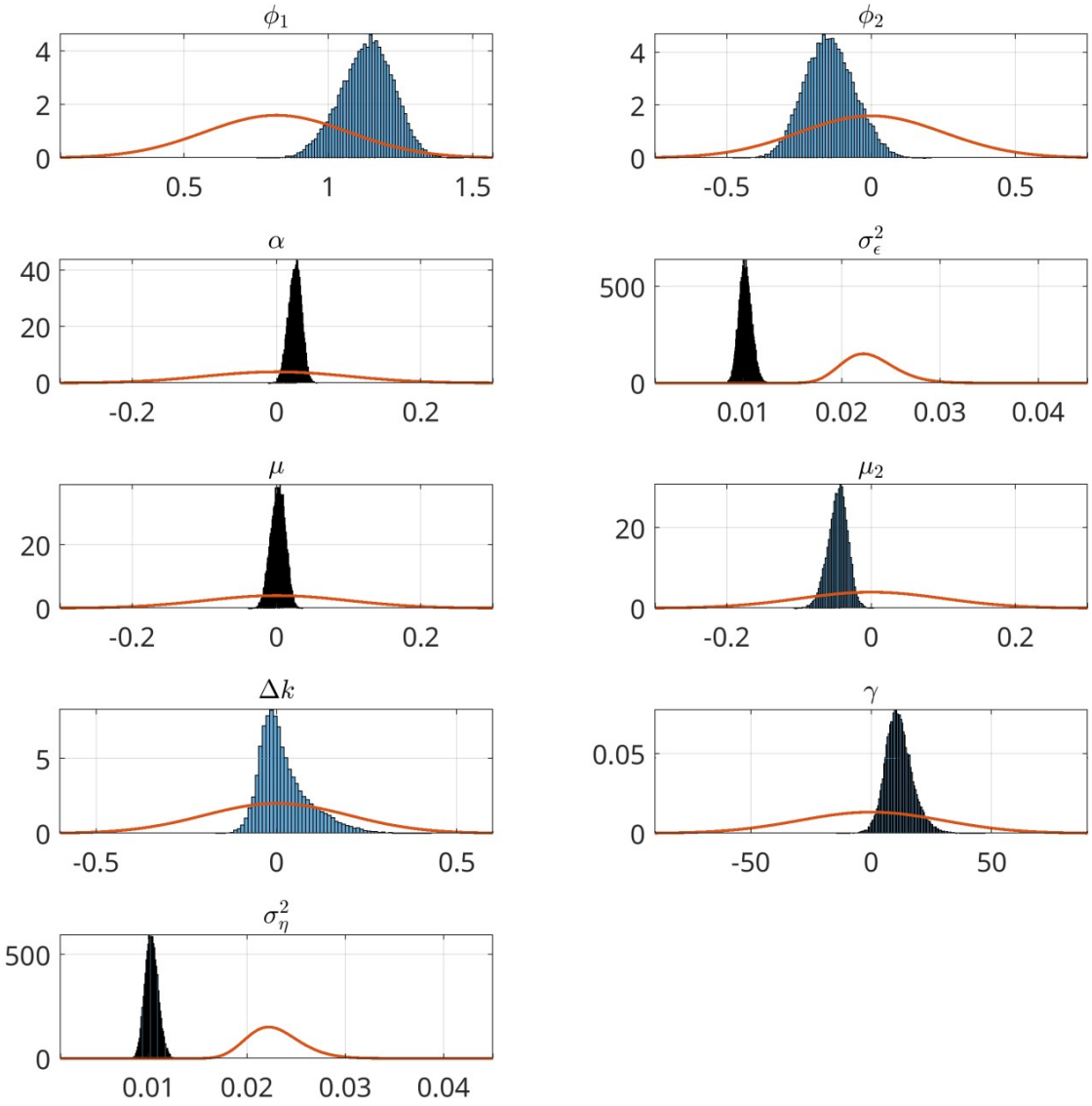
The vector e_t comprises the two uncorrelated shocks. The resulting covariance matrix contains the variances of the shocks.

$$e_t = \begin{pmatrix} \eta_t \\ \varepsilon_t \\ 0 \end{pmatrix} \quad E_t(e_t e_t') = \begin{pmatrix} \sigma^2_{\eta,t} & 0 & 0 \\ 0 & \sigma^2_{\varepsilon,t} & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

B. Appendix B: Trace plots for Germany



C. Appendix C: A-priori and A-posteriori distribution for Germany



D. Appendix D: Transfer logic

ISIC REV 3.1.	ISIC REV 4
A-B	A
C	B
D	C
E	D-E
F	F
G-H	G + I
I	H + J
J-K	K + L
L-N	M-N
O-P	O-U

E. Appendix E: Results of the panel estimation

Table: Full results of the panel estimation

Parameter	Mean	Median	90% HPD	Probability (x<0)
Germany				
AR(1) coefficient (ϕ_1)	1.0827	1.0852	[0.950; 1.208]	0.000
AR(2) coefficient (ϕ_2)	-0.0946	-0.0968	[-0.217; 0.032]	0.888
Recession (α)	0.0262	0.0264	[0.008; 0.044]	0.009
Drift (μ)	0.0012	0.0015	[-0.017; 0.019]	0.451
Drift (μ) after structural break	-0.0489	-0.0482	[-0.075; -0.025]	1.000
United Kingdom				
AR(1) coefficient (ϕ_1)	1.0777	1.0801	[0.917; 1.233]	0.000
AR(2) coefficient (ϕ_2)	-0.0848	-0.0869	[-0.240; 0.075]	0.810
Recession (α)	0.0220	0.0217	[0.004; 0.040]	0.020
Drift (μ)	-0.0053	-0.0054	[-0.018; 0.008]	0.752
France				
AR(1) coefficient (ϕ_1)	1.0534	1.0567	[0.898; 1.204]	0.000
AR(2) coefficient (ϕ_2)	-0.0642	-0.0666	[-0.213; 0.090]	0.762
Recession (α)	0.0184	0.0194	[-0.000; 0.033]	0.053
Drift (μ)	0.0161	0.0167	[-0.000; 0.030]	0.054
Drift (μ) after structural break	-0.0179	-0.0166	[-0.038; -0.002]	0.966