Inflation dynamics during the Financial Crisis in Europe: cross-sectional identification of trend inflation

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Abstract

We investigate in drivers of EMU inflation dynamics by proposing a modified Phillips Curve specification that identifies a common long run trend inflation for EMU countries by exploiting cross-section dimension of the data. Our approach simultaneously allows for country-specific inflation and unemployment gaps as well as time varying parameters. We find that declining long run trend inflation and rising inflation persistence indicate altered risk of inflation expectations de-anchoring. Lower trend inflation together with persistently negative unemployment gaps and increasing Phillips curve slope predominately explain the disinflationary pressures of consumer prices in EU10 countries in the recent episode of low inflation.

JEL-Classification: C22, E31, E5

Keywords: inflation dynamics, trend inflation, non-linear Kalman filter, European Monetary Union

1 Introduction

Despite the slow but ongoing recovery of the European Monetary Union (EMU) and expansionary measures taken by the European Central Bank (ECB) EMU inflation rates remain below the inflation target of the ECB of "below but close to 2%". Moreover, inflation rates depict distinct dynamics since the beginning of the Great Recession compared to the first half of the 2000s. As it can be seen in 1 panel (a) inflation measured by the Harmonized Consumer Price Index (HICP) for the EU10 (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) fluctuated relatively closely around 2% from the beginning of the Monetary Union until the start of the Great Recession. In contrast, inflation rates exhibit higher volatility and increased persistence since the outbreak of the crisis. Moreover, inflation rates remained below the inflation target since 2012. According to economic theory various factors might influence slacking inflation developments and changed dynamics in the EU10 countries since the start of the financial crisis:

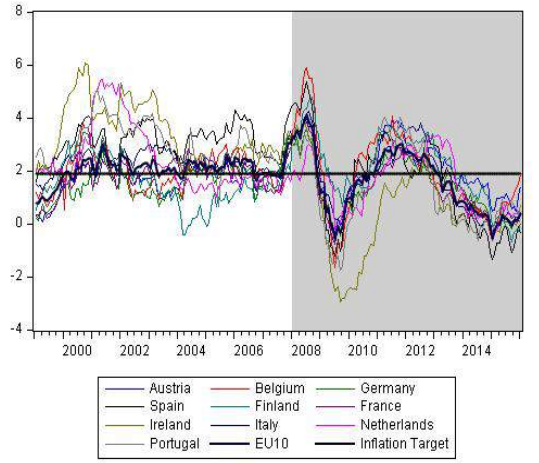
Firstly, falling oil prices might have driven down inflation rates by directly decreasing energy prices and by indirectly influencing price adjustments of other prices. As depicted in panel (b) of 1, Brent crude oil price inflation dropped by around 40% percent in the first quarter of 2014 and remained at low levels.

The second possible explanation is a de-anchoring of inflation expectations and therewith a decline in ECB's credibility in the course of the double dip recession. De-anchored inflation expectations alter the effect of macroeconomic surprises on inflation developments. Monthly Consensus survey data on inflation expectations (two years ahead) as depicted in 1 panel (c) have a mean of 1.9 % for the sub-sample spanning from 1999 until 2009 but a mean of 1.6 % for the sub-sample ranging from 2009 until 2016.

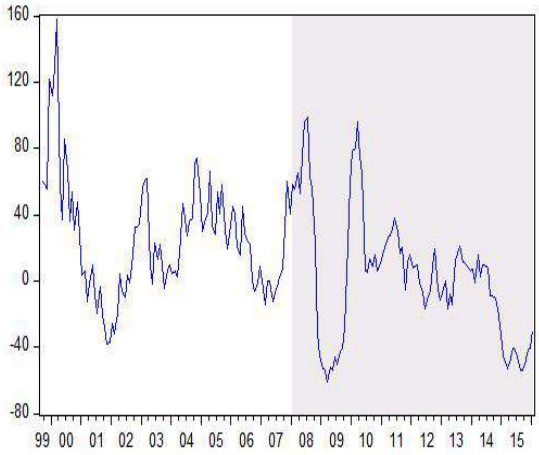
In this line changes in inflation expectations and increased inflation volatility in the first phase of the financial crisis in the EMU could have led to changes in inflation indexation and thus increased inflation persistence. In that sense, inflation rates do not revered back to its mean as quickly as before because price adjustments are guided by past inflation

Figure 1: EMU inflation dynamics and possible drivers

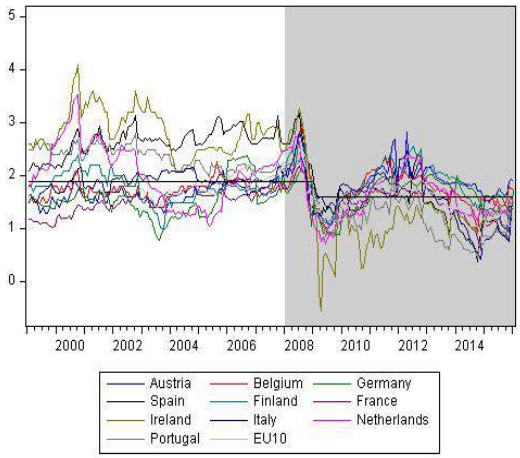
(a) Overall HICP inflation (yoy, in percent)



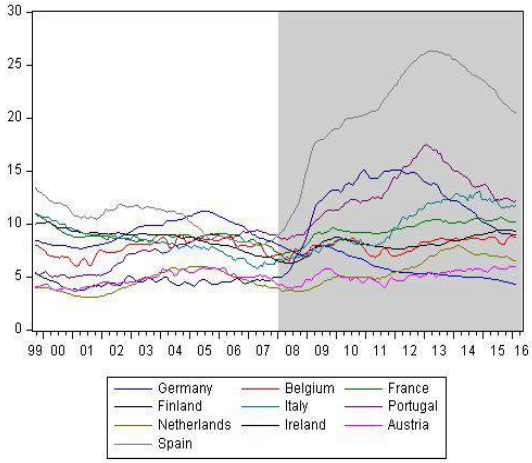
(b) Brent crude oil inflation (yoy, in percent)



(c) Inflation expectations 2y ahead (Consensus survey, in percent)



(d) OECD unemployment rate (in percent)



developments.

Lastly, hampered inflation rates might be due to the sluggish recovery with unemployment rate above the natural rate. Since 2008 unemployment rate in most EU10 countries increased, especially for Spain, Portugal, Ireland as well as Italy and have not come down to pre-crisis levels as seen in 1 panel (d). High unemployment rates combined with low wage inflation might impose downward pressure on consumer price adjustments.

Whether one or the combination of these sources predominately cause inflation rates of EU10 countries to prevail below ECB's inflation target has not been clarified in the literature[1] but has very important and distinct policy implications, in particular for future ECB policy. Therefore, in this paper we investigate in the causes of low inflation in the euro area since the start of the Great Recession. In particular, we are interested in the a consistent estimate of long run trend inflation for EMU 10 countries but also on the impact of cost-push shocks, inflation indexation and economic slack to recent inflation developments and whether the explanatory power of theses factors have changed in the course of the double dip recession. Therefore, we estimate time-varying parameters, country specific NAIRUs and long run trend inflation exploiting cross-section of our country sample with a modification of commonly used Phillips Curve specification 10 EMU countries from 2000 until 2016 by applying a two-stage non-linear Kalman filter. We add to the existing literature in three aspects.

Firstly, we provide a new approximation of inflation expectation that we recover from a Phillips Curve estimation and therewith gain insights on whether inflation expectations have been de-anchored during the Great Recession. Existing empirical work on this aspect uses either inflation expectations retrieved out of inflation indexed bonds or survey-based expectations. Inflation indexed bonds are only available for a few countries in the EMU and are traded in low volumes, which aggravates the correct estimation of risk premiums other than inflation expectations, making estimates of inflation expectations depend on the selection and estimation method of risk premiums. Deriving inflation expectations from

[1]For recent contribution see Conti, Neri & Nobili (2017), Ciccarelli, Garcia & Montes-Galdon (2017) and Busetti, Delle Monache, Gerali & Locarno (2017)

inflation indexed bonds and applying multiple endogenous break tests, Pagenhardt, Nautz & Strohsal (2015) find that inflation expectations of the EMU were well anchored until late 2011 but since then react significantly to macroeconomic news. In contrast, Autrup & Grothe (2014) do not find any evidence of expectations de-anchoring in the EMU, following a similar approach as Pagenhardt et al. (2015) but using a smaller time-span and different indicator to control for the liquidity risk premium. On the other hand survey-based inflation expectations might be driven by social and psychological factors. Van der Klaauw, Bruine de Bruin, Topa, Potter & Bryan (2008) show that the phrasing of questions in the inflations-expectations survey of Reuters/University of Michigan Survey of Consumers for US lead to distinct interpretations and increases dispersions in given answers. Moreover, participants might respond in accordance to socially desirable answer in favour of the issuer of the questionnaire (Paulhus 2002).

Secondly, we contribute to the literature on inflation dynamics during the Great Recession and the debate of missing (dis-) inflation. Watson (2014) compared inflation predictions stemming from traditional Phillips Curve estimates with actual inflation in the course of the financial recession for the US and found that inflation did not fall as predicted given the size of the unemployment gap during the Great Recession. He suggested that several factors could be at work including anchored inflation expectations, changes in inflation indexation and changes in the slope of the Phillips curve. Applying a time-varying parameter model to 23 advanced economies, Blanchard, Cerutti & Summers (2015) found that the slope of the Phillips curve has significantly declined in the nineties but has remained stable until then. Riggi & Venditti (2015) find that the elasticity of output gap and inflation has increased since the crisis for the euro area and they suggest that the increased output gap elasticity could either be driven by lower nominal rigidities or an underestimated output gap.

Thirdly, we contribute to Phillips curve estimation techniques by applying a non-linear Kalman filter as Matheson & Stavrev (2013) for US data. At least to our knowledge there exists no work on euro area Phillips Curve estimation that jointly estimates the unemployment

gap and time-varying coefficients.

The paper is organized as follows. The second section outlines the empirical methodology and the data. In the third section we present the results on time-varying coefficients and estimates of the country-specific unemployment gaps, inflation gaps, NAIRUs and a common long run trend inflation estimates. In the fourth section we perform robustness checks followed by the fifth section in which we briefly conclude the results.

2 The Econometric Model

We estimate the traditional unemployment-based Phillips curve similar to Ball & Mazumder (2011) but we exploit the cross-section for the identification of the long run trend inflation. Our benchmark model is of the following form

$$
\begin{aligned}
\pi_{i,t} &= \bar{\pi_t}^e + \pi_{i,t-1}^{gap} \\
\bar{\pi_t}^e &= \bar{\pi_t}^e(-1) + \epsilon^{\pi^e} \\
\pi_{i,t}^{gap} &= \theta_t \pi_{i,t-1}^{gap} + \kappa_t u_{i,t-1}^{gap} + \beta_t^1 \sum_{s=1}^{S} \pi_{t-s}^{oil} + \epsilon_{i,t}^{\pi^g ap} \\
u_{i,t}^{gap} &= \phi u_{i,t-1}^{gap} + \epsilon^{u^{gap}} \\
u_{i,t}^{nairu} &= u_{i,t}^{nairu}(-1) + \epsilon^{nairu}
\end{aligned}
\tag{1}
$$

,where $\pi_{i,t}$ is monthly changes of harmonized consumer prices (HICP),$\bar{\pi_t}^e$ reflect inflation expectations, $u_{i,t}$ is the unemployment rate, $u_{i,t}^{nairu}$ is the non-accelerating inflation rate of unemployment (NAIRU), π_t^{oil} are monthly changes of crude oil prices and ϵ_t^{π},$\epsilon^{u^{gap}}$,ϵ^{nairu} and ϵ^{π^e} is Gausian white noise. Note that the measures of unemployment rate, NAIRU, unemployment gap and inflation gap are country-specific. Coefficients of the the unemployment gap, inflation persistence and the oil changes as well as trend inflation is the same for all countries $i = 1, ..., 10$. Moreover, the slope of the Phillips Curve κ_t, inflation persistence θ_t as well as the coefficients on oil price changes β_t^1 are assumed to be time-varying and are modelled as random walks. Also, the NAIRU and the long run trend inflation are summed

to evolve as random walks over time.

As we seek to estimate the NAIRU, unemployment gap, inflation gap and the long run rend inflation jointly with time-varying coefficients θ_t and κ_t (also β_t^1) the Phillips curve is non-linear in parameters. Therefore, we apply a two stage non-linear Kalman filter, which consists of an iterative approach of linear Kalman filtering of the following form:

$$x_t = Fx_{t-1} + w_t \quad w_t \ N(0, Q) \tag{2}$$

$$z_t = h(x_t) + v_t \quad v_t \ N(0, R) \tag{3}$$

whereby the state equations are represented by x_t and the measurement equations are represented by z_t. Then recursion of the filter follows:

$$\begin{aligned}
&\text{Prediction} && x_{t|t-1} = x_{t|t-1} + w_{t|t-1} \\
& && P_{t|t-1} = F_{t-1}P_{t|t-1}F'_{t-1} + Q \\
&\text{Update} && \bar{y_t} = \bar{t_t} - h(\hat{x_{t|t-1}}) \\
& && S_t = H_t P_{t|t-1} H_t^{'} + R \\
&\text{Kalman gain} && K_t = P_{t|t-1} H_t^{'} S_{t-1} \\
&\text{State} && \hat{x_t} = \hat{x_{t|t-1}} + K_t \bar{x_t} \\
&\text{Covariance} && \hat{P_t} = (I - K_t H_t) P_{t|t-1}
\end{aligned} \tag{4}$$

The two stage iteration starts by filtering the states $x_t \ell[(u_{i,t} - u_{i,t}^{nairu}), u_{i,t}^{nairu}, \pi_t^e]$ holding coefficients fixed over time. The second step is the filtering of states $x_t \ell[(\theta_t, \kappa_t, \beta_t^1, \beta_t^2]$ conditional on $(u_{i,t} - \hat{u}_{i,t}^{nairu})^k$,$u_{i,t}^{\hat{nairu},k}$ and $\pi_t^{\hat{e}}, k$, whereby k indicates the number of iteration. The third step involves filtering of $x_t \ell[(u_{i,t} - u_{i,t}^{nairu}), u_{i,t}^{nairu}, \pi_t^e]$ conditional on $\hat{\theta_t}^k$, $\hat{\kappa_t}^k$, $\hat{\beta_t^1}^k$. Step two and three are repeated until convergence (by 0.00001) of estimates is achieved.

3 Data and Estimation

We use seasonally adjusted data on a monthly frequency for EU10 countries including Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain from 2000m01 until 2016m09. As a measure of consumer price index we use the overall HICP provided by the ECB Data warehouse. The unemployment rate is taken from Eurostat. For oil prices we use the Brent crude oil spot price from Datastream. We calculate month to month percentage changes for all series except the unemployment rate. Moreover, we demean changes of oil prices so that the estimate of the trend component of inflation, does exclusively capture time-fixed effects of actual inflation dynamics. We estimate the cumulative coefficient for a 6 months lag structure of oil price inflation. Regarding starting values for the states and their variances, we perform a rolling-window OLS estimation to obtain starting values for the parameter states and their variances. The starting values for states and variances regarding the NAIRUs and unemployment gaps we use HP-filtered cyclical and trend components and their implied variances. Additionally, we impose country-specific a noise-to-signal ratios between the NAIRUs and the unemployment gaps as well as the a noise-to-signal ratio of 3.5 between trend inflation component and the inflation gaps.

4 Results

We discuss our results in two steps. We first examine the country-specific NAIRUs, unemployment and inflation gaps, highlighting the main dynamics for each country , respectively. Second we turn the long-run trend inflation expectations for the EU10 region and the time varying parameter estimates, in particular we over and after the global financial crisis and sovereign debt crisis.

4.1 NAIRU and unemployment gap

Figure 17 illustrates the smoothed filtered series of the NAIRUs of the EU10 countries with 95th confidence bands together with the actual unemployment rate (black line) and the NAWRU estimates of the European Commission (red line). As it can be seen from the actual unemployment rates, the evolution of unemployment is heterogeneous across countries. In line with this, the filtered NAIRU estimates also depict heterogeneity and track well country-specific evolution of labour markets. Whereby, we can infer two group of countries from figure 17. Ireland, Italy, Portugal, Spain and Austria form one group that experiences an increase of the NAIRU. Except for Austria, these countries have been severely hit by the sovereign debt crisis, whereby Ireland, Spain and Portugal experiences rises in the NAIRU between 4% and 6 % and are recipient countries from the European Stability Mechanism. For the second group of countries, France, Belgium, Germany, Finland and Netherlands, NAIRUs stayed either rather stable or declined over time. For Germany and Finland NAIRUs declined between 2% and 4%. These dynamics match well the ongoing structural changes of these labour markets due to large scale labour market reforms in the late 1990s and early 2000s. Generally, our NAIRU estimates capture well recent economic episodes for each country, respectively, and also compare well to the NAWRU estimates of the European Commission. For Ireland, Portugal, Spain and Finland our NAIRU estimates lie slightly above the EC's NAWRU.

The corresponding smoothed filtered unemployment gaps are illustrated in figure 3. Unemployment gaps peak around 2013 and 2014 depict a declining tendency thereafter for all countries except for Germany, implying increasing deflationary pressure for EU10 consumer prices in the aftermath of the sovereign debt crisis. In relation to the estimated NAIRU estimates, unemployment gaps for Portugal, Spain, Ireland and Italy have the largest absolute changes in the unemployment gap over the sample. For example, Spain's unemployment gap increased from -5,5 % in 2007M5 to 4,3 in 2013M07. The decline in unemployment gaps after 2014 might imply rising tendency for inflation at the end of the sample.

Figure 2: Estimated NAIRU and actual rate of unemployment for EU10 (in percent)

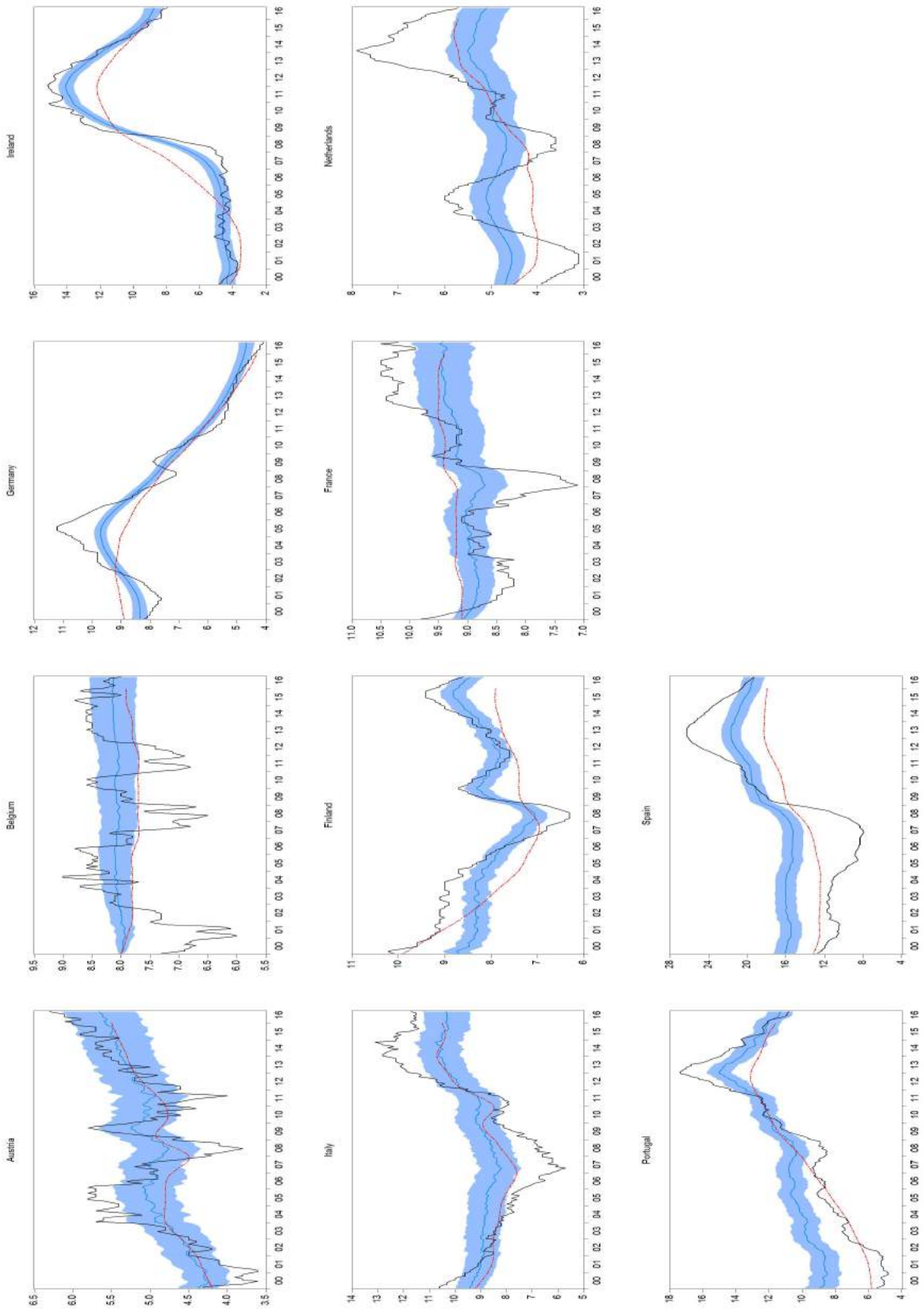
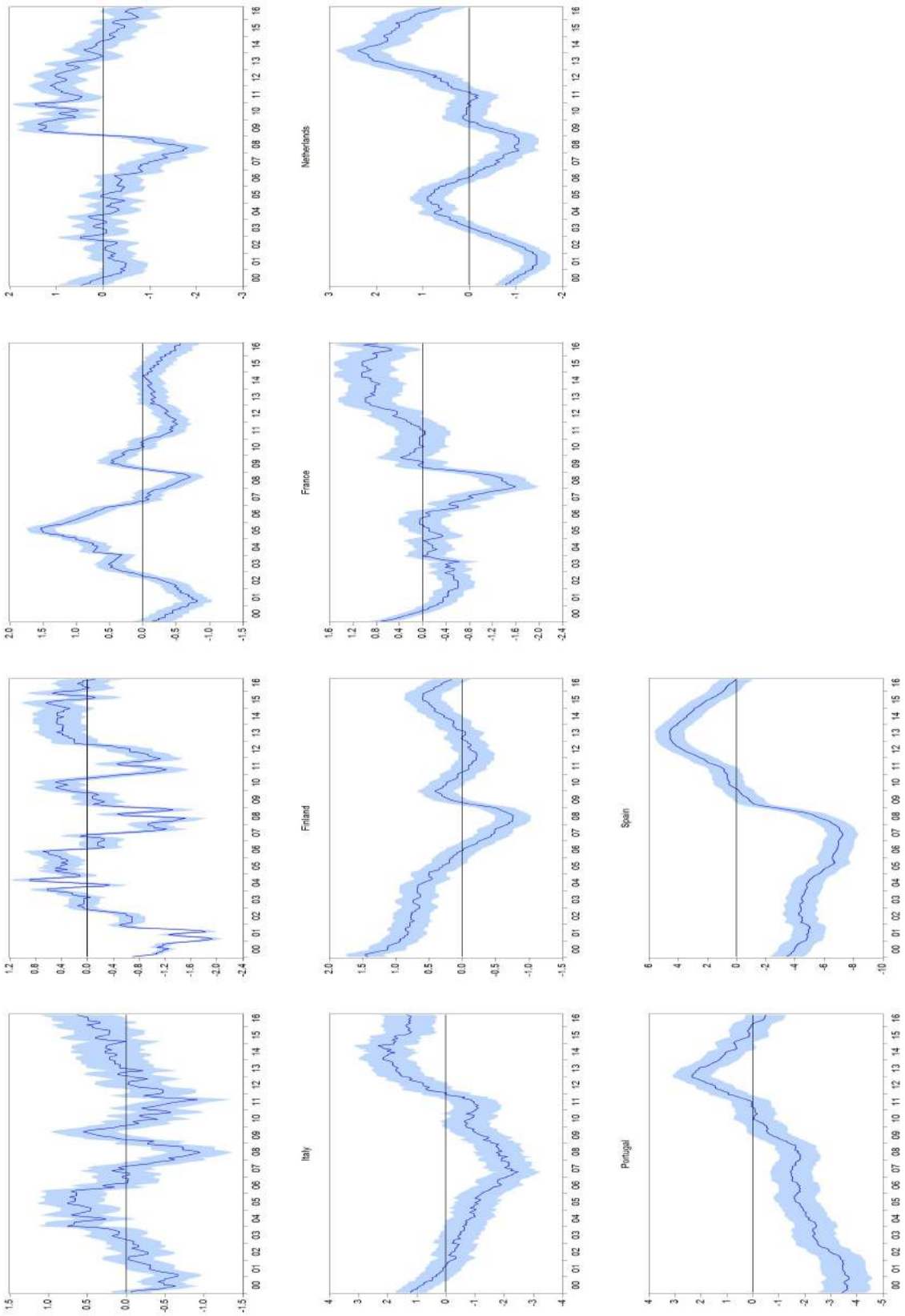


Figure 3: Estimated unemployment gap for EU10 (in percent)



4.2 Long run trend inflation, inflation gaps and time varying parameters

The long run trend inflation smoothed filtered series is displayed in panel a of figure 4. Long run trend inflation declines from roughly 2% at the beginning of 2000 to 1.7% in late 2016. Thereby, the a large proportion of the decline in long run trend inflation is around 2008 to 2010. This drop of long run inflation might signal increasing risk of inflation expectations de-anchoring in the course of the sovereign debt crisis, which has ,according to the presented estimates, not been restored to pre crisis levels. Moreover, decreased inflation expectations anchoring might increase the impact of cost-push factors and movements of the unemployment gap on consumer inflation, which might have contributed to the recent disinflationary episode in EU10 countries.

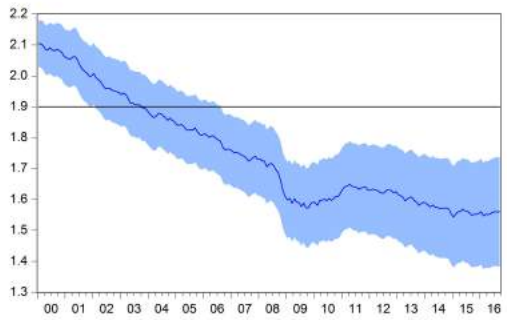
The country-specific inflation gaps (figure 5) reveal heterogeneous dynamics across countries. The inflation gaps of Ireland, Italy, Portugal and Spain are persistently above zero from 2000 to 2007, while the inflation gap for Germany is below zero. For France, Belgium and Austria inflation gaps fluctuate around zero and inflation gaps of the Netherlands and Finland show country-specific events up to global financial crisis. Across countries inflation gaps turn negative from 2013 to 2016, whereby in Belgium, Germany Finland and Portugal exhibit an increasing tendency towards the end of the sample.

Turning to the time varying parameter estimates, the coefficient of inflation persistence (panel b, figure 4) declines from 0.94 to 0.9 from the beginning of the 2000s up to the global financial crisis. In correspondence to the results on the long run trend inflation, inflation persistence increases to 0.96. in late 2009 to the extent that inflation persistence from 2009 onwards in significantly higher than before. Thus, increasing risk of de-anchored long run inflation expectations might be associated with a rise in back-ward looking price setting behaviour.

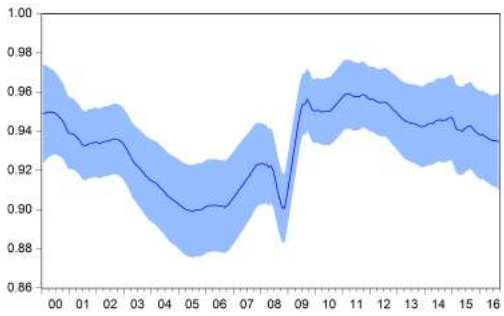
The time varying slope of the Phillips Curve can be seen in panel c of figure 4 and varies around 0.01 and -0.043, whereby it is not significantly larger than 0 over the entire sample.

Figure 4: Inflation trend and time varying parameter estimates

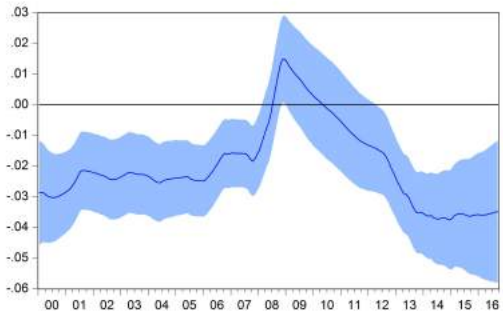
(a) long run inflation trend (in percent)



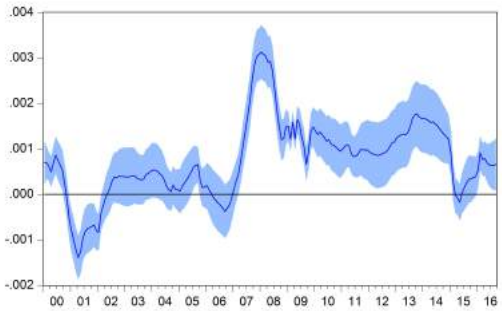
(b) coefficient on inflation persistence



(c) coefficient on unemployment gap



(d) coefficient on oil price



Before 2007 the coefficient of the unemployment gap is stable around -0.031 and increases in the course of the global financial crisis, implying a flattening of the Phillips curve. From 2009 onwards the coefficients declines to 0.043 at the end of 2016. Thus, in the course of sovereign debt crisis movements in cyclical unemployment gained importance for inflation dynamics and in part explain observed disinflation in the recent episode.

The impact of oil price movements on inflation has been rather limited through the first half of the sample up to the start of the sovereign debt crisis (panel d, figure 4. In late 2007 the importance of oil price movements for inflation dynamics gains momentum as the coefficient on oil increases from 0.0001 to 0.003 and stabilizes around 0.0017 in early 2009.

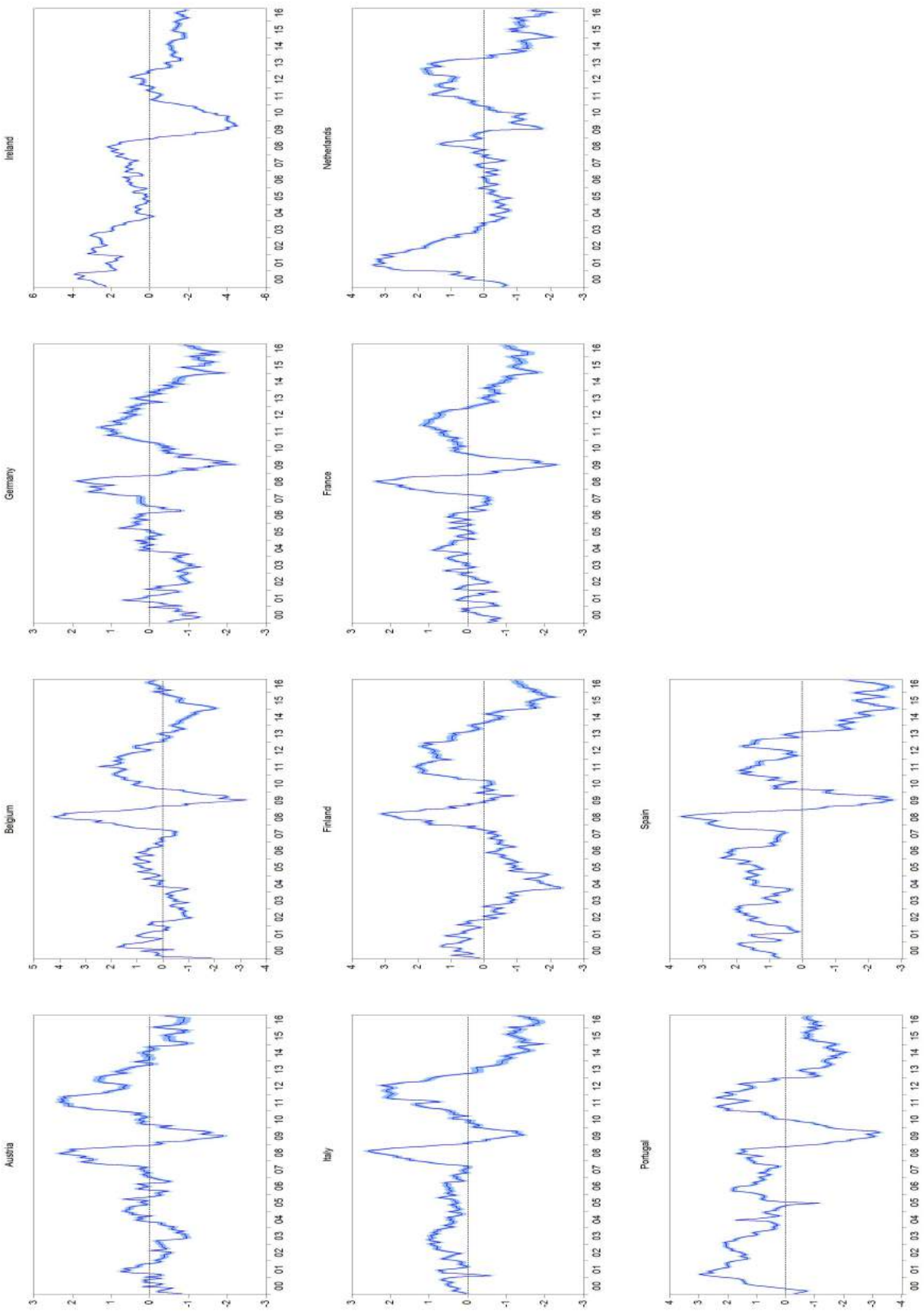


Figure 5: Estimated inflation gap for EU10 (in percent)

Overall, persistently negative unemployment gaps, especially in countries that have been severely hit by the sovereign debt crisis, and an increasing Phillips Curve slope in the course of the sovereign debt crisis might partially explain the disinflationary pressures of consumer prices in EU10 countries. Moreover, declining long run trend inflation and rising inflation persistence indicate altered risk of inflation expectations de-anchoring and an increasing degree of backward lookingness in price setting. Both findings but also a slightly higher impact of oil price movements have contributed to the prolonged period of low inflation in the recent episode.

5 Robustness Tests

This section reports on a series of sensitivity analyses on our benchmark model, equation (1), on several dimensions. To assess the robustness of our key findings we assess the performance of our estimation on two key dimensions, namely data choices and measures of CPI, inclusion and variation of cost-push factors. Our qualitatively findings are robust to all these sensitivity checks. Corresponding results are therefore just outlined here and depict in detail in the appendix.

Since sharp movements of the overall HICP might stem from underlying energy and food price movements that are highly volatile over time, we estimate our benchmark model using HICP without energy and food prices. Due to a generally lower level of the inflation measure trend inflation , coefficient and inflation gap estimates reveal qualitatively the same dynamics as the results of the benchmark model however differ substantially in quantity. Estimates of the NAIRU and the unemployment gap only differ slightly quantitatively compared to the benchmark model results. Since changes in administrated prices might influence inflation dynamics of measured by the overall HICP we we re-estimate our benchmark model using HICP excluding administrated price as a second robustness check. As a third robustness test, to account for a longer pass-through of oil prices re-estimate our benchmark model

using accumulate oil price changes up to 12 months as a third robustness test.

6 Conclusion

In this paper we investigate in the causes of low inflation in the euro area since the start of the Great Recession. In particular, we are interested in the a consistent estimate of long run trend inflation for EMU 10 countries but also on the impact of cost-push shocks, inflation indexation and economic slack to recent inflation developments and whether the explanatory power of theses factors have changed in the course of the double dip recession. Therefore, we propose a cross-sectional identification of long run trend inflation estimate. We simultaneously allow for country specific NAIRUs, unemployment gaps and inflation gaps as well as time variation in parameters in a modified Phillips Curve specification. For the joint estimation of state variables and time varying parameters we apply a two step approach using the Kalman filter. We find that NAIRUs and unemployment gaps depict substantial heterogeneity across countries that match well with country-specific labour market reforms and changes. Moreover, negative unemployment gaps together with an increasing Phillips Curve slope in the course of the sovereign debt crisis might partially explain the disinflationary pressures of consumer prices in EU10 countries. Our estimates of the long run trend inflation have declined from 2009 onwards and indicate altered risk of inflation expectations de-anchoring. We also find rising inflation persistence. Our results reveal that predominately negative unemployment gaps, declining long run trend inflation together with a simulations increase in the degree of backward lookingness and to a less extent the impact of oil price movements have contributed to the prolonged period of low inflation in the recent episode.

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7 Apppendix

7.1 Robustness: Different measures of consumer price inflation

7.1.1 Using HICP without energy and food prices

Figure 6: Estimated NAIRU and actual rate of unemployment for EU10 (in percent)

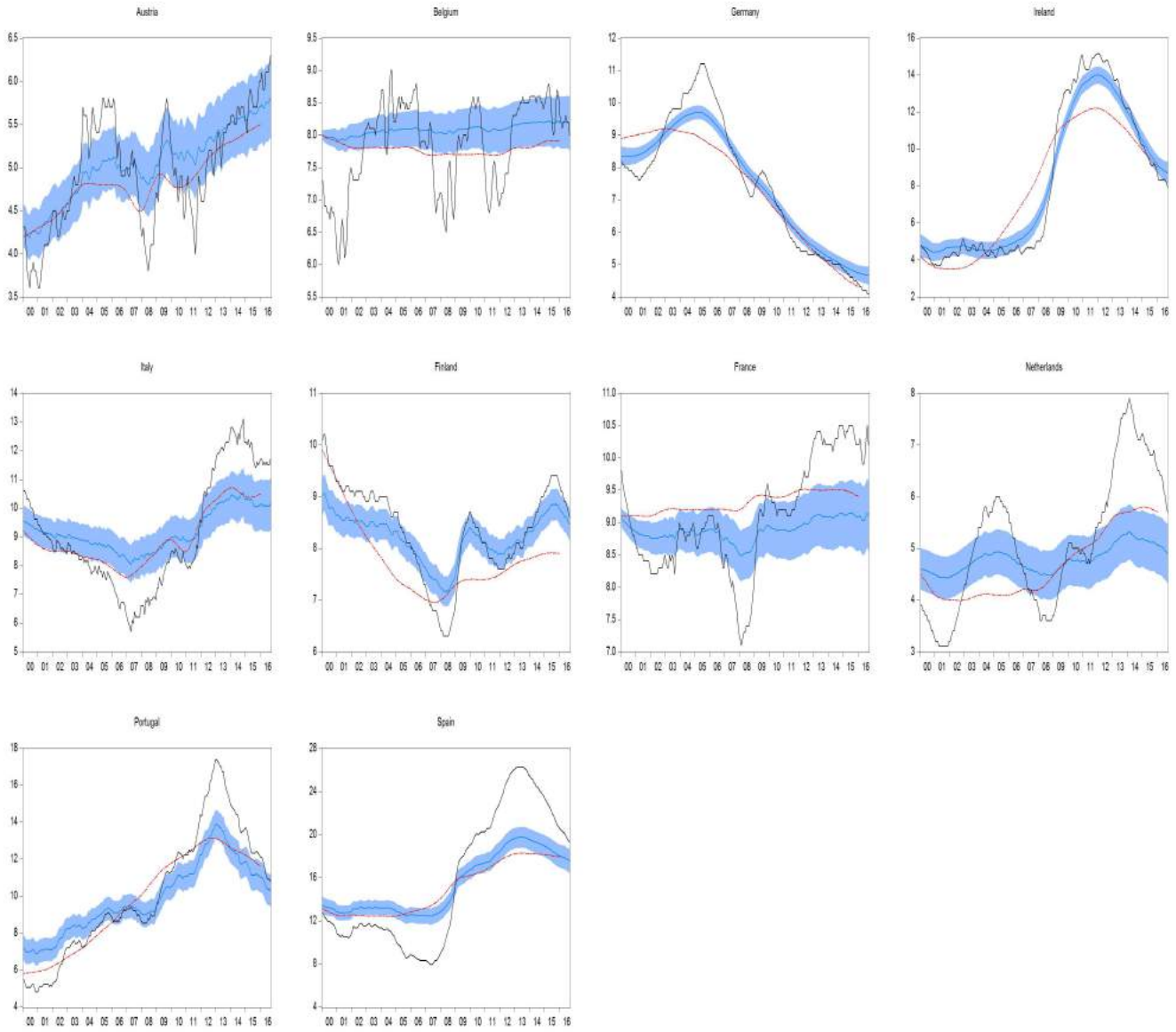


Figure 7: Estimated unemployment gap for EU10 (in percent)

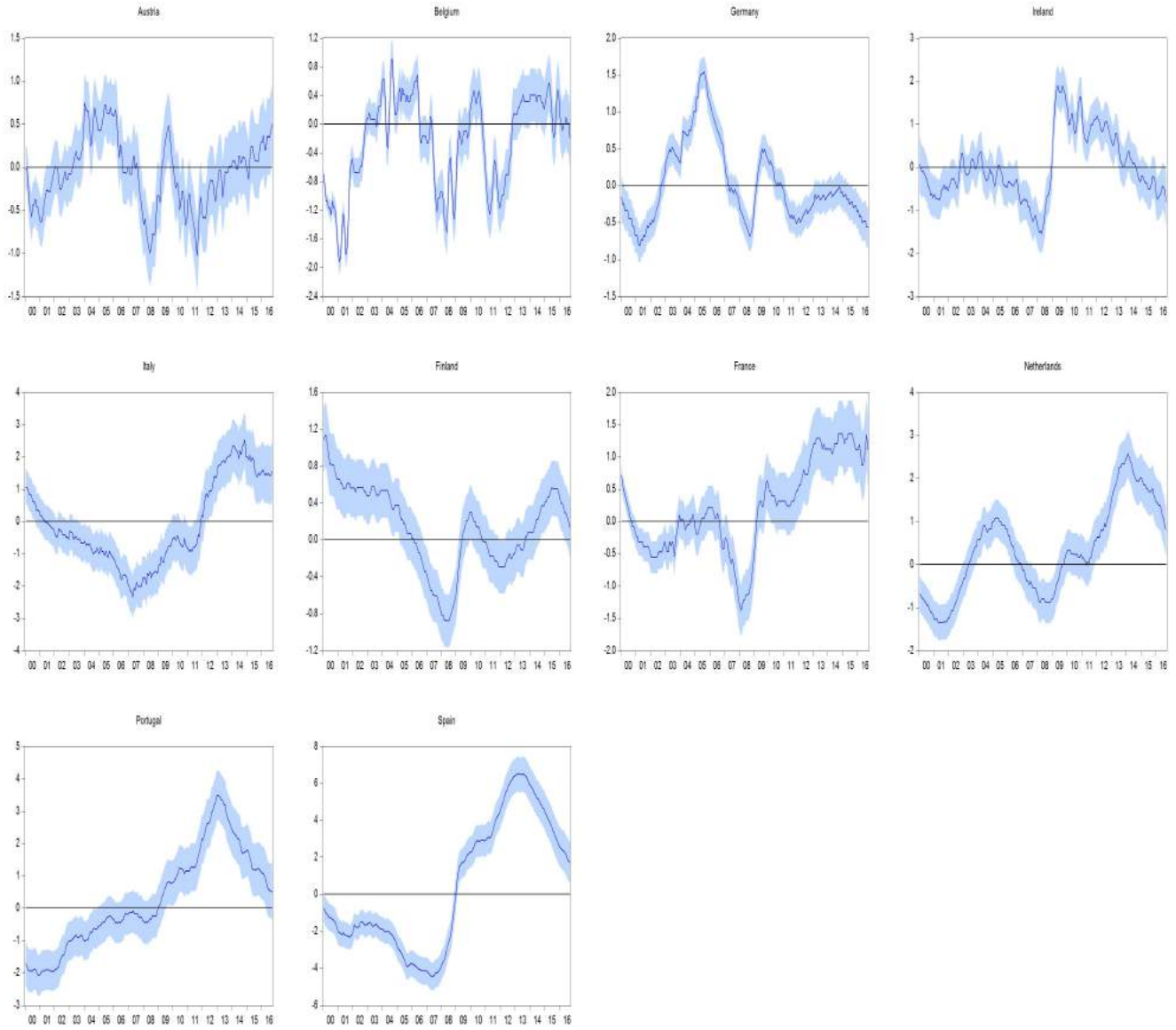


Figure 8: Estimated inflation gap for EU10 (in percent)

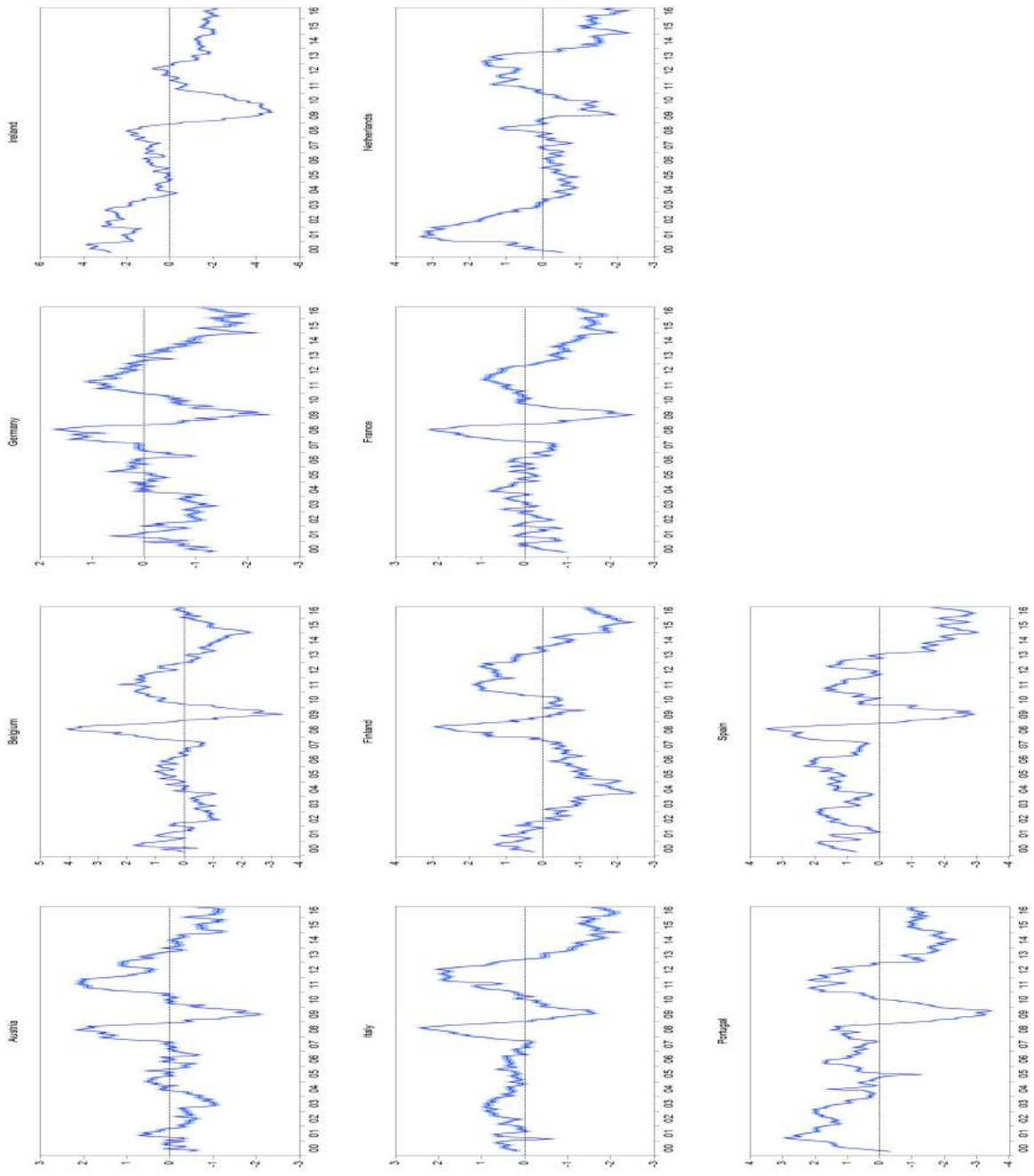
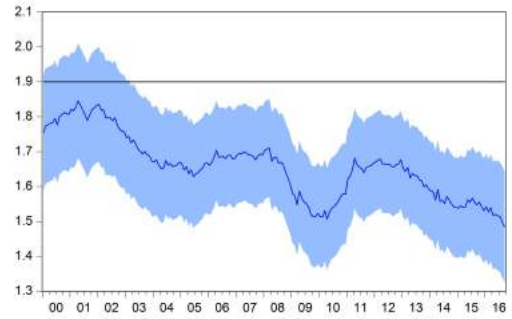
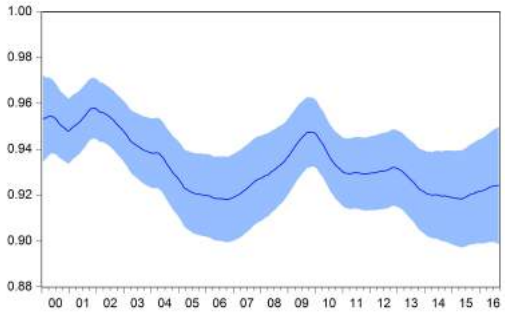


Figure 9: Estimated long run trend inflation and time varying coefficients

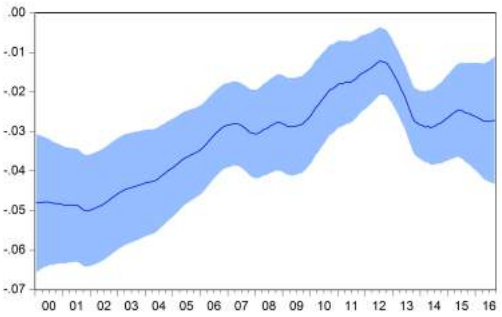
(a) long run inflation trend (in percent)



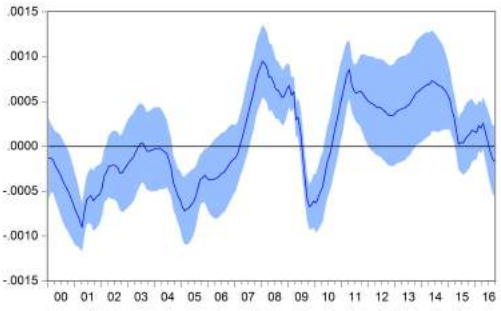
(b) coefficient on inflation persistence



(c) coefficient on unemployment gap



(d) coefficient on oil price



7.1.2 Using HICP without administrated prices

Figure 10: Estimated NAIRU and actual rate of unemployment for EU10 (in percent)

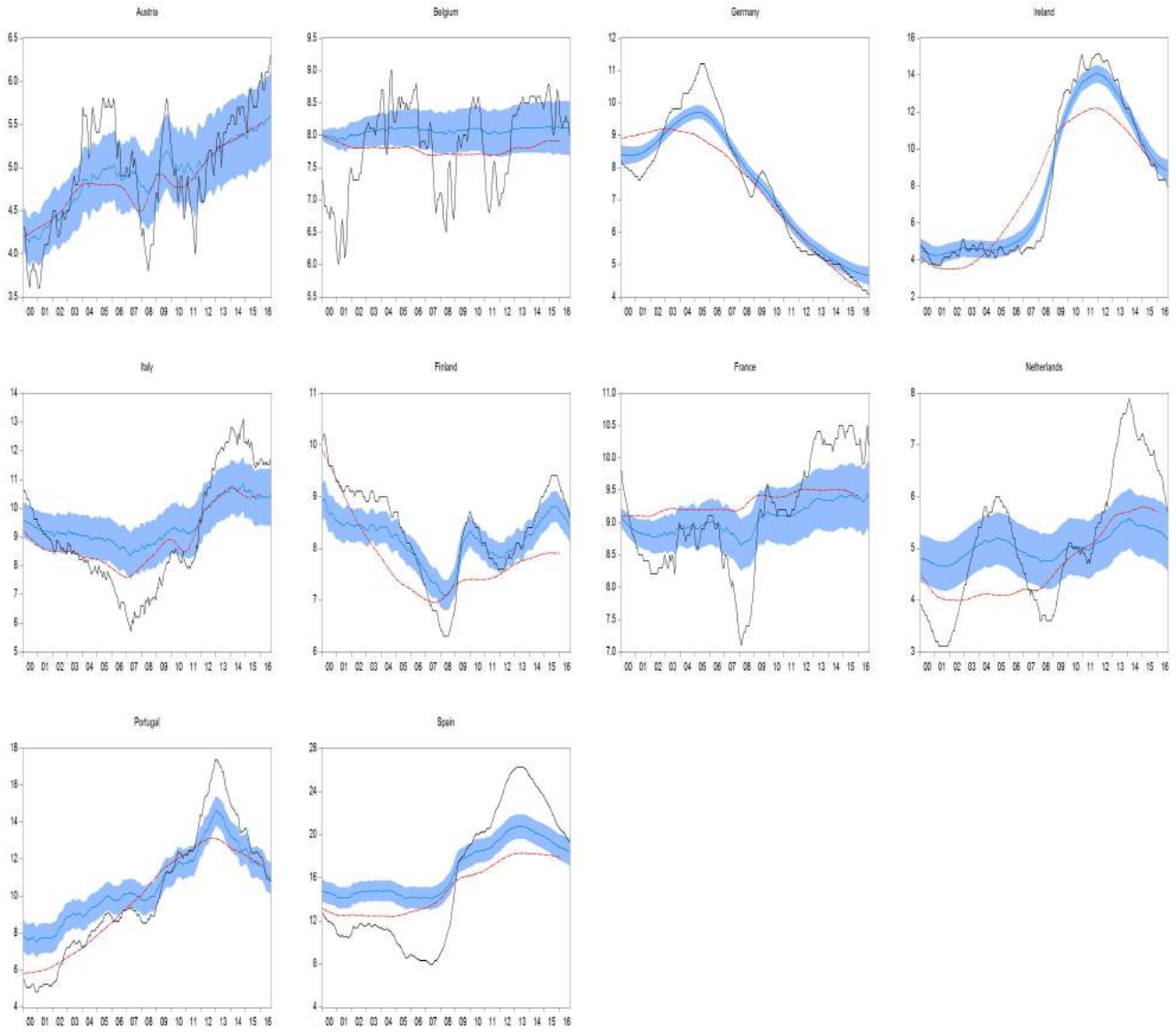


Figure 11: Estimated unemployment gap for EU10 (in percent)

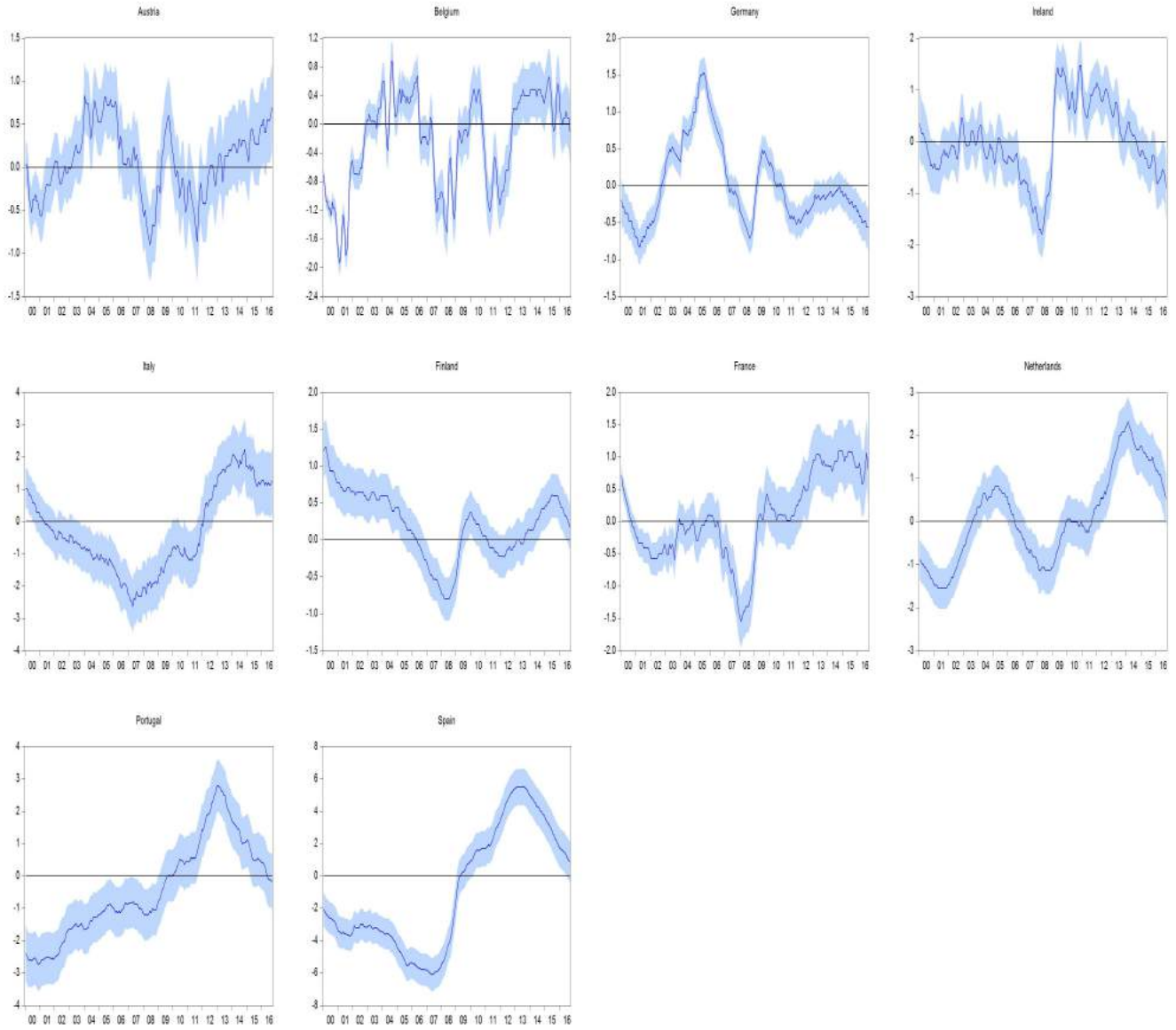


Figure 12: Estimated inflation gap for EU10 (in percent)

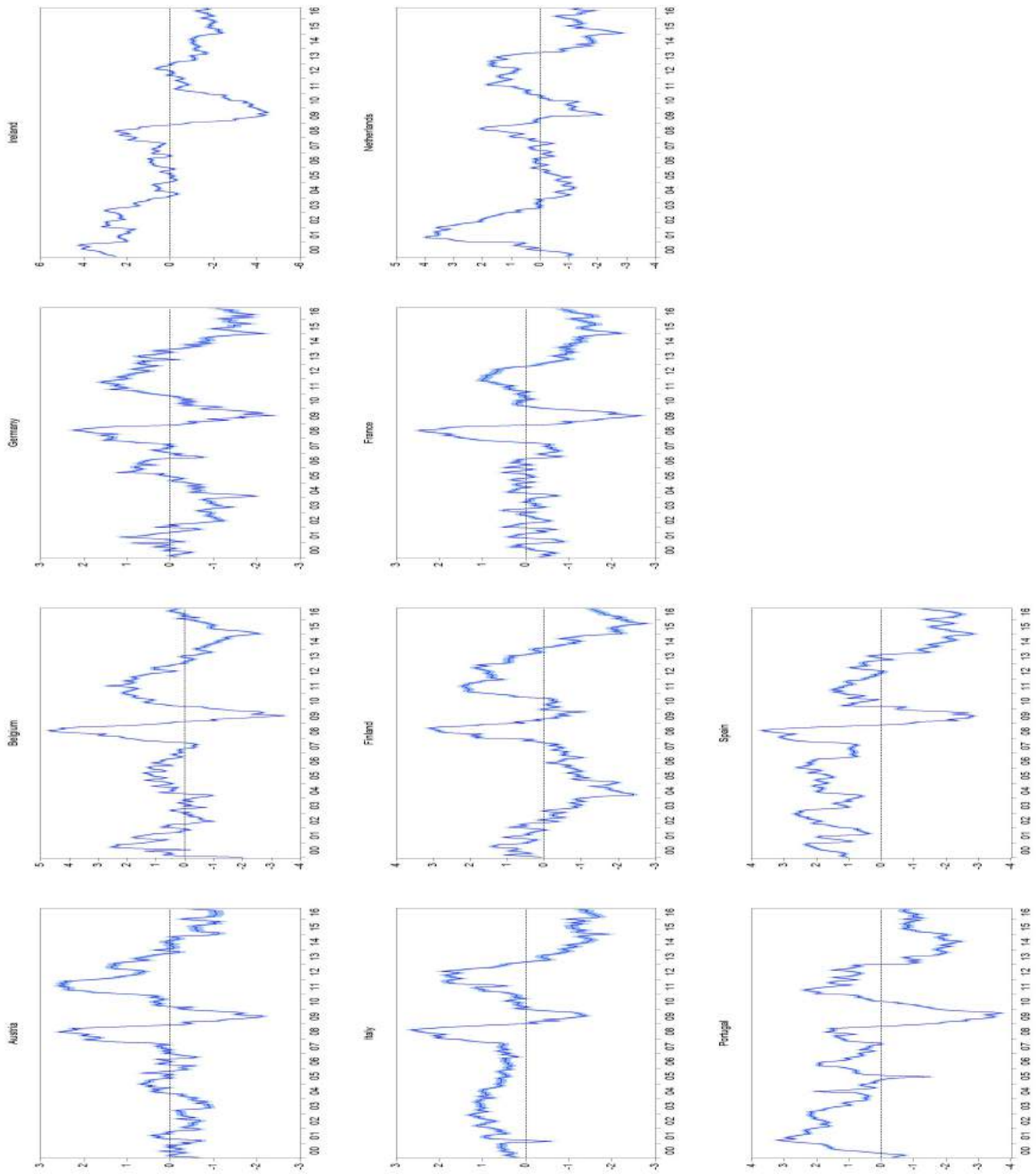
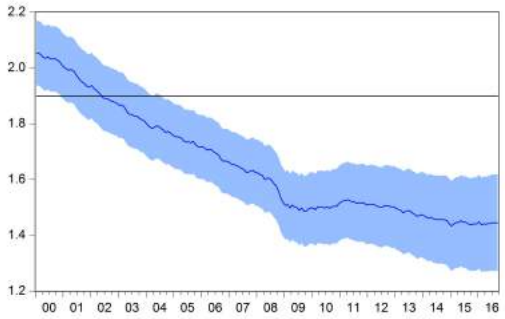
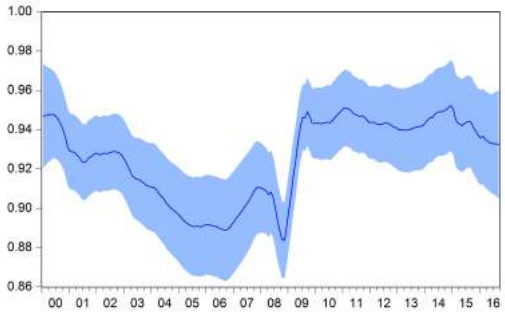


Figure 13: Estimated long run trend inflation and time varying coefficients

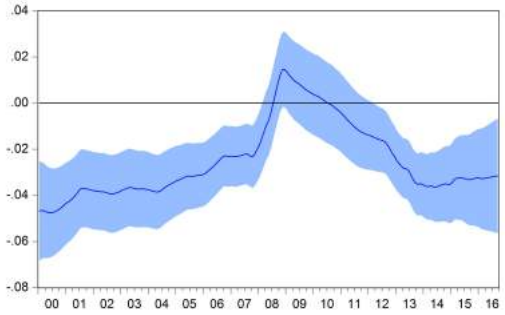
(a) long run inflation trend (in percent)



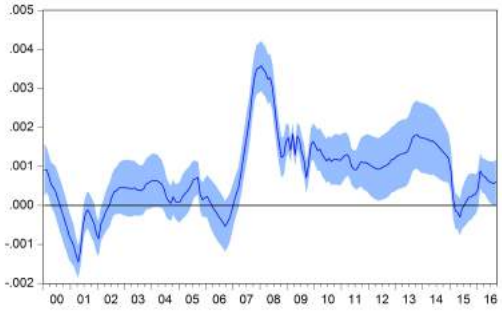
(b) coefficient on inflation persistence



(c) coefficient on unemployment gap



(d) coefficient on oil price



7.2 Robustness: Inclusion and variation of cost-push factors

7.2.1 Using cumulative oil price inflation of up to 12 lags

Figure 14: Estimated NAIRU and actual rate of unemployment for EU10 (in percent)

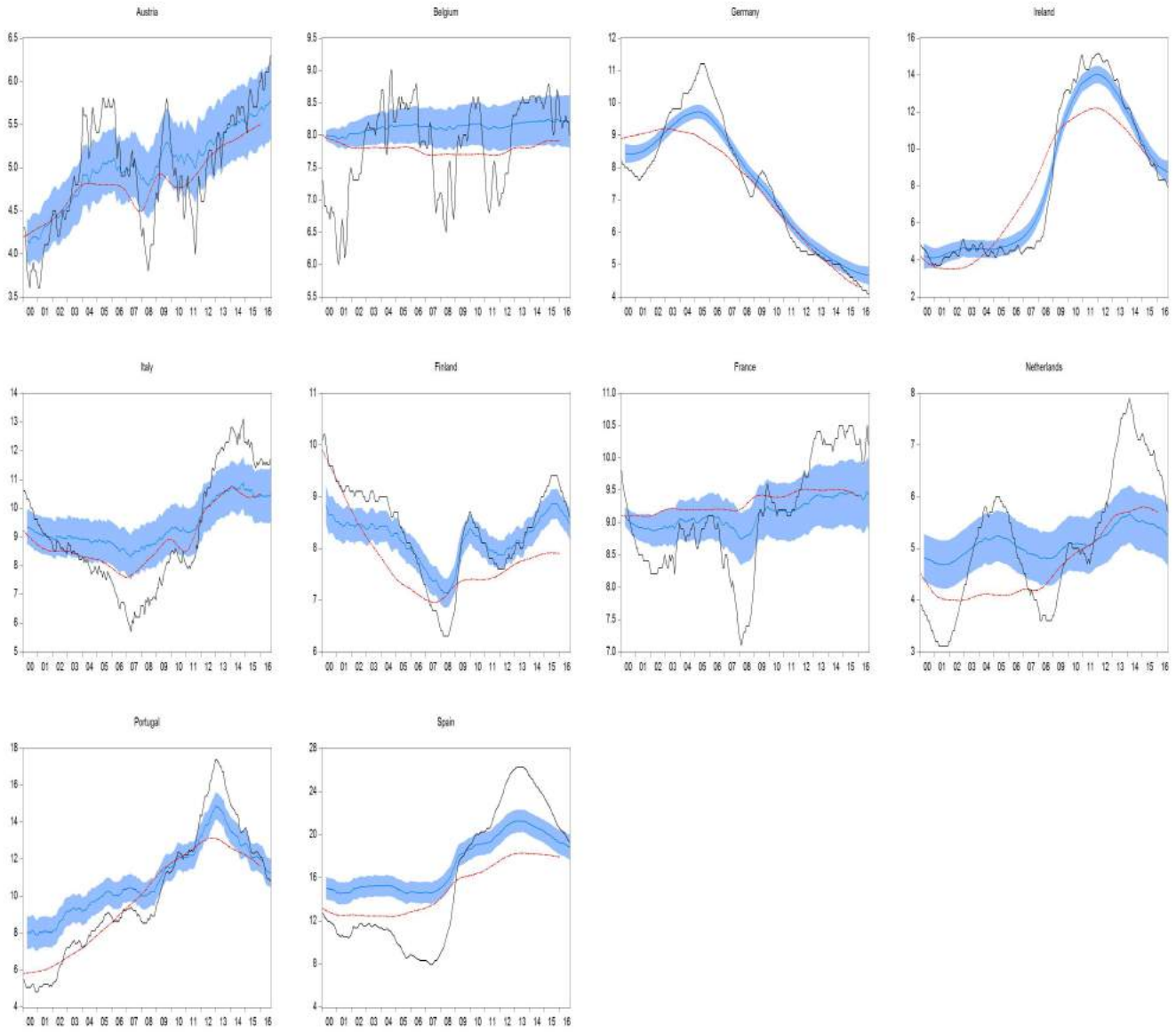


Figure 15: Estimated unemployment gap for EU10 (in percent)

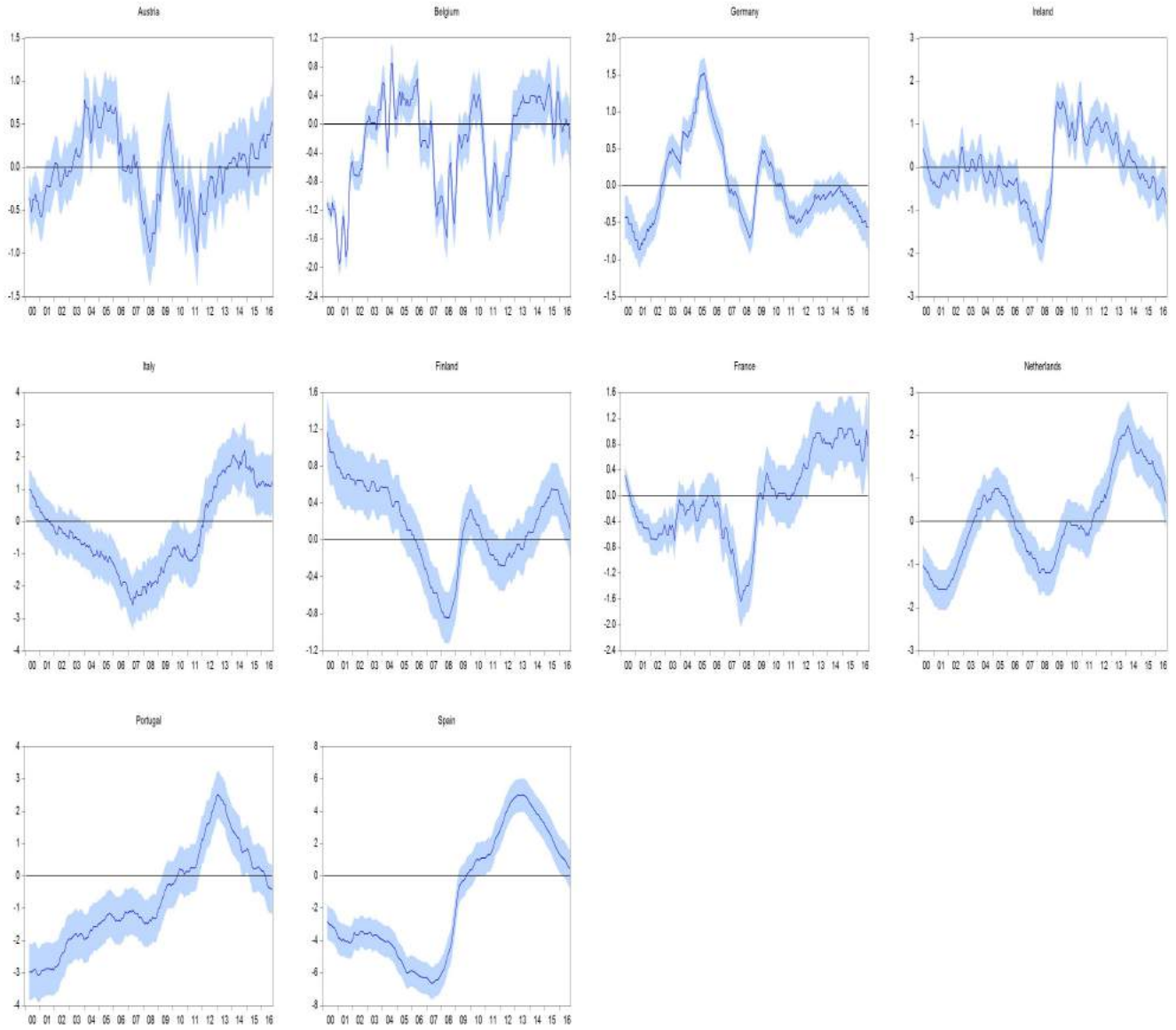


Figure 16: Estimated inflation gap for EU10 (in percent)

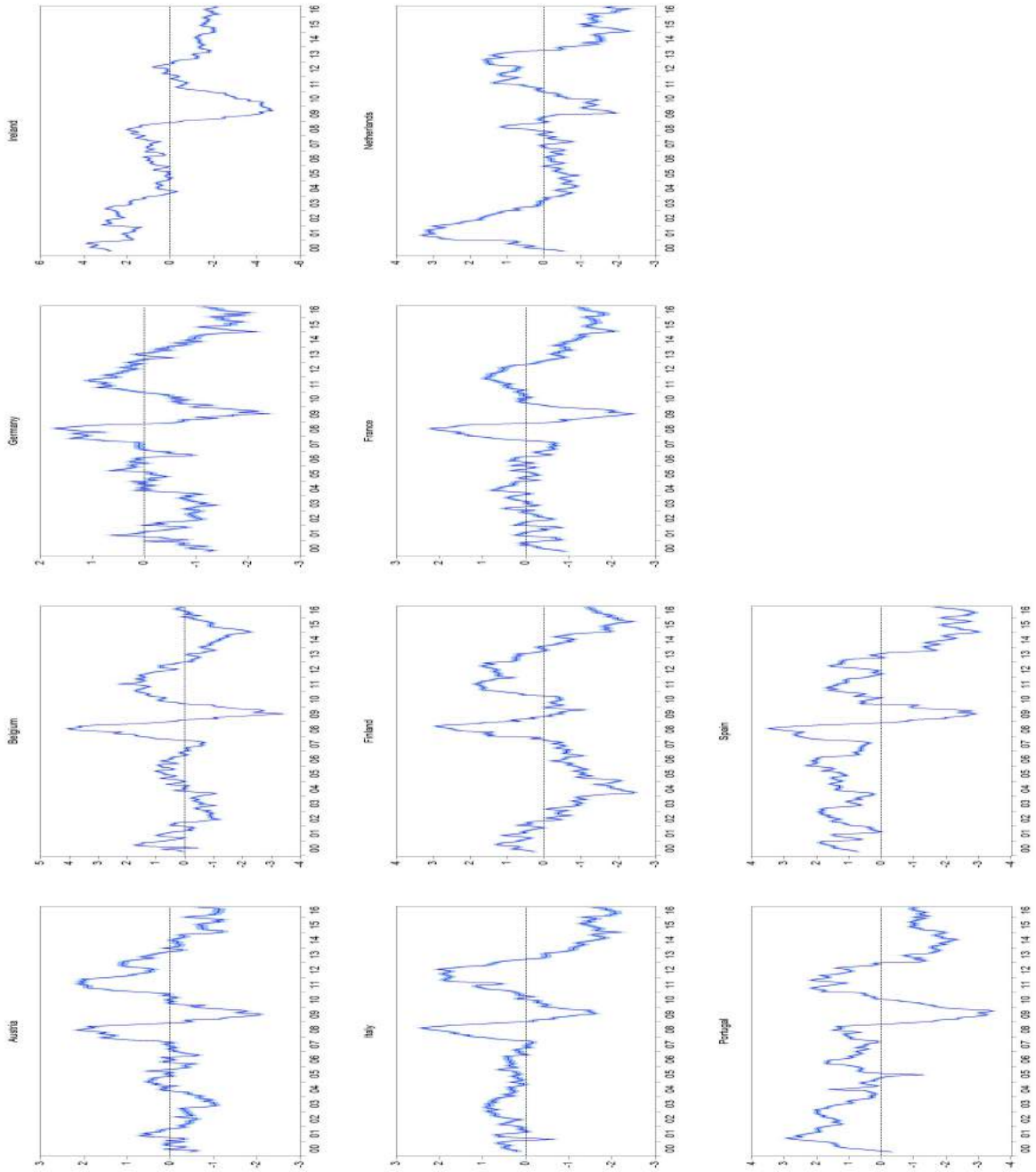
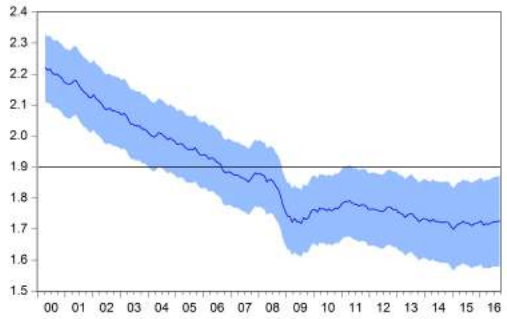
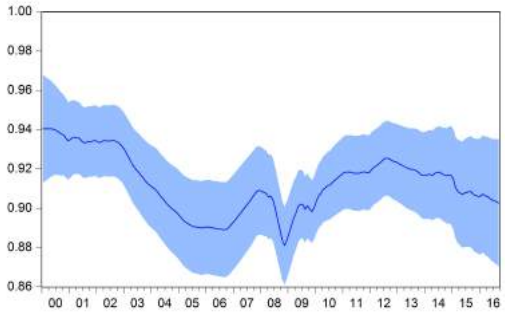


Figure 17: Estimated long run trend inflation and time varying parameters

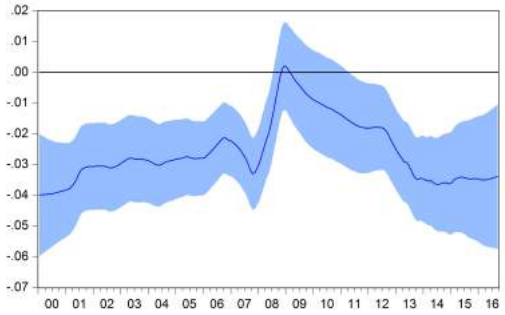
(a) long run inflation trend



(b) coefficient on inflation persistence



(c) coefficient on unemployment gap



(d) coefficient on oil price