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# Dynamics and Factors of Inflation Convergence in the European Union

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## Abstract:

We provide comprehensive evidence of the widespread occurrence of inflation convergence between all countries of the European Union from 1999 to 2016. We also show that convergence was more inclusive in the years after the global financial crisis—including the European sovereign debt crisis and the period of zero lower bound—and that price-stability-oriented monetary strategies might have in fact facilitated this convergence. Our results are robust with respect to the use of three inflation benchmarks (the cross-sectional average, the inflation target of the European Central Bank, and the Maastricht criterion), structural breaks, and a core inflation measure. Our main findings imply that further enlargement of the euro area is feasible from the perspective of the convergence of inflation rates between the countries of the European Union.

**Keywords:** inflation convergence, European Union, global financial crisis, zero lower bound, monetary strategy

**JEL:** C32, E31, E58, F45, G01, K33

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## 1. Introduction and motivation

In this paper, we analyze the dynamics of inflation convergence in the European Union (EU) as well as the effect of various major factors on the convergence process.<sup>1</sup> Inflation convergence is one of the Maastricht prerequisites to join the Economic and Monetary Union (EMU) that was established in Europe in 1999 (Siklos, 2010). The introduction of the euro and the creation of the euro area marks a key step in the process of European monetary integration, which is ongoing since the 1970s. So far, 19 out of 28 member states of the EU have adopted the euro and more are obliged to follow based on the Maastricht Treaty.<sup>2</sup> The bloc of countries still does not exactly satisfy all the criteria for optimum currency area (OCA) theory (De Grauwe, 2010) and, disturbingly, “net benefits of joining a currency area change over time” (Aizenman, 2016). Despite that inflation convergence is not an OCA prerequisite it remains a major issue that has received substantial attention in the past literature (reviewed in Section 2). Nevertheless, recent economic developments have brought new factors that might impact inflation convergence in the EU.

We therefore revisit the topic of inflation convergence, operate on the scale of the entire EU, and introduce several factors of convergence. This is novel in the literature. Our analysis is motivated by questions that are grounded in recent economic developments along with the process of EU integration. First, we study whether price stability-oriented monetary strategies exhibit an effect on the convergence of inflation rates in the EU towards the inflation benchmark. This hypothesis is based on the idea that the inflation rates of countries operating under the same or a very similar monetary strategy might converge with respect to each other (Kočenda and Papell, 1997; Kočenda et al., 2006).

Second, we are interested in whether there was weakened inflation convergence in the EU in the period from September 2008—when the global financial crisis (GFC) erupted—to July 2012, when Mario Draghi’s famous speech facilitated a turn in the European sovereign debt crisis (Afonso et al., 2017). Crucially, both crises had a heterogeneous impact on the evolution of the gross domestic product (GDP) across EU countries, which implies that inflation rates were also likely affected in a heterogeneous manner (Groot et al., 2011). Third, following the GFC and the European sovereign debt crisis, a number of countries have been confronted with a zero lower bound (ZLB) or zero interest rate policy. ZLB constrains conventional monetary policy and has been shown to be an important factor affecting inflation persistence (Buiter, 2009; Swanson and Williams, 2014). All three periods (the GFC, the European sovereign debt crisis, and the period of ZLB) can be regarded as unique events with potentially distortive impacts on the process of inflation convergence in the EU via various economic channels (Cheung et al., 2010; Ball, 2013; Fratzscher, 2012; Lane, 2012; Claessens and Van Horen, 2015).

Fourth, the EU enlargement and integration process requires that a set of strict criteria, labelled as *acquis communautaire* (AC), are fully met by the prospective new members before EU accession (Grabbe, 2002). The AC guarantees that new EU members are sufficiently close to the old members in terms of their economic and institutional level (Hille and Knill, 2006).

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<sup>1</sup> We do not analyze price level convergence unlike e.g. Lutz (2004) or Fischer (2012).

<sup>2</sup> An opt-out clause was negotiated by Denmark and the United Kingdom. These countries are not obliged to join the euro area in the future. Sweden declined euro adoption in a 2003 referendum and is not expected to join the euro area.

Hence, on the point of their accession, the prospective EU members might have already exhibited some effort towards alignment with the old EU member states. Such an effort in economic terms might have contributed to a decrease in inflation differential. To investigate that we ask whether AC fulfilment might have led to stronger inflation convergence in new EU member states.

In order to answer our questions, we perform an empirical analysis in which we use data on the harmonized index of consumer prices (HICP) from Eurostat, starting in 1999. The reason for the use of this measure is anchored in the definition of the Maastricht inflation criterion and circumvents heterogeneous definitions of the CPI measure across countries. For each EU country in our sample, we construct a series of annual inflation rates with monthly HICP data and consequently also a series of inflation differentials. We assume three types of inflation benchmark: (i) the cross-sectional average (Kočenda and Papell, 1997; Lopez and Papell, 2012), (ii) the inflation target of “below, but close to, 2% over the medium term” pursued by the ECB, and (iii) the inflation rate based on the Maastricht criterion (Kočenda et al., 2006; Siklos, 2010).

In our analysis, we follow and extend the methodological approach used by Lopez and Papell (2012) by employing the seemingly unrelated regressions (SUR) framework built on Augmented Dickey-Fuller (ADF) tests. This method should deliver more efficient results than separate ordinary least squares (OLS) regressions would. We enrich the ADF equation for each country with dummy variables corresponding to our factors of convergence. The dummies account for (i) the period of the GFC and the European sovereign debt crisis, (ii) the ZLB, (iii) the implementation of *acquis communautaire*, and (iv) the employment of the price stability-oriented monetary strategies inflation targeting (IT) and a constraining exchange rate arrangement (CERA). Moreover, we explicitly test for the presence of structural breaks in the series of inflation differentials of individual countries using the test by Bai and Perron (1998). Without accounting for structural breaks, our results could be biased towards not rejecting the null hypothesis of no convergence (Perron, 1989). Consequently, we include detected breaks in the convergence model for each EU member state. Since we depart from the standard ADF test specification, we derive country-specific critical values via Monte Carlo simulations.

The baseline specification is estimated on the full sample of 28 countries from 1999 to 2016 with additional covariates. We also provide robustness checks of the main results. First, we estimate the model separately during 1999–2008 and 2009–2016 for all three inflation benchmarks and without covariates. We do so to assess whether there were different convergence dynamics in the pre-crisis and the post-crisis periods. Importantly, the latter period includes the GFC, the European sovereign debt crisis, and the period of ZLB. Second, we re-estimate the model for the post-crisis years with a core inflation measure instead of the HICP to assess whether our baseline results are robust with respect to a significant fall in commodity prices in 2014.

Our paper contributes to the literature on inflation convergence in Europe in three ways. First, we focus on the entire EU, rather than on the euro area or old and new EU member states separately; we assume that based on the obligations set by the Maastricht Treaty, the vast majority of EU member states is expected to adopt the common currency at some point in the future. Second, the period under investigation spans from 1999 to 2016. Hence, we cover the period from the euro introduction up to almost the present day. In this

respect, we provide new results as so far there has been little research on inflation convergence after the GFC and during the period of benchmark interest rates on the ZLB. Third, we also provide evidence of the impact of price stability-oriented monetary strategies and of the process of fulfilling the AC (the common EU law) on inflation convergence in the EU. Such issues have not been covered in the literature on the topic of inflation convergence in Europe yet.

The paper is structured as follows. Section 2 offers a literature review of the previous research on inflation convergence in Europe and highlights several features that are employed in our analysis. Section 3 presents data, variables, and testable hypotheses. In Section 4 we describe the methodological approach. We display our results and inferences in Section 5. The last section concludes.

## **2. Literature review**

The topic of inflation convergence in Europe has drawn substantial attention, but empirical research is fragmented and differs in several ways. First, various target groups of countries are analyzed. While some studies cover the entire EU, others concentrate on inflation convergence in the euro area or in new EU member states only. Second, the array of methodological approaches is broad. Most studies favor unit-root testing either in time series or panel unit-root versions while others examine the distributional features of the series of inflation rates or employ wavelet analysis to study the issue of inflation convergence in the time-frequency domain. Third, the definition of the inflation benchmark varies as well: benchmarks can be based on the Maastricht criterion, the inflation rate of Germany, the European Central Bank's (ECB) target of (close to) 2% or a simple cross-sectional average in a given time period. Fourth, the literature unsurprisingly provides vastly different conclusions on the presence of inflation convergence in Europe.

For the reasons above, we sample the literature that is closest to our analysis, divide it into three subgroups, and review it based on a mix of geographic and monetary criteria: inflation convergence in the EU, in current euro area members, and in prospective euro area members.

### *2.1 Inflation convergence in the EU*

Kočenda and Papell (1997) analyze inflation convergence among the EU countries under the earlier European Monetary System (EMS). They employ a panel version of the ADF unit root test for which they compute finite sample critical values using Monte Carlo simulations. The findings of Kočenda and Papell (1997) document the existence of inflation convergence in the EU that is even stronger for countries participating in the Exchange Rate Mechanism (ERM). Since the ERM can be understood as a constraining exchange rate arrangement, it seems that the ERM helped to facilitate a gradual disinflation in countries with relatively high initial inflation rates as low inflation was imported from Germany, a country with comparatively more stable macroeconomic fundamentals.

### *2.2 Inflation convergence in the euro area*

Studies on inflation convergence between current euro area members assume that the guidance of the ECB should sooner or later deliver inflation convergence between the

countries using the common currency (Weber and Beck, 2005). Persistent differences, however, may aggravate the conduct of monetary policy by the ECB. The single interest rate may prove too tight or too loose for various members of the euro area (Canarella et al., 2011).

This is, however, not confirmed by Lopez and Papell (2012) who study the convergence of the inflation rates of countries constituting the initial members of the euro area and find rather robust evidence of convergence after the introduction of the Maastricht Treaty and especially after the adoption of the common currency in 1999. Moreover, Lopez and Papell (2012) show that after the onset of the global financial crisis, inflation rates of the euro area members mostly do not deviate from the path dictated by ECB monetary policy. On the methodological level, the authors employ a set of ADF tests in the seemingly unrelated regressions (SUR) framework, while assuming a homogenous rate of convergence across the euro area countries and the cross-sectional average inflation rate as the benchmark.

A contrasting finding is in Giannellis (2013). He employs a threshold unit root test, uses the cross-sectional average as the inflation benchmark, and reports that the majority of euro area members exhibit rather persistent inflation differentials. This implies that the ECB one-size-fits-all policy might not be optimal for all countries using the common currency.

Next, Lee and Mercurelli (2014) use the structural vector autoregressive framework to examine if shocks affecting the economies of France, Germany, and Italy have become more symmetric after the adoption of the common currency. This hypothesis can be reframed in the context of the concept of optimum currency area (OCA) theory. The authors uncover clear evidence in favor of more symmetric shocks after the advent of the euro that was interrupted by the GFC but surprisingly not at all by the turmoil caused by the euro crisis after 2010. Overall, the findings by Lee and Mercurelli (2014) speak in favor of multilateral endogeneity effects among Germany, France, and Italy.

### *2.3 Inflation convergence in the prospective euro area countries*

Finally, a sizable portion of the literature, such as Kočenda et al. (2006) or Cuestas et al. (2016), studies the inflation convergence of prospective members of the euro area towards the current members. Importantly, these studies introduce structural breaks into the discussion on the topic of inflation convergence.

More specifically, Kočenda et al. (2006) examine among other things monetary convergence in the new EU member states. The authors note that such research is vital in the sense of possible implications for monetary policy (as well as exchange rate policies) before Euro adoption. Another interesting phenomenon that Kočenda et al. (2006) tackle is the performance of inflation targeting in Central and Eastern European (CEE) countries (the Czech Republic, Hungary, Poland, and Slovakia). On the methodological level, the authors employ the Vogelsang test for inflation convergence, which allows for endogenously determined structural breaks. Their findings then show that (i) the majority of new EU member states were able in the second part of the dataset (2000–2005) to reduce inflation rates to the level of old EU countries and (ii) they managed to avoid repeated divergence from the path that the countries guided by the ECB follow (Kočenda et al., 2006). The findings also speak in favor of the inflation targeting framework, which might have helped some new EU member states to better align their inflation rates with those of the old EU countries.



Next, Cuestas et al. (2016) focus on the recent post-crisis years and a group of Central, Eastern and Southeastern European (CESEE) countries and (i) show that the GFC should be considered when estimating series of inflation differentials and (ii) find evidence of structural breaks and non-linear elements in inflation differentials. The results in Cuestas et al. (2016) imply that a certain degree of non-linearity in the series of inflation differentials should be considered when planning the adoption of the common currency in the prospective euro area members.

Finally, Siklos (2010) employs both a univariate and multivariate unit root and cointegration test, adding covariates in the ADF regressions to increase their power, and provides a rather favorable conclusion on the extent of inflation convergence in the group of new EU member states.

## *2.4 Summary of the literature*

In Table 1, we provide a summary of the literature on inflation convergence in Europe. We mention several characteristics, in line with the introduction to Section 2: the target group of countries, methodology, inflation benchmark, and results.

Interestingly, the majority of studies use the cross-sectional average as the inflation benchmark. Also, two papers that consider modified ADF tests—Giannellis (2013) and Cuestas et al. (2016)—find evidence against convergence. In our analysis, we attempt to reconcile the latest trends in the inflation convergence literature with a traditional approach: we employ the ADF-SUR test (Lopez and Papell, 2012) but allow for structural breaks in our specification (Kočenda et al., 2006; Cuestas et al., 2016). Moreover, to provide a richer set of results, we use two additional inflation benchmarks apart from the cross-sectional average: the Maastricht benchmark and the ECB target of “below, but close to, 2% over the medium term”.

## **3. Data, variables, and hypotheses**

We collected a dataset of monthly inflation rates for all current EU members. We do not omit any EU member state as it is reasonable to assume that the vast majority of them will have adopted the common currency at some point in the future, based on the obligations set by the Maastricht Treaty.<sup>3</sup>

The period under study spans 17 years from January 1999 to December 2016. We choose January 1999 as our starting point for three reasons. First, January 1999 was a breakthrough for old EU member states as it marks the establishment of the common currency, albeit initially only in accounting form. Second, by this year, the vast majority of the new member states of the EU (that entered in 2004 and later) had applied for EU membership. Third, accession negotiations were ongoing by 1999 (Kočenda et al., 2006). We include the new EU member states in the dataset from the very start as we assume that they might have immediately exhibited some effort towards the alignment with the old EU

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<sup>3</sup> Despite a few recent turbulent years, no member state out the 18 has ever left the euro-area. On the contrary, Baltic countries joined in 2011 (Estonia), 2014 (Latvia), and 2015 (Lithuania). These new entrants suggest the enduring appeal of the common currency. Moreover, countries without the opt-out that have so far refrained from a genuine pursuit of euro adoption (Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania) are still obliged to join the euro-area once they achieve compliance with all Maastricht criteria.

countries. We also test for this hypothesis by the inclusion of an *acquis communautaire* dummy, as we describe later.

### 3.1 Inflation rates and inflation differentials

We work with annual inflation rates based on monthly HICP data from the Eurostat database.<sup>4</sup> This measure is defined for country  $i$  and time period  $t$  as:

$$\pi_{i,t} = \ln(HICP_{i,t}) - \ln(HICP_{i,t-12}), \quad (1)$$

where  $\ln(HICP_{i,t})$  is the HICP value for the current month and  $\ln(HICP_{i,t-12})$  is HICP value one year ago.

The summary statistics (mean, median, and standard deviation) of the series of inflation rates for all 28 EU member states are shown in graphical form in Figure 1. The volatility of inflation rates has decreased dramatically over the years. Moreover, the current very low inflation environment in Europe is reflected by very low values of the cross-sectional mean and median, which has been around zero in recent years. Generally, there is also a pattern of general disinflation in the EU over the last two decades, except for the time preceding the global financial crisis (GFC).

Further, we present the dynamics of the inflation rates' means, medians and standard deviations separately for the 15 old EU member states (Figure 2) and the 13 new EU member states (Figure 3). In the old-EU group, one can observe mean-reverting behavior for all three measures (mean, median, and standard deviation). In the new-EU group, relatively high values of inflation rates are present in the beginning of the sample. These might be explained by the adjustment of relative prices in the new EU member states during the transition process that led to higher inflation (Holub and Čihák, 2001). Moreover, high capital inflows might have affected the level of inflation rates as well (Staehr, 2010). Still, a decreasing trend during the entire sample period is clearly visible. Interestingly, the years following the GFC show comparable behavior of inflation rates' descriptive statistics in both groups (Figures 2 and 3).

Next, we construct a series of inflation differentials  $d_{i,t}$  as:

$$d_{i,t} = \pi_{i,t} - \pi_t^{benchmark}, \quad (2)$$

where  $\pi_t^{benchmark}$  is the inflation benchmark for a given time period  $t$ . We assume three types of inflation benchmarks: (i) the cross-sectional average (Kočenda and Papell, 1997; Lopez and Papell, 2012), (ii) the inflation target of “below, but close to, 2% over the medium term” as pursued by the European Central Bank,<sup>5</sup> and (iii) the inflation rate based on the

<sup>4</sup> We opt for the HICP measure over the Consumer Price Index since the Maastricht convergence criteria explicitly operate with HICP and approaches to CPI measurement differ across countries. We acknowledge that HICP is partly comprised of very volatile food and energy prices and we address this shortcoming by employing a core inflation measure as a robustness check for the post-crisis period.

<sup>5</sup> The analysis based on the ECB target of “below, but close to, 2% over the medium term” starts in May 2003 when the current definition of the inflation benchmark was adopted by the Governing Council of the ECB (Sauer and Sturm, 2007). For the ECB target, we follow the quantification of Kočenda and Varga (2017) and use 1.75% as a numerical benchmark.

Maastricht criterion (Kočenda et al., 2006; Siklos, 2010).<sup>6</sup> Figures A1–A28 show the evolution of the inflation rate for each EU member state with respect to the three inflation benchmarks.

### 3.2 Price stability-oriented monetary strategies

When considering factors that might have impacted inflation convergence in the EU over the past two decades, we begin with price stability-oriented monetary strategies. In a group of countries with the same or a very similar monetary strategy, inflation rates might converge with respect to each other (Kočenda and Papell, 1997) or with respect to a certain benchmark (Kočenda et al., 2006). Following the classification of Kočenda and Varga (2017), we assume two types of price stability-oriented monetary strategies: inflation targeting (IT) and a constraining exchange rate arrangement (CERA).<sup>7</sup>

EU countries have had extensive experience with both types of strategy in recent years. The ECB might not be expected to stabilize inflation at close to 2% for individual member states of the euro area but for the euro area as a whole. Hence, the ECB can be characterized as an inflation targeter. Further, several new EU member states (e.g. the Czech Republic, Hungary, Poland) have used the IT strategy for more than a decade. Still, in case of the IT framework, we need to distinguish countries operating within and outside the euro area. For euro area members, IT might be in fact a tool to achieve convergence (Neumann and von Hagen, 2002). For countries outside the euro area that have been operating under IT for several years (i.e. the Czech Republic, Hungary, Sweden), it is useful to realize that their inflation targets mimic that of the ECB. Jointly, IT may prove to enhance convergence in both groups of countries. However, inflation targeting alone does not necessarily need to facilitate inflation convergence in the new EU member states. In this respect, Baxa et al. (2015) show that inflation targeting is by no means a sufficient condition for a decrease in inflation persistence, which is crucial to achieve convergence. Finally, a CERA, widespread among European countries two decades ago, is now limited to only a few countries (e.g. Bulgaria, Denmark, Hungary). Based on the above reasoning we formulate the monetary strategy hypothesis:

*Hypothesis #1: A price stability-oriented monetary strategy has no effect on the convergence of inflation rates in the EU (towards the benchmark).*

To capture the effect of IT and CERA, we combine the information provided by the two inherent features of our baseline model (which is introduced in Section 4): the intercept and the time trend. Essentially, the intercept conveys whether the inflation rate of a particular

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<sup>6</sup> Following the standard practice in the literature, we construct the inflation benchmark based on the Maastricht criterion as the average of the three lowest non-negative inflation rates of the EU member states in a given month.

<sup>7</sup> The objective of the IT strategy is primarily to guarantee price stability, which should consequently support broad macroeconomic stability. A CERA can be in turn characterized as a monetary strategy that aims to achieve a stable exchange rate (and potentially lower inflation as a by-product). This is achieved by pegging a domestic currency to a reference currency of another country with stable macroeconomic conditions. A pegging country can gradually achieve a certain degree of synchronization with the reference country both in the level of the inflation rate as well as its dynamics (Jochem, 1999; Yeyati et al., 2010).

country was on average above or below the inflation benchmark during the entire sample period. Similarly, the time trend reveals whether the time series of inflation differentials was on average decreasing or increasing during the entire sample period. Thus, if the intercept is statistically significant and negative (positive) and the coefficient on the (linear) time trend is statistically significant and positive (negative), one can claim that the inflation rate of a particular country converged towards the benchmark over the entire sample period. In our analysis this coincides with the period when a price stability-oriented monetary strategy was in operation.

For the assessment, we construct dummy variables indicating the presence of each type of price stability-oriented monetary strategies in the EU countries: the IT dummy and the CERA dummy. The dummy variable is coded 1 for the period the strategy was exercised and zero otherwise. Construction is based on data from Kočenda and Varga (2017; Table A1), who provide a detailed classification and timing of both types of strategies for 68 countries including the entire EU. Indeed, for the majority of countries in our sample it suffices to include only one strategy dummy variable since one of the strategies was in operation all the time (e.g., Croatia, the United Kingdom, euro area countries that adopted the euro in 1999) or the switch from one strategy to another happened immediately (e.g., Cyprus, Slovakia, the Baltics). Table A1 contains detailed information on the strategy dummy classification.

### *3.3 The global financial crisis and the European sovereign debt crisis*

We assume the occurrence of the global financial crisis (GFC) and the European sovereign debt crisis can be factors potentially affecting inflation convergence in the EU. These crises are considered as a single factor because the turmoil associated with the GFC in 2008 and 2009 smoothly evolved into the European sovereign debt crisis (Lane, 2012). Moreover, the latter crisis started to subside only after Mario Draghi's famous speech in July 2012 (Afonso et al., 2017). It is vital to consider these crises as a potential factor affecting inflation convergence in the EU for two reasons. First, the GFC proved to be a distortive/transformational phenomenon in a number of economic activities: international trade flows (Chor and Manova, 2012), global capital flows (Fratzscher, 2012), the interdependence of global stock markets (Cheung et al., 2010), and to some extent global banking (Claessens and Van Horen, 2015). Moreover, in the context of the EU, the GFC had a profound impact on sovereign bond yields and the evolution of public debt in the case of the euro area periphery, which in fact to a certain extent triggered the European sovereign debt crisis (Lane, 2012). Second, both crises had a very heterogeneous impact on the evolution of GDP across EU countries, which implies that inflation rates were also likely affected in a heterogeneous manner (Groot et al., 2011). Thus, inflation convergence in the EU was potentially affected by both crises.

On the other hand, the pace of inflation convergence in the EU might have been sustained in the crisis years 2008 to 2012 because the majority of the EU countries had been members at least since 2004, some of them even sharing the same currency. Thus, the advantage of several years of common pre-crisis development might have proven useful during the crisis: although the GFC and the European sovereign debt crisis might have disrupted the ongoing processes, it could not have reversed the processes, similarly to what

Lee and Mercurelli (2014) as well as Lopez and Papell (2012) show. Based on the above reasoning we formulate the crisis-effect hypothesis:

*Hypothesis #2: Inflation convergence in the EU does not weaken after the global financial crisis or during the European sovereign debt crisis.*

We assess the effect of both crises by including a crisis dummy. Like other empirical studies, we consider the fall of Lehman Brothers in September 2008 as the event that arguably triggered the acute phase of the GFC (von Hagen et al., 2011). The GFC then smoothly evolved into the European sovereign debt crisis, which started to subside only after Mario Draghi's famous speech in July 2012 (Afonso et al., 2017). The crisis dummy is defined for all countries in the same way: it takes a value of 1 from September 2008 to July 2012 and 0 otherwise. Importantly, the interpretation of the coefficient of the crisis dummy depends on the sign of the inflation differential, i.e. one has to check if the inflation rate for each EU member state was, during the period from 2008 to 2012, above or below the inflation benchmark. If the inflation differential was negative (the inflation rate of a given country is lower than the value of the inflation benchmark) and at the same time the coefficient of the crisis dummy is negative and statistically significant, one can conclude that the GFC and the European sovereign debt crisis had a distortive impact on the convergence of the inflation rate of a given country towards the benchmark (see Figures A1–A28).

### *3.4 The zero lower bound*

As the next factor potentially affecting inflation convergence in the EU, we consider the period of the zero lower bound (ZLB). This phenomenon has been analyzed for almost a decade because it constrains conventional monetary policy as its standard tools became insufficient to stimulate economies in the post-crisis world (Buiter, 2009; Swanson and Williams, 2014). It is unsure to what extent unconventional instruments can affect inflation and it might well be true that steering inflation in such an environment is relatively more cumbersome than in normal times (Ball, 2013). Moreover, the ZLB materialized in different countries at different times (except for the set of countries constituting the euro area) which might imply that disturbances in inflation rates evolve in a heterogeneous manner. Based on the above we formulate the ZLB-effect hypothesis:

*Hypothesis #3: Inflation convergence in the EU does not weaken during the period of zero lower bound.*

We assess the ZLB hypothesis by creating a ZLB dummy. We follow the approach of Kočenda and Varga (2017), who assume that the ZLB applies from the value of 0.5% and lower, corresponding to values when globally important central banks in the US, UK, euro area, Canada, etc. started to implement their ZLB-related policies (Buiter, 2009; Swanson and Williams, 2014). It should be noted that the vast majority of the EU finds itself in the situation of the ZLB nowadays. Moreover, no country except for Sweden has so far managed to escape the ZLB once reaching it. Table A1 contains detailed information on the ZLB dummy classification. Again, regarding the interpretation of the coefficient of the ZLB dummy, one

has to assess if the inflation rate of a particular country lies above or below the inflation benchmark and should conduct a similar discussion as the one outlined in Section 3.3 about the effect of the GFC.

### *3.5 The implementation of *acquis communautaire**

The term *acquis communautaire* (AC) represents, broadly speaking, all accumulated EU law that a candidate country for EU membership must adopt prior to actual accession (Grabbe, 2002). The AC set guarantees that new EU members are sufficiently close to the old members in terms of economic and institutional levels (Hille and Knill, 2006). We hypothesize that the period when common EU law was implemented before the accession of new members in the 2000's might as well coincide with a period of stronger inflation convergence. It might have been achieved as a byproduct of broader harmonization efforts. On the other hand, the effect of AC can be hardly regarded as straightforward. Its implementation required several reform steps that might have created shocks in the economy, including effects on the inflation rate. Based on the above facts we formulate the following AC hypothesis:

*Hypothesis #4: The fulfilling of *acquis communautaire* in prospective EU members did not contribute to their inflation convergence (a decrease in inflation differentials).*

The AC effect relates exclusively to new EU member states. For 13 new EU member states, the value of the AC dummy is 1 during the relevant periods shown in the Table A1 and 0 otherwise.<sup>8</sup> For the old EU countries, the value of the AC dummy is 0 over the whole period under study. Table A1 contains detailed information on AC dummy classification. The effect of AC is assessed in the same way as the effect of the GFC and the ZLB: one has to consider the sign of the inflation differential in the period when AC was implemented in the new EU member states.

## **4. Methodology**

### *4.1 Model specification*

We follow and extend the methodological approach of Lopez and Papell (2012), who use an ADF-SUR test with contemporaneously correlated errors. We refine the test with an addition of dummy variables and a linear time trend. Moreover, we control for structural breaks as in related research (Kočenda et al., 2006; Cuestas et al., 2016). The following specification with covariates is then jointly estimated in the seemingly unrelated regressions (SUR) framework for the 28 member states of the EU:

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<sup>8</sup> The AC dummy is coded 1 from the point when the first AC chapter starts to be implemented in a particular country until the moment when the last AC chapter is closed. Transitional arrangements, potentially prolonging the implementation period of certain chapters of AC, are not considered; it is assumed that during the period defined in Table A1, the decisive portion of the work on implementing AC was conducted.

$$\begin{aligned}
\Delta d_{1,t} &= \alpha_1 + \rho_1 d_{1,t-1} + \sum_{l=1}^L \beta_{1,l} \Delta d_{1,t-l} + \sum_{m=1}^3 \gamma_{1,m} DUM_{1,m,t} + \sum_{n=1}^5 \delta_{1,n} BR_{1,n,t} + \omega_1 t + \varepsilon_{1,t} \\
&\vdots \\
\Delta d_{28,t} &= \alpha_{28} + \rho_{28} d_{28,t-1} + \sum_{l=1}^L \beta_{28,l} \Delta d_{28,t-l} + \sum_{m=1}^3 \gamma_{28,m} DUM_{28,m,t} + \sum_{n=1}^5 \delta_{1,n} BR_{28n,t} \\
&\quad + \omega_{28} t + \varepsilon_{28,t},
\end{aligned} \tag{3}$$

where  $d$  denotes the inflation differential;  $\rho_i$  the country-specific rate of convergence for  $i = 1, \dots, 28$ ;  $\alpha_i$  the country-specific intercept for  $i = 1, \dots, 28$ ;  $L$  the optimal number of lags;  $DUM$  a set of dummy variables (*crises*, *ZLB*, *AC*);  $BR$  a set of structural breaks;  $t$  the time trend; and  $\varepsilon$  a white noise process for which we assume that  $(\varepsilon_{1,t}, \dots, \varepsilon_{28,t})$  has a covariance matrix that needs to be estimated to capture the contemporaneous correlation. The  $t$  subscript defines the time span of the analysis, the start of which depends on the optimal number of lags.<sup>9</sup>

As a final output, we obtain the estimated values of coefficients  $\rho$ ,  $\gamma$ ,  $\delta$ , and  $\omega$  along with the standard errors, which allow us to determine the corresponding  $t$ -statistics. While for the coefficients of the dummy variables and break variables we assume the usual comparison with the quantile of the standard normal distribution, we cannot apply the same procedure for the set of convergence coefficients; rather, we simulate critical values of  $\rho_i$  for  $i = 1, \dots, 28$  using the Monte Carlo technique.<sup>10</sup> In the end, we can nonetheless give a verdict, at a certain level of confidence, on the presence of inflation convergence in the EU as well as on the effect of various covariates capturing the factors of inflation convergence. To show convergence, the coefficient on the lagged value of the inflation differential has to be negative and statistically significant as we use the augmented version of the Dickey-Fuller test.<sup>11</sup>

#### 4.2 Estimation method

We conduct the estimation procedure in two steps. First, we analyze the series of inflation differentials for each country separately and determine the optimal lag order of the ADF test, the timing of structural breaks as well as critical values of the convergence coefficient  $t$ -statistics by the Monte Carlo technique. Second, we collect the information from the first step and jointly estimate the model in the SUR framework for all 28 EU countries, with the underlying assumption of correlated error terms across equations.

On the individual country-specific level, we first need to determine a lag order of every series of inflation differentials as we use the augmented version of the Dickey-Fuller test to account for potential serial correlation in the series. This can be achieved by a recursive lag selection technique similarly as in Kočenda and Papell (1997). Furthermore, we include

<sup>9</sup> For example, if 12 lags are chosen as the optimal number for the ADF test, then the starting period is  $t = 13$ .

<sup>10</sup> Critical values also differ for the specification of the ADF test with the intercept, with the intercept and the time trend, or with neither.

<sup>11</sup> Essentially, one can add 1 to the estimated values of convergence coefficients to operate in the usual scale, with 1 indicating the unit root.

the dummy variables capturing the effect of factors of inflation convergence and the linear time trend, as discussed in Section 3. Next, we deal with the issue of structural breaks. Not accounting for structural breaks biases the estimates towards the non-rejection of the null hypothesis of no convergence (Perron, 1989). Structural breaks in both intercept and trend are endogenously determined with the multiple-break test of Bai and Perron (1998). We then construct dummy and trend variables capturing the specific breaks.

As a final step on the individual level, we generate critical values of the convergence coefficient  $t$ -statistics for each country using a Monte Carlo simulation with 10,000 replications. The simulation process is the same as described in Kočenda and Papell (1997): an AR process with an optimal lag length is first estimated for each series of inflation differentials and sample variance is stored. Next, 10,000 artificial processes governed by the estimated parameters of the estimation from the previous step are generated, followed by the estimation of the country-specific convergence equation (including the covariates) from which the critical values are obtained. We can then use those critical values for evidence on the presence of inflation convergence for each country in our sample.

On the aggregate level, we bring together all 28 equations into one system. We estimate such a system by the framework of seemingly unrelated regressions (SUR), similarly to Lopez and Papell (2012). SUR offers a convenient way how to estimate several equations with potentially different explanatory variables together in a more efficient way than when estimated separately equation-by-equation using the ordinary least squares (OLS) technique. Moreover, the SUR model assumes that errors are contemporaneously correlated across the equations. In fact, if they are not, then the SUR framework delivers identical results as the OLS approach. Both assumptions seem to be a priori reasonable for our case: we combine several (refined) ADF regressions, which can by definition stand on their own, and shocks to inflation rates of individual EU countries might indeed be quite correlated.

Next, a covariance matrix  $V$ , capturing the relationships between residuals in a given time period, has to be determined from the residuals from the individual equations. Following the procedure from Zellner (1962), we estimate the diagonal elements of matrix  $V$  as:

$$s_{ii} = \frac{r_i' r_i}{n - k_i}, \quad (4)$$

where  $r_i$  denotes the residuals from the  $i$ -th equation,  $n$  the number of observations, and  $k_i$  the number of explanatory variables in the  $i$ -th equation. Off-diagonal elements are obtained in a similar way:

$$s_{ij} = \frac{r_i' r_j}{\sqrt{n - k_i} \sqrt{n - k_j}}. \quad (5)$$

Since we consequently use an estimated matrix in estimating our main model, we note that the feasible generalized least squares is our main estimation technique.

A key merit of the SUR approach is that it allows us to exploit ex-ante information about the composition of our sample to impose a certain structure on the variance-covariance



matrix. Specifically, in the spirit of Zellner (1962), the variance-covariance matrix  $V$  can be formulated as:

$$V = \begin{pmatrix} \sigma_{11}I & \cdots & \sigma_{1s}I \\ \vdots & \ddots & \vdots \\ \sigma_{s1}I & \cdots & \sigma_{ss}I \end{pmatrix}, \quad (6)$$

where  $m = 1, \dots, s$  denotes the total number of equations. Diagonal elements express that although there can be different variances in different equations, in an individual equation, the assumption of homoscedasticity and no serial correlation must hold. This is realistic, considering the ADF test is conducted in the OLS framework and exploiting the fact that we explicitly remove any serial correlation from the error term by inserting lags of the dependent variable into each equation. As for off-diagonal elements, they imply that error terms can be correlated across equations. The covariance is, however, restricted to be constant over time (Zellner, 1962). This is a rather strong assumption, but is nonetheless an improvement over assuming no correlation between error terms at all.<sup>12</sup>

Finally, having a general model in the matrix notation  $y = X\beta + u$ , we can estimate the parameter vector  $\beta$  and the variance-covariance matrix of  $\beta$  using the feasible generalized least squares approach like Zellner (1962):

$$b_{fGLS} = (X'V^{-1}X)^{-1}X'V^{-1}y, \quad (7)$$

$$Var(b_{fGLS}) = (X'V^{-1}X)^{-1}. \quad (8)$$

## 5. Results

We test our hypotheses using a full-sample model (1999–2016, 28 member states of the EU) with additional covariates indicating factors of convergence and capturing the occurrence of structural breaks in the series of inflation differentials. Moreover, we repeat the analysis for all three inflation benchmarks: the cross-sectional average, the ECB target, and the benchmark based on the Maastricht convergence criterion.

In the preliminary steps on the country-specific level, we first obtain the optimal lag length of 12, 13, or 14. This reflects the fact that during the construction of a series of yearly inflation rates from monthly data, an artificial moving average process of order 12 is created (Lopez and Papell, 2012). Next, the estimated structural breaks are shown in Tables A2, A3, and A4 for all three inflation benchmarks, respectively.

### 5.1 Convergence with respect to the cross-sectional average

The results of the estimation of the full-sample model with the cross-sectional average as the inflation benchmark are captured in Table 2a (convergence coefficients) and Table 2b (covariates).<sup>13</sup> There seems to be a widespread presence of inflation convergence in the European Union over the period 1999–2016, revealed by negative and statistically significant

<sup>12</sup> After the estimation of the SUR framework, the Breusch-Pagan test statistic reports the suitability of the assumption of correlated errors in our case. This is routinely reported by STATA.

<sup>13</sup> We do not report the estimates of the coefficients of the lags of the differences of the dependent variable or the coefficients of the variables capturing the structural breaks as their interpretation is not economically interesting.

coefficients in the second column in Table 2a. Except for Ireland, the inflation rates of all of the member states of the EU are found to have converged towards the cross-sectional average after controlling for the potential effect of covariates as well as structural breaks. Moreover, we mostly find strong evidence of convergence: for 18 countries, convergence is present at the 1% level of confidence and for another 7 member states at the 5% level. The largest convergence coefficients in absolute terms are shown by Luxembourg and Germany, whereas one of the lowest ones are reported in countries unlikely to ever adopt the common currency (Denmark, Sweden, and the United Kingdom). Finally, the result of the Breusch-Pagan test shows that errors are indeed correlated across the equations in the SUR specification and that we obtain gains in efficiency.<sup>14</sup> Overall, our results imply that the current line-up of EU countries would score well in the category of synchronized inflation cycles. This is arguably one of the key prerequisites for the successful functioning of a monetary union.

The effect of covariates is reported in Table 2b. Recall that one has to consider whether the inflation differential is positive or negative when assessing the effect of covariates. Further, one has to bear in mind that the coefficients are generally small in absolute terms and this implies that their economic effect is small and should not be overrated. First, the effect of price stability-oriented monetary strategies is captured by the combination of the intercept and the coefficient of the linear time trend. In this sense, the results show that the inflation rates of some countries converged to the cross-sectional average “from below” during the period when these countries operated under price stability-oriented monetary strategies. This is shown by negative and statistically significant estimates of the intercept and positive and statistically significant estimates of the coefficient of the time trend. This group includes some euro area countries (Austria, Belgium, France, Germany, Italy, Malta, the Netherlands) as well as countries unlikely to ever adopt the common currency (Denmark, Sweden, and the United Kingdom). At the same time, during the period when they operated under price stability-oriented monetary strategies, the inflation rates of some countries converged “from above”. This is shown by positive and statistically significant estimates of the intercept and negative and statistically significant estimates of the coefficient of the time trend. This group of countries includes new EU member states with generally higher inflation rates in the beginning of our sample period: Bulgaria, Hungary, Romania, and Slovakia. Finally, there are several countries where a beneficial impact of price stability-oriented monetary strategies is not present (e.g., the Czech Republic, Finland, Luxembourg, Spain). These cases show that the effect of price stability-oriented monetary strategies is not universally beneficial for inflation convergence. Still, we are inclined to reject Hypothesis 1: price stability-oriented monetary strategies seem to matter and enhance inflation convergence between the EU countries both “from above” and “from below”, i.e. from states with initially too low/too high inflation rates with respect to the cross-sectional average. A graphical exposition is provided in Figures A1–A28, which support the findings regarding price stability-oriented monetary strategies from the baseline estimation.

Second, when interpreting the effect of the GFC and the European sovereign debt crisis, one has to consult Figures A1–A28, together with Table 2b, which gives an overview of the statistical significance of the coefficients of the crisis dummy. In several countries, the

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<sup>14</sup> With the null hypothesis of no correlated errors, the p-value is virtually zero.

inflation rate came closer to the cross-sectional average in the crisis period compared to the pre-crisis years (Austria, Finland, Italy, Latvia, the Netherlands, Portugal, Romania) but one can also observe diverging tendencies after 2008 (Luxembourg, Poland, Slovenia, Spain). Still, it seems that inflation convergence in the EU has been sustained in the post-crisis years. In fact, maybe it even intensified, since there might have simply been strong foundations for convergence from the pre-crisis years in the first place, similarly to what Lee and Mercurelli (2014) show. Overall, we cannot reject Hypothesis 2: the convergence of inflation rates did not weaken in the crisis years.

Third, the effect of the ZLB is also ambiguous, as Table 2b and Figures A1–A28 reveal. For Austria, Bulgaria, and Sweden, there is some evidence for a divergence from the cross-sectional average during the period of the ZLB while the opposite—a positive effect—is the case of Estonia, Germany, and Portugal. We conclude that there is no persuasive pattern about the ZLB inducing a wide-scale divergence of inflation rates from the cross-sectional average, which likely stems from the temporary nature of the ZLB. The results provide enough evidence not to reject Hypothesis 3.

Fourth, we note that the impact of AC is not straightforward. While we have evidence of decreasing inflation rates with respect to the cross-sectional average for Croatia, the Czech Republic, Romania, and Slovakia, the opposite is true for Hungary, Latvia, and Slovenia. These results underscore the country-specific effect of AC, and point to a non-rejection of Hypothesis 4. Overall, we do not find sufficient evidence in favor of a positive impact of AC on inflation convergence.

## 5.2 *Convergence with respect to the ECB target and the Maastricht criterion*

In our baseline regression we use the cross-sectional average as this inflation benchmark is the prevalent choice in the literature. Our results from the baseline regression are supported by the results for two other benchmarks: the ECB target (Tables 3a and 3b) and the Maastricht criterion (Tables 4a and 4b). Both specifications provide evidence of the widespread occurrence of inflation convergence in most EU countries.

Interestingly, the results with the other two benchmarks also shed some light on the impact of factors of convergence. For the ECB target (Table 3b), one can observe a prevalence of negative and statistically significant coefficients on the ZLB dummy. From Figures A1–A28 for the corresponding countries, one can conclude that during the period of the ZLB, there is some evidence for a divergence of inflation rates from the ECB target for a sizable sample of countries (e.g., Belgium, France, Italy). The effect of the GFC and the European sovereign debt crisis is not straightforward to discern: while for some countries, we can argue for increased inflation convergence after 2008 (e.g., Bulgaria, Slovenia, Spain), the opposite is the case for some other EU member states (e.g., Ireland, the Netherlands, Poland); the effect for other countries is ambiguous. The implementation of AC had a positive impact on the inflation convergence of Bulgaria, but exhibited a negative impact for Romania. Again, similar to the results in Table 2b for the cross-sectional average, we find some evidence for a beneficial impact of price stability-oriented monetary strategies, as revealed by the presence of convergence “from above” (e.g., Bulgaria, Hungary, Romania) as well as convergence “from below” (e.g., Finland, Sweden).

The results for the last inflation benchmark—the Maastricht criterion—do not bring any major new insights into the discussion on the impact of factors of convergence, but at the same time confirm the pattern of widespread occurrence of inflation convergence between most EU countries. The effect of the GFC and the European sovereign debt crisis and the period of the ZLB is mixed and we conclude that neither of these periods is generally distortive to convergence. The impact of the implementation of AC is also not entirely clear although beneficial for most countries (e.g., Croatia, Latvia, Slovakia). Regarding the effect of price stability-oriented monetary strategies, we obtain a widespread pattern of convergence “from above” (e.g., Cyprus, Germany, Hungary). This means that IT and CERA likely contributed to a gradual convergence towards the benchmark based on the Maastricht criterion which attained too-low values for most countries in the beginning of the sample. Yet, for some countries we find no indication of a beneficial impact of price stability-oriented monetary regimes on inflation convergence. Some of these countries are either not pursuing euro adoption yet (Bulgaria, the Czech Republic) or they belong the euro area periphery (Greece, Spain). Still, the inflation rates of these countries (apart from Spain) on average converge towards the Maastricht benchmark, as shown in Table 4a.

### *5.3 Synthesis of the results*

Overall, (i) we obtain comprehensive evidence of the widespread occurrence of inflation convergence between EU countries, using any of the three inflation benchmarks, (ii) we can attribute some of the positive influence on convergence to price stability-oriented monetary strategies, (iii) we obtain mixed evidence on the impact of the GFC and the European sovereign debt crisis as well as the period of the ZLB and we conclude that neither of these periods exhibited a distortive impact on inflation convergence, and (iv) the effect of AC is also ambiguous, underscoring the likely country-specific effect of the implementation of common EU law.

We can relate our results to the previous literature on the topic of inflation convergence in Europe. To some extent, we follow the approach of Kočenda and Papell (1997) and offer an update on the issue of inflation convergence using a similar methodological framework, albeit with an extended sample of countries that includes new EU member states. The conclusion of both Kočenda and Papell (1997) and ours is nevertheless similar: there seems to be evidence in favor of the existence of inflation convergence in the EU. Also, we in essence merge the literature on inflation convergence in the euro area and in new EU member states. As for the former strand of literature, our findings corroborate with the main results of Lopez and Papell (2012), who report some evidence for the convergence of inflation rates in the euro area after the introduction of the common currency. Moreover, in the spirit of Lee and Mercurelli (2014) as well as Lopez and Papell (2012), we show that the global financial crisis was not decisively distortive to the process of the economic integration of old EU member states, which includes the convergence of inflation rates. Regarding the latter strand of literature on inflation convergence in prospective euro area members, our results mostly corroborate those of Kočenda et al. (2006): we determine that the inflation rates of the new EU member states seem to be synchronized with those of the old EU member states and that the period under which central banks use inflation targeting coincides with inflation convergence.

#### 5.4 Robustness checks

We perform several types of robustness checks of our previous analyses conducted for all three inflation benchmarks. Importantly, we test for each country if the series of inflation differential is potentially trend or level stationary or neither (which we label as “neither”) in the spirit of the classic Dickey and Fuller (1979). This distinction has crucial implications for critical values and thus also for the (non-)rejection of the null hypothesis of no convergence.

First, we split the sample into pre-crisis (1999–2008) and crisis/post-crisis (2009–2016) periods and omit all covariates as well as variables capturing the timing of structural breaks. Importantly, the latter period contains the GFC, the European sovereign debt crisis, and the period of the ZLB. The results of the first robustness check are captured in Tables 5a and 5b. Two points should be mentioned. First, assuming both the cross-sectional average and the Maastricht benchmark, there seems to be a more persuasive pattern of convergence in the crisis and post-crisis periods than before 2009: using the HICP measure, we obtain that 26 (27 for the Maastricht benchmark) countries converged in the period from 2009 to 2016 compared to only 16 before 2009. This is in line with the results of our baseline model for any of the inflation benchmarks: the crisis period and the period of the ZLB did not have a distortive impact on inflation convergence in the EU. Also, it shows that the convergence was more inclusive in the years after 2008. However, this does not mean that the speed of convergence was generally stronger in the crisis and post-crisis years, as shown by the results in Tables 5a and 5b for the ECB target. Using this benchmark, the inflation rates of all countries are found to have converged both before and after 2008, but the convergence coefficients are much larger in absolute terms in the pre-crisis years. This can be attributed to the fact that the major alignment towards the ECB target occurred before 2008. Lately, inflation rates have been fluctuating around the target value.

Second, we analyze the issue of inflation convergence in the crisis and the post-crisis period in a similar manner using a core inflation measure (HICP excluding food and energy prices) instead of the all-items HICP. The results are shown in Table 6. Similar to the results of the first robustness check, the vast majority of EU member states is found to have converged in terms of their inflation rates towards any of the three inflation benchmarks. This result implies that it is unlikely that the detection of inflation convergence is spurious, e.g. due to the oil shock in 2014 and 2015.

Third, we also estimated specification (3) with additional dummy variables representing a fall in commodity prices. The dummy is defined in the following way: it attains a value of 1 if there was a month-on-month fall in the IMF’s All Commodities Price index and 0 otherwise. As a fall in commodity prices might have a slow lagged impact on headline inflation, we determined the appropriate lag of the dummy with the Bayesian Information Criterion. This modification of the baseline model, however, did not alter our results in any way.<sup>15</sup>

## 6. Conclusions

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<sup>15</sup> The results are available upon request.

Inflation convergence is one of the Maastricht prerequisites to join the Economic and Monetary Union and since the vast majority of EU countries will have adopted the common currency at some point in the future, it is needed to analyze inflation convergence even today. The topic of inflation convergence in Europe, the EU, or the euro area has been covered in the literature but results among studies typically differ as a consequence of the variety of techniques, sample compositions, and time windows used.

We contribute to this strand of literature by employing a dataset based on a HICP measure of all 28 current member states of the EU that spans 18 years from 1999 to 2016. We use three types of inflation benchmarks: the cross-sectional average, the ECB target of “below, but close to, 2% over the medium term”, and the inflation benchmark based on the Maastricht criterion. Moreover, we analyze how several factors—the global financial crisis, the zero lower bound, price stability-oriented monetary strategies, and the implementation of *acquis communautaire* (AC)—affect the inflation convergence of various countries. Methodologically, we employ a seemingly unrelated regressions (SUR) framework built on ADF tests with additional dummy variables representing these events as covariates. Furthermore, we include into our analysis structural breaks explicitly and generate critical values for convergence coefficients of individual countries using the Monte Carlo technique.

Our results overwhelmingly suggest that the inflation rates of the vast majority of EU member states converged towards all of the three inflation benchmarks in the period from 1999 to 2016. Moreover, this process was, in general, interrupted neither by the GFC and the European sovereign debt crisis nor the period of the ZLB (aside from the results for the ECB target). As for contributive factors, we show that price stability-oriented monetary strategies, being in operation in all EU member states, might have in fact provided a base for inflation convergence in the EU. The effect of the implementation of AC is not entirely clear and generally does not support the theory that new EU member states might have worked on their alignment towards the EU also in terms of inflation rates prior to their accession to the EU.

As for robustness checks, we show that after splitting the sample into pre-crisis (1999–2008) and crisis/post-crisis (2009–2016) periods, there is a more inclusive pattern of inflation convergence in the crisis period and the period of the ZLB, supporting the findings on the non-negative nature of the GFC, the European sovereign debt crisis, and the ZLB from the baseline regressions. Moreover, we employ a core inflation measure for the post-crisis period to check if the finding of inflation convergence from the main regression and the first robustness check—where we use the HICP measure—was not spurious because of the substantial oil price shock in 2014. Results based on the core inflation measure are similar to those based on the HICP measure and further enhance the robustness of our results.

Our main conclusions on inflation convergence in the EU imply that (i) price stability-oriented monetary strategies, being in operation in each EU member state, can be considered as aiding the process of inflation convergence, (ii) the ECB’s one-size-fits-all monetary policy did not contribute to a divergence in inflation rates between EU countries in extraordinary post-crisis times, and (iii) inflation synchronization does not seem to pose a challenge for further enlargement of the euro area.

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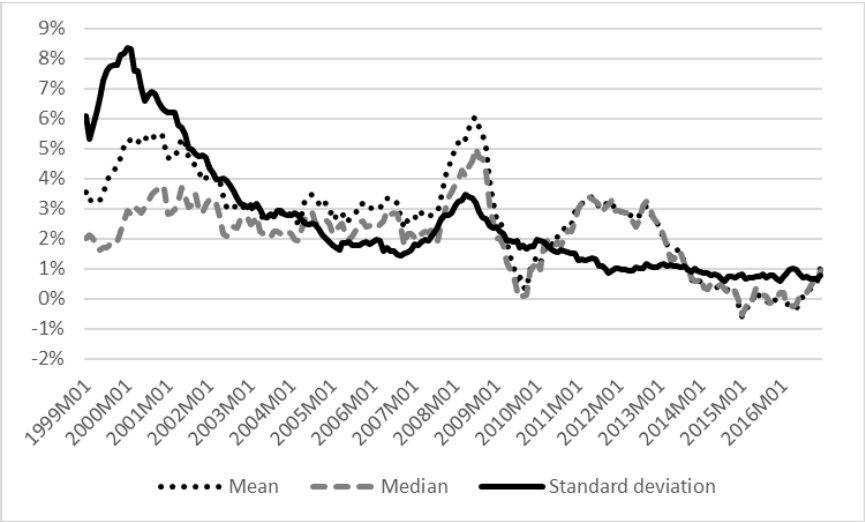
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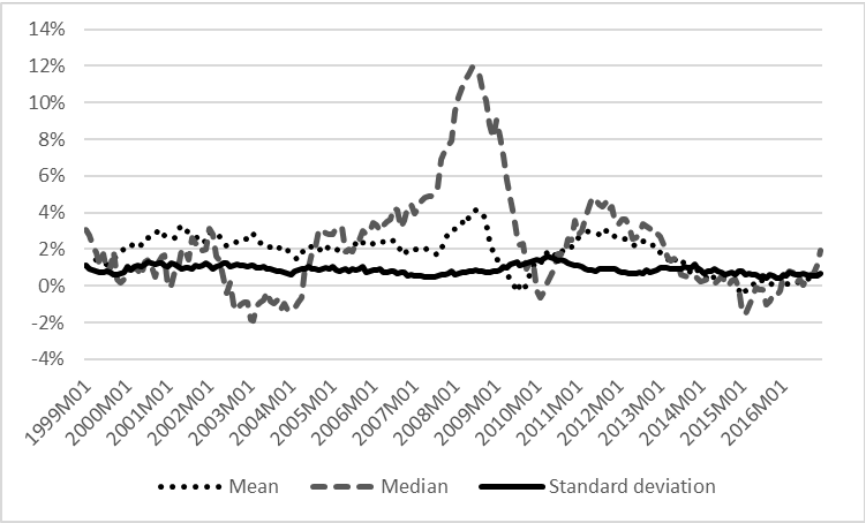
**Table 1: Summary of the literature on inflation convergence in Europe**

| Study                     | Target group                | Method                                    | Benchmark                        | Results  |
|---------------------------|-----------------------------|---|----------------------------------|--|
| Kočenda and Papell (1997) | EU member states (1997)     | Panel ADF, Monte Carlo                    | Cross-sectional average          | In favor of convergence, the evidence of “imported” low inflation  |
| Lopez and Papell (2012)   | Initial euro-area members   | ADF-SUR test                              | Cross-sectional average          | In favor of convergence, both after the Maastricht Treaty and euro introduction  |
| Giannellis (2013)         | Euro-area members (2009)    | Threshold autoregressive unit-root tests  | Cross-sectional average          | Evidence against convergence, one-size-fits-all policy of the ECB not optimal  |
| Lee and Mercurelli (2014) | France, Germany, Italy      | Structural vector autoregressive model    | none                             | Evidence in favor of more symmetric shocks affecting France, Germany, and Italy; the process not decisively interrupted by the GFC |
| Kočenda et al. (2006)     | New EU member states (2004) | Vogelsang test (structural breaks)        | Maastricht                       | In favor of inflation convergence, the impact of inflation targeting   |
| Cuestas et al. (2016)     | CESEE countries             | ADF test allowing for non-linear elements | Euro-area average inflation rate | Evidence against convergence, structural breaks, non-linearities present   |
| Siklos (2010)             | New EU member states (2004) | Unit-root, cointegration tests            | Maastricht                       | In favor of convergence  |

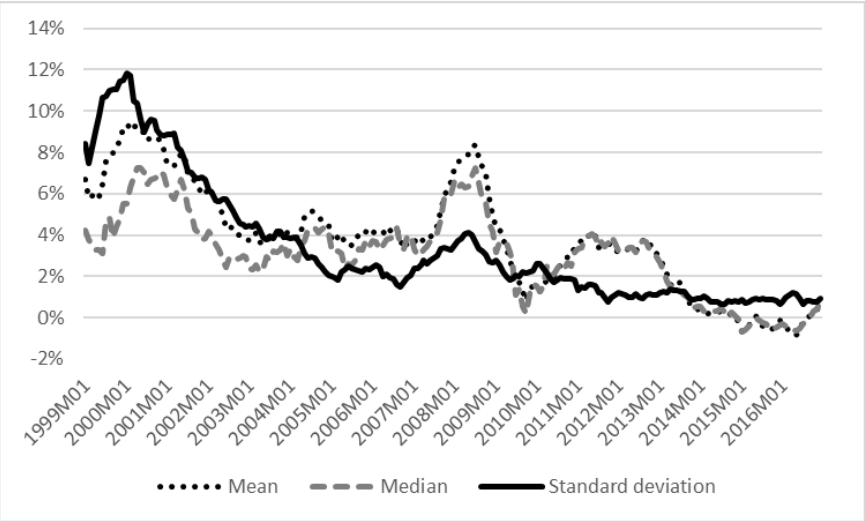
**Figure 1: Summary statistics of inflation rates: all 28 EU member states**



**Figure 2: Summary statistics of inflation rates: 15 old EU member states**



**Figure 3: Summary statistics of inflation rates: 13 new EU member states**



**Table 2a: Convergence towards an inflation benchmark: cross-sectional average**

| Country               | Lag of ID  | t-stat of<br>Lag of ID | Monte Carlo<br>1% t-stat | Monte Carlo<br>5% t-stat | Monte Carlo<br>10% t-stat |
|-----------------------|------------|------------------------|--------------------------|--------------------------|---------------------------|
| <i>Austria</i>        | -0.3796*** | -6.37                  | -4.64                    | -4.05                    | -3.74                     |
| <i>Belgium</i>        | -0.3575**  | -5.71                  | -6.35                    | -5.71                    | -5.37                     |
| <i>Bulgaria</i>       | -0.1954*** | -5.01                  | -4.88                    | -4.27                    | -3.92                     |
| <i>Croatia</i>        | -0.4138*** | -5.85                  | -5.74                    | -5.11                    | -4.79                     |
| <i>Cyprus</i>         | -0.4531*** | -6.34                  | -5.09                    | -4.44                    | -4.11                     |
| <i>Czech Republic</i> | -0.2998*   | -5.05                  | -5.74                    | -5.06                    | -4.72                     |
| <i>Denmark</i>        | -0.1807*** | -4.84                  | -4.66                    | -4.03                    | -3.73                     |
| <i>Estonia</i>        | -0.1663**  | -5.23                  | -5.64                    | -5.00                    | -4.67                     |
| <i>Finland</i>        | -0.1742*   | -4.24                  | -4.96                    | -4.31                    | -3.98                     |
| <i>France</i>         | -0.1369*** | -5.47                  | -5.12                    | -4.42                    | -4.07                     |
| <i>Germany</i>        | -0.4873*** | -7.50                  | -6.10                    | -5.50                    | -5.17                     |
| <i>Greece</i>         | -0.3476*** | -8.19                  | -5.11                    | -4.37                    | -3.97                     |
| <i>Hungary</i>        | -0.2042*** | -5.65                  | -4.95                    | -4.31                    | -3.97                     |
| <i>Ireland</i>        | -0.1332    | -4.12                  | -5.39                    | -4.72                    | -4.36                     |
| <i>Italy</i>          | -0.3552*** | -6.72                  | -6.18                    | -5.56                    | -5.20                     |
| <i>Latvia</i>         | -0.1635*** | -6.77                  | -5.46                    | -4.79                    | -4.40                     |
| <i>Lithuania</i>      | -0.2511**  | -5.58                  | -5.64                    | -5.04                    | -4.71                     |
| <i>Luxembourg</i>     | -0.4775*** | -7.76                  | -5.54                    | -4.93                    | -4.57                     |
| <i>Malta</i>          | -0.4369*** | -6.30                  | -5.71                    | -5.13                    | -4.80                     |
| <i>Netherlands</i>    | -0.2854*** | -6.83                  | -5.44                    | -4.87                    | -4.53                     |
| <i>Poland</i>         | -0.1101**  | -4.44                  | -4.75                    | -4.17                    | -3.84                     |
| <i>Portugal</i>       | -0.1637*** | -4.84                  | -4.56                    | -3.90                    | -3.56                     |
| <i>Romania</i>        | -0.2412**  | -5.48                  | -5.82                    | -5.18                    | -4.85                     |
| <i>Slovakia</i>       | -0.1975*** | -6.68                  | -5.21                    | -4.62                    | -4.29                     |
| <i>Slovenia</i>       | -0.2223*** | -5.21                  | -4.98                    | -4.34                    | -3.98                     |
| <i>Spain</i>          | -0.4221*** | -7.92                  | -5.86                    | -4.89                    | -4.80                     |
| <i>Sweden</i>         | -0.1610**  | -4.96                  | -5.48                    | -4.89                    | -4.54                     |
| <i>United Kingdom</i> | -0.1069**  | -4.13                  | -4.75                    | -4.12                    | -3.81                     |

Note: Results of the full-sample estimation based on seemingly unrelated regressions (SUR). ID denotes an inflation differential. Sample-specific critical values are derived from the Monte Carlo simulation process as in Kočenda and Papell (1997) with 10,000 replications. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 2b: Factors of inflation convergence towards an inflation benchmark: cross-sectional average**

| Country               | Crises     | ZLB       | AC         | Trend      | Intercept  |
|-----------------------|------------|-----------|------------|------------|------------|
| <i>Austria</i>        | 0.0011*    | 0.0032*** |            | 0.0003***  | -0.0188*** |
| <i>Belgium</i>        | 0.0003     | 0.0008    |            | 0.0001***  | -0.0115*** |
| <i>Bulgaria</i>       | -0.0007    | -0.0040*  | -0.0009    | -0.0001*   | 0.0084***  |
| <i>Croatia</i>        | -0.0002    |           | -0.0031*** | -0.0000    | -0.0017    |
| <i>Cyprus</i>         | 0.0012     | -0.0007   | -0.0025    | -0.0001**  | -0.0038*   |
| <i>Czech Republic</i> | -0.0022    | -0.0025   | 0.0039**   | 0.0000     | -0.0085*** |
| <i>Denmark</i>        | -0.0007    | -0.0015   |            | 0.0000*    | -0.0039*** |
| <i>Estonia</i>        | -0.0005    | -0.0027*  | 0.0018     | 0.0000     | -0.0020    |
| <i>Finland</i>        | -0.0017**  | 0.0001    |            | 0.0000     | -0.0040*** |
| <i>France</i>         | 0.0000     | 0.0007    |            | 0.0001*    | -0.0063*** |
| <i>Germany</i>        | 0.0007     | 0.0029*** |            | 0.0002***  | -0.0226*** |
| <i>Greece</i>         | 0.0006     | -0.0040** |            | 0.0000     | -0.0066*** |
| <i>Hungary</i>        | 0.0004     |           | 0.0017*    | -0.0000*** | 0.0071***  |
| <i>Ireland</i>        | -0.0007    | 0.0004    |            | -0.0001*** | 0.0026**   |
| <i>Italy</i>          | 0.0033***  | 0.0010    |            | 0.0002***  | -0.0123*** |
| <i>Latvia</i>         | -0.0018*   | 0.0020    | -0.0026*   | 0.0001***  | -0.0033    |
| <i>Lithuania</i>      | -0.0017    | 0.0001    | 0.0008     | 0.0001     | -0.0115*** |
| <i>Luxembourg</i>     | -0.0014*   | 0.0013    |            | -0.0000    | -0.0075*** |
| <i>Malta</i>          | 0.0013     | 0.0026    | 0.0001     | 0.0002***  | -0.0131*** |
| <i>Netherlands</i>    | 0.0022***  | -0.0021   |            | 0.0004***  | -0.0116*** |
| <i>Poland</i>         | 0.0021***  |           | -0.0011    | -0.0000    | 0.0033***  |
| <i>Portugal</i>       | 0.0016*    | 0.0021**  |            | -0.0000    | 0.0001     |
| <i>Romania</i>        | -0.0032*   |           | -0.0063*** | -0.0011*** | 0.0993***  |
| <i>Slovakia</i>       | 0.0004     | -0.0013   | -0.0122*** | -0.0002*** | 0.0212***  |
| <i>Slovenia</i>       | -0.0014*   | -0.0010   | 0.0023**   | 0.0000     | 0.0053***  |
| <i>Spain</i>          | -0.0030*** | 0.0022    |            | 0.0000     | -0.0074*** |
| <i>Sweden</i>         | -0.0005    | 0.0015**  |            | 0.0003***  | -0.0106*** |
| <i>United Kingdom</i> | 0.0005     | -0.0017   |            | 0.0002***  | -0.0083*** |

Note: Crises denotes a dummy variable for the global financial crisis and the European sovereign debt crisis. ZLB is the zero lower bound dummy variable. AC is the *acquis communautaire* dummy variable. The intercept and the time trend capture the effect of price stability-oriented monetary strategies as they were in place in all EU member states during the entire sample period. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 3a: Convergence towards an inflation benchmark: ECB target**

| Country               | Lag of ID  | t-stat of<br>Lag of ID | Monte Carlo<br>1% t-stat | Monte Carlo<br>5% t-stat | Monte Carlo<br>10% t-stat |
|-----------------------|------------|------------------------|--------------------------|--------------------------|---------------------------|
| <i>Austria</i>        | -0.3032*** | -7.87                  | -5.91                    | -5.22                    | -4.89                     |
| <i>Belgium</i>        | -0.1882    | -4.27                  | -5.88                    | -5.20                    | -4.83                     |
| <i>Bulgaria</i>       | -0.2882*** | -7.09                  | -5.40                    | -4.73                    | -4.41                     |
| <i>Croatia</i>        | -0.1558*** | -5.39                  | -5.05                    | -4.45                    | -4.08                     |
| <i>Cyprus</i>         | -0.3774*   | -5.37                  | -6.23                    | -5.50                    | -5.16                     |
| <i>Czech Republic</i> | -0.2128*** | -6.57                  | -5.18                    | -4.54                    | -4.18                     |
| <i>Denmark</i>        | -0.2040*** | -5.39                  | -4.64                    | -3.97                    | -3.65                     |
| <i>Estonia</i>        | -0.2201*** | -8.70                  | -4.70                    | -4.09                    | -3.75                     |
| <i>Finland</i>        | -0.4174*** | -7.32                  | -6.32                    | -5.63                    | -5.26                     |
| <i>France</i>         | -0.2814*** | -8.17                  | -4.83                    | -4.21                    | -3.87                     |
| <i>Germany</i>        | -0.3780*** | -7.74                  | -5.24                    | -4.53                    | -4.13                     |
| <i>Greece</i>         | -0.3869*** | -6.39                  | -5.14                    | -4.48                    | -4.16                     |
| <i>Hungary</i>        | -0.2796*** | -7.55                  | -4.98                    | -4.30                    | -3.92                     |
| <i>Ireland</i>        | -0.1020    | -2.44                  | -5.65                    | -5.05                    | -4.74                     |
| <i>Italy</i>          | -0.1515    | -2.68                  | -5.72                    | -5.06                    | -4.71                     |
| <i>Latvia</i>         | -0.0911*** | -5.01                  | -5.00                    | -4.33                    | -3.98                     |
| <i>Lithuania</i>      | -0.1187**  | -4.71                  | -5.04                    | -4.40                    | -4.06                     |
| <i>Luxembourg</i>     | -0.3975*** | -8.81                  | -4.98                    | -4.32                    | -3.97                     |
| <i>Malta</i>          | -0.3418**  | -5.39                  | -5.79                    | -5.16                    | -3.62                     |
| <i>Netherlands</i>    | -0.3320*** | -6.63                  | -5.56                    | -4.84                    | -4.47                     |
| <i>Poland</i>         | -0.1725*** | -6.46                  | -4.83                    | -4.13                    | -3.80                     |
| <i>Portugal</i>       | -0.3099**  | -5.69                  | -5.78                    | -5.14                    | -4.79                     |
| <i>Romania</i>        | -0.1304    | -3.29                  | -4.48                    | -3.89                    | -3.56                     |
| <i>Slovakia</i>       | -0.3095*** | -7.81                  | -5.15                    | -4.47                    | -4.09                     |
| <i>Slovenia</i>       | -0.3137*** | -6.26                  | -5.52                    | -4.88                    | -4.52                     |
| <i>Spain</i>          | -0.2124    | -4.72                  | -5.85                    | -5.20                    | -4.86                     |
| <i>Sweden</i>         | -0.2384    | -3.86                  | -5.46                    | -4.86                    | -4.54                     |
| <i>United Kingdom</i> | -0.1123    | -2.37                  | -5.31                    | -4.61                    | -4.26                     |

Note: Results of the full-sample estimation based on seemingly unrelated regressions (SUR). ID denotes an inflation differential. Sample-specific critical values are derived from the Monte Carlo simulation process as in Kočenda and Papell (1997) with 10,000 replications. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 3b: Factors of inflation convergence towards an inflation benchmark: ECB target**

| Country               | Crises     | ZLB        | AC         | Trend      | Intercept  |
|-----------------------|------------|------------|------------|------------|------------|
| <i>Austria</i>        | -0.0007    | -0.0016*   |            | -0.0000    | 0.0023     |
| <i>Belgium</i>        | -0.0020*   | -0.0032**  |            | -0.0000    | 0.0022**   |
| <i>Bulgaria</i>       | -0.0024*   | -0.0074**  | -0.0098*** | -0.0002*** | 0.0197***  |
| <i>Croatia</i>        | -0.0005    |            | -0.0006    | 0.0000**   | 0.0012     |
| <i>Cyprus</i>         | -0.0007    | -0.0006    |            | -0.0001    | 0.0037     |
| <i>Czech Republic</i> | -0.0049*** | -0.0053*** |            | -0.0001    | 0.0009     |
| <i>Denmark</i>        | -0.0012    | -0.0025**  |            | 0.0000***  | -0.0005    |
| <i>Estonia</i>        | -0.0020    | -0.0041**  |            | 0.0002***  | -0.0008    |
| <i>Finland</i>        | -0.0026*** | -0.0006    |            | 0.0001**   | -0.0062*** |
| <i>France</i>         | -0.0000    | -0.0016*   |            | -0.0000*** | 0.0022***  |
| <i>Germany</i>        | -0.0013    | 0.0021*    |            | 0.0000     | 0.0009     |
| <i>Greece</i>         | -0.0020    | 0.0018     |            | 0.0000     | 0.0044***  |
| <i>Hungary</i>        | -0.0006    |            |            | -0.0001*** | 0.0099***  |
| <i>Ireland</i>        | -0.0020**  | -0.0003    |            | -0.0000    | 0.0018*    |
| <i>Italy</i>          | -0.0052*** | -0.0022*   |            | 0.0000**   | -0.0007    |
| <i>Latvia</i>         | -0.0025**  | 0.0038***  |            | -0.0001*** | 0.0081***  |
| <i>Lithuania</i>      | -0.0014    | 0.0017     |            | -0.0001*** | 0.0019     |
| <i>Luxembourg</i>     | 0.0003     | -0.0035**  |            | -0.0001*** | 0.0097***  |
| <i>Malta</i>          | 0.0071***  | -0.0016    |            | -0.0000    | 0.0040*    |
| <i>Netherlands</i>    | -0.0015*   | -0.0024*   |            | 0.0000     | -0.0016    |
| <i>Poland</i>         | 0.0020***  |            |            | -0.0000*** | 0.0022***  |
| <i>Portugal</i>       | -0.0009    | 0.0004     |            | 0.0000     | 0.0017     |
| <i>Romania</i>        | 0.0020**   |            | 0.0049**   | -0.0001*** | 0.0093***  |
| <i>Slovakia</i>       | 0.0019*    | -0.0040*** |            | -0.0021*** | 0.0502***  |
| <i>Slovenia</i>       | -0.0054*** | -0.0010    |            | -0.0001    | 0.0064***  |
| <i>Spain</i>          | -0.0028*** | -0.0005    |            | -0.0000    | 0.0047***  |
| <i>Sweden</i>         | -0.0032*** | -0.0003    |            | 0.0000***  | -0.0024**  |
| <i>United Kingdom</i> | -0.0011    | 0.0000     |            | 0.0000     | 0.0004     |

Note: Crises denotes a dummy variable for the global financial crisis and the European sovereign debt crisis. ZLB is the zero lower bound dummy variable. AC is the *acquis communautaire* dummy variable. The intercept and the time trend capture the effect of price stability-oriented monetary strategies as they were in place in all EU member states during the entire sample period. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 4a: Convergence towards an inflation benchmark: Maastricht criterion**

| Country               | Lag of ID  | t-stat of<br>Lag of ID | Monte Carlo<br>1% t-stat | Monte Carlo<br>5% t-stat | Monte Carlo<br>10% t-stat |
|-----------------------|------------|------------------------|--------------------------|--------------------------|---------------------------|
| <i>Austria</i>        | -0.3433*** | -6.77                  | -5.08                    | -4.48                    | -4.14                     |
| <i>Belgium</i>        | -0.2471*** | -5.77                  | -4.52                    | -3.88                    | -3.59                     |
| <i>Bulgaria</i>       | -0.3318*** | -6.80                  | -5.73                    | -5.04                    | -4.70                     |
| <i>Croatia</i>        | -0.2451**  | -5.58                  | -5.64                    | -4.98                    | -4.65                     |
| <i>Cyprus</i>         | -0.4002*** | -5.74                  | -5.55                    | -4.87                    | -4.52                     |
| <i>Czech Republic</i> | -0.2379**  | -5.44                  | -5.90                    | -5.15                    | -4.81                     |
| <i>Denmark</i>        | -0.2972*** | -5.50                  | -4.92                    | -4.31                    | -3.96                     |
| <i>Estonia</i>        | -0.1547*** | -5.56                  | -5.19                    | -4.60                    | -4.23                     |
| <i>Finland</i>        | -0.1701*   | -4.51                  | -5.44                    | -4.69                    | -4.32                     |
| <i>France</i>         | -0.3062*** | -7.21                  | -5.36                    | -4.76                    | -4.42                     |
| <i>Germany</i>        | -0.4016*** | -7.30                  | -5.21                    | -4.52                    | -4.20                     |
| <i>Greece</i>         | -0.3401*** | -6.24                  | -4.73                    | -4.12                    | -3.81                     |
| <i>Hungary</i>        | -0.2082*** | -6.44                  | -4.93                    | -4.27                    | -3.94                     |
| <i>Ireland</i>        | -0.2654*** | -6.61                  | -5.54                    | -4.88                    | -4.54                     |
| <i>Italy</i>          | -0.3225*** | -7.17                  | -5.13                    | -4.50                    | -4.18                     |
| <i>Latvia</i>         | -0.1469*** | -6.80                  | -5.15                    | -4.49                    | -4.10                     |
| <i>Lithuania</i>      | -0.0552    | -2.61                  | -4.92                    | -4.28                    | -3.96                     |
| <i>Luxembourg</i>     | -0.2669*** | -7.36                  | -5.02                    | -4.38                    | -4.05                     |
| <i>Malta</i>          | -0.3557*** | -4543                  | -4.86                    | -4.20                    | -3.87                     |
| <i>Netherlands</i>    | -0.1973*** | -6.12                  | -5.15                    | -4.41                    | -4.05                     |
| <i>Poland</i>         | -0.1127*** | -5.30                  | -4.71                    | -4.09                    | -3.77                     |
| <i>Portugal</i>       | -0.2606*** | -6.25                  | -4.90                    | -4.29                    | -3.93                     |
| <i>Romania</i>        | -0.0881**  | -4.43                  | -5.09                    | -4.43                    | -4.08                     |
| <i>Slovakia</i>       | -0.2220*** | -8.07                  | -5.29                    | -4.63                    | -4.27                     |
| <i>Slovenia</i>       | -0.1591**  | -4.57                  | -4.95                    | -4.30                    | -3.97                     |
| <i>Spain</i>          | -0.1778    | -4.09                  | -5.40                    | -4.75                    | -4.41                     |
| <i>Sweden</i>         | -0.1962    | -3.77                  | -5.34                    | -4.69                    | -4.35                     |
| <i>United Kingdom</i> | -0.1993*** | -5.50                  | -4.78                    | -4.10                    | -3.79                     |

Note: Results of the full-sample estimation based on seemingly unrelated regressions (SUR). ID denotes an inflation differential. Sample-specific critical values are derived from the Monte Carlo simulation process as in Kočenda and Papell (1997) with 10,000 replications. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 4b: Factors of inflation convergence towards an inflation benchmark: Maastricht criterion**

| Country               | Crises     | ZLB        | AC         | Trend      | Intercept  |
|-----------------------|------------|------------|------------|------------|------------|
| <i>Austria</i>        | 0.0003     | 0.0005     |            | -0.0000*** | 0.0029***  |
| <i>Belgium</i>        | -0.0003    | -0.0014    |            | 0.0000     | 0.0015**   |
| <i>Bulgaria</i>       | -0.0022    | -0.0049*   | 0.0010     | -0.0001    | 0.0256***  |
| <i>Croatia</i>        | -0.0026**  |            | -0.0029*** | -0.0001*** | 0.0092***  |
| <i>Cyprus</i>         | 0.0009     | -0.0046**  | -0.0085*** | -0.0002*   | 0.0205***  |
| <i>Czech Republic</i> | -0.0023    | -0.0038*   | 0.0001     | -0.0001    | 0.0065**   |
| <i>Denmark</i>        | 0.0009     | -0.0006    |            | 0.0000     | 0.0026***  |
| <i>Estonia</i>        | -0.0004    | -0.0045**  | -0.0014    | 0.0001***  | 0.0041**   |
| <i>Finland</i>        | 0.0007     | -0.0013    |            | -0.0001**  | 0.0038**   |
| <i>France</i>         | -0.0001    | -0.0000    |            | -0.0000*   | 0.0020***  |
| <i>Germany</i>        | -0.0008    | 0.0012     |            | -0.0000*   | 0.0018***  |
| <i>Greece</i>         | -0.0001    | -0.0037**  |            | 0.0000     | 0.0067***  |
| <i>Hungary</i>        | 0.0010     |            | 0.0033***  | -0.0001*** | 0.0137***  |
| <i>Ireland</i>        | 0.0000     | -0.0002    |            | -0.0000*   | 0.0093***  |
| <i>Italy</i>          | 0.0012*    | -0.0026*** |            | -0.0000*   | 0.0047***  |
| <i>Latvia</i>         | -0.0002    | 0.0010     | -0.0024*   | 0.0000     | 0.0040**   |
| <i>Lithuania</i>      | -0.0013    | 0.0011     | -0.0030**  | -0.0000**  | 0.0035**   |
| <i>Luxembourg</i>     | -0.0015*   | -0.0020    |            | -0.0000*** | 0.0062***  |
| <i>Malta</i>          | 0.0031**   | 0.0016     | -0.0011    | -0.0000*   | 0.0062***  |
| <i>Netherlands</i>    | 0.0004     | -0.0015    |            | -0.0000*   | 0.0056***  |
| <i>Poland</i>         | 0.0025***  |            | -0.0010    | -0.0000*** | 0.0074***  |
| <i>Portugal</i>       | -0.0007    | 0.0022     |            | -0.0000*** | 0.0069***  |
| <i>Romania</i>        | -0.0000    |            | -0.0036    | -0.0008*** | 0.0464***  |
| <i>Slovakia</i>       | -0.0001    | -0.0045**  | -0.0149*** | -0.0003*** | 0.0332***  |
| <i>Slovenia</i>       | -0.0018*   | -0.0031**  | 0.0028***  | 0.0000     | 0.0073***  |
| <i>Spain</i>          | -0.0050*** | 0.0005     |            | -0.0000    | 0.0042***  |
| <i>Sweden</i>         | 0.0001     | 0.0007     |            | 0.0003***  | -0.0061*** |
| <i>United Kingdom</i> | 0.0018***  | -0.0007    |            | 0.0000***  | -0.0011*** |

*Note:* Crises denotes a dummy variable for the global financial crisis and the European sovereign debt crisis. ZLB is the zero lower bound dummy variable. AC is the *acquis communautaire* dummy variable. The intercept and the time trend capture the effect of price stability-oriented monetary strategies as they were in place in all EU member states during the entire sample period. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.



**Table 5a: Convergence in the pre-crisis period (1999–2008) towards inflation benchmarks: cross-sectional average, ECB target, Maastricht criterion**

| Country               | Cross-sectional average |                  | ECB target |                  | Maastricht criterion |                  |
|-----------------------|-------------------------|------------------|------------|------------------|----------------------|------------------|
|                       | Lag of ID               | Type of ADF test | Lag of ID  | Type of ADF test | Lag of ID            | Type of ADF test |
| <i>Austria</i>        | -0.0293***              | neither          | -0.1578*** | neither          | -0.1890**            | level            |
| <i>Belgium</i>        | -0.0579***              | neither          | -0.1047*** | trend            | -0.1427              | level            |
| <i>Bulgaria</i>       | -0.0251***              | neither          | -0.4852*** | trend            | -0.0108              | neither          |
| <i>Croatia</i>        | -0.5069***              | trend            | -0.6117*** | trend            | -0.1138              | level            |
| <i>Cyprus</i>         | -0.0517                 | neither          | -0.1477*** | neither          | -0.2169**            | level            |
| <i>Czech Republic</i> | -0.0916                 | level            | -0.2583*** | trend            | -0.0572***           | neither          |
| <i>Denmark</i>        | -0.1862***              | trend            | 0.8565***  | trend            | -0.1718***           | level            |
| <i>Estonia</i>        | -0.0922                 | trend            | -0.2574*** | trend            | -0.0606              | trend            |
| <i>Finland</i>        | -0.126*                 | level            | 0.8195***  | trend            | -0.0753***           | neither          |
| <i>France</i>         | -0.0153**               | neither          | -0.2690*** | level            | -0.0404**            | neither          |
| <i>Germany</i>        | -0.0172**               | neither          | -0.2427*** | neither          | -0.0461              | neither          |
| <i>Greece</i>         | -0.1432***              | neither          | -0.5757*** | level            | -0.2885***           | trend            |
| <i>Hungary</i>        | -0.1164***              | trend            | -0.0343**  | trend            | -0.0858***           | trend            |
| <i>Ireland</i>        | -0.1138**               | trend            | -0.1205*** | neither          | -0.2194***           | trend            |
| <i>Italy</i>          | -0.082**                | level            | -0.1292*** | neither          | -0.3003***           | level            |
| <i>Latvia</i>         | -0.1277*                | trend            | -0.1651*** | trend            | -0.0816              | trend            |
| <i>Lithuania</i>      | -0.0564                 | trend            | -0.2178*** | trend            | -0.0395              | trend            |
| <i>Luxembourg</i>     | -0.0311                 | neither          | -0.4222*** | level            | -0.1349*             | level            |
| <i>Malta</i>          | -0.1178                 | level            | -0.1301**  | neither          | -0.0590***           | neither          |
| <i>Netherlands</i>    | -0.1391***              | trend            | -0.6768*** | trend            | -0.1323***           | trend            |
| <i>Poland</i>         | -0.045***               | neither          | -0.0656*** | neither          | -0.0399***           | neither          |
| <i>Portugal</i>       | -0.0773                 | trend            | 0.8559***  | neither          | -0.1193              | trend            |
| <i>Romania</i>        | -0.0052                 | trend            | -0.2020*** | trend            | 0.0013               | trend            |
| <i>Slovakia</i>       | -0.0989                 | trend            | -0.1040*** | neither          | -0.0389***           | neither          |
| <i>Slovenia</i>       | -0.0856                 | trend            | -0.3556*** | level            | -0.0707              | trend            |
| <i>Spain</i>          | -0.0012                 | trend            | -0.4483*** | level            | -0.1188              | level            |
| <i>Sweden</i>         | -0.1028***              | level            | -0.0901**  | neither          | -0.0611              | neither          |
| <i>United Kingdom</i> | -0.0816                 | trend            | -0.4982*** | trend            | -0.2186***           | trend            |

Note: Results of the estimation for the pre-crisis period (1999–2008) based on seemingly unrelated regressions (SUR). Inflation differentials (ID) are based on the Harmonized Index of Consumer Prices (HICP) measure. ADF denotes the Augmented Dickey-Fuller test; there are three versions of the ADF test: (i) the version without the intercept and without the time trend (denoted by neither), (ii) the version with the intercept but without the time trend (denoted by level), (iii) the version with the intercept and the time trend (denoted by trend). \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 5b: Convergence in the crisis/post-crisis period (2009–2016) towards inflation benchmarks: cross-sectional average, ECB target, Maastricht criterion**

| Country               | Cross-sectional average |                  | ECB target |                  | Maastricht criterion |                  |
|-----------------------|-------------------------|------------------|------------|------------------|----------------------|------------------|
|                       | Lag of ID               | Type of ADF test | Lag of ID  | Type of ADF test | Lag of ID            | Type of ADF test |
| <i>Austria</i>        | 0.9494***               | neither          | 0.9366***  | neither          | -0.0570***           | level            |
| <i>Belgium</i>        | -0.1584                 | trend            | -0.1404*** | trend            | -0.1112***           | neither          |
| <i>Bulgaria</i>       | -0.1732***              | trend            | -0.188***  | trend            | -0.1551***           | trend            |
| <i>Croatia</i>        | 0.9297***               | neither          | -0.0349*   | neither          | -0.0801***           | neither          |
| <i>Cyprus</i>         | -0.137***               | neither          | -0.0635*** | neither          | -0.1118***           | neither          |
| <i>Czech Republic</i> | -0.3635***              | trend            | -0.1287*** | neither          | 0.8654***            | neither          |
| <i>Denmark</i>        | -0.1263***              | neither          | 0.9438***  | neither          | -0.3437*             | trend            |
| <i>Estonia</i>        | -0.2962***              | level            | -0.0873*** | level            | -0.1906***           | trend            |
| <i>Finland</i>        | 0.8961***               | neither          | -0.0659*** | neither          | 0.9280               | neither          |
| <i>France</i>         | -0.0449**               | neither          | -0.0632**  | neither          | -0.1429***           | neither          |
| <i>Germany</i>        | -0.2673***              | trend            | -0.0827*** | neither          | -0.0950**            | neither          |
| <i>Greece</i>         | -0.1245***              | trend            | -0.1447*** | trend            | -0.0832***           | neither          |
| <i>Hungary</i>        | 0.898***                | trend            | 0.898***   | trend            | 0.8703***            | trend            |
| <i>Ireland</i>        | -0.0085                 | neither          | -0.0315**  | neither          | -0.1353***           | trend            |
| <i>Italy</i>          | -0.1031**               | neither          | -0.1092*** | trend            | 0.8903***            | neither          |
| <i>Latvia</i>         | -0.0891***              | neither          | -0.1019*** | neither          | -0.0828***           | neither          |
| <i>Lithuania</i>      | -0.1223***              | neither          | -0.0796*** | neither          | -0.0938*             | neither          |
| <i>Luxembourg</i>     | -0.1396***              | neither          | -0.1370*** | trend            | -0.0961***           | neither          |
| <i>Malta</i>          | -0.4402***              | trend            | 0.8100***  | neither          | 0.8839***            | neither          |
| <i>Netherlands</i>    | -0.1304***              | neither          | 0.9493***  | neither          | -0.0954***           | neither          |
| <i>Poland</i>         | -0.2748***              | trend            | -0.0034**  | neither          | -0.2214***           | trend            |
| <i>Portugal</i>       | 0.8933***               | neither          | -0.1080*** | level            | -0.1151***           | neither          |
| <i>Romania</i>        | -0.3279***              | trend            | -0.2557*** | Trend            | -0.5010***           | trend            |
| <i>Slovakia</i>       | -0.1108***              | neither          | -0.0642*** | neither          | -0.0980***           | neither          |
| <i>Slovenia</i>       | -0.2844***              | neither          | -0.1518*** | trend            | -0.1726**            | trend            |
| <i>Spain</i>          | -0.1278***              | neither          | 0.9154***  | neither          | -0.1233***           | neither          |
| <i>Sweden</i>         | -0.032*                 | neither          | -0.0653*** | neither          | -0.0686**            | neither          |
| <i>United Kingdom</i> | -0.1606***              | level            | 0.9654***  | neither          | -0.1446***           | trend            |

Note: Results of the estimation for the crisis/post-crisis period (2009–2016) based on seemingly unrelated regressions (SUR). Inflation differentials (ID) are based on the Harmonized Index of Consumer Prices (HICP) measure. ADF denotes the Augmented Dickey-Fuller test; there are three versions of the ADF test: (i) the version without the intercept and without the time trend (denoted by neither), (ii) the version with the intercept but without the time trend (denoted by level), (iii) the version with the intercept and the time trend (denoted by trend). \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 6: Convergence in the crisis/post-crisis period (2009–2016) with a core inflation measure towards inflation benchmarks: cross-sectional average, ECB target, Maastricht criterion**

| Country               | Cross-sectional average |                  | ECB target |                  | Maastricht criterion |                  |
|-----------------------|-------------------------|------------------|------------|------------------|----------------------|------------------|
|                       | Lag of ID               | Type of ADF test | Lag of ID  | Type of ADF test | Lag of ID            | Type of ADF test |
| <i>Austria</i>        | -0.1896*                | level            | -0.1523*** | neither          | -0.2473***           | level            |
| <i>Belgium</i>        | -0.2683*                | trend            | -0.4127*** | level            | -0.6780***           | level            |
| <i>Bulgaria</i>       | 0.0022                  | neither          | -0.1054**  | trend            | -0.1520***           | trend            |
| <i>Croatia</i>        | 0.9582                  | neither          | -0.1196    | level            | 0.8944***            | neither          |
| <i>Cyprus</i>         | 0.6733***               | trend            | 0.7516***  | trend            | -0.7585***           | trend            |
| <i>Czech Republic</i> | -0.3147***              | trend            | -0.2430*** | trend            | -0.2746***           | trend            |
| <i>Denmark</i>        | -0.2332***              | neither          | -0.4142*** | trend            | -0.3921***           | trend            |
| <i>Estonia</i>        | -0.2389***              | level            | -0.1898*** | trend            | -0.2079***           | level            |
| <i>Finland</i>        | -0.0706                 | level            | -0.1721    | trend            | -0.2376*             | trend            |
| <i>France</i>         | -0.1974***              | neither          | -0.3529*** | trend            | -0.3042***           | level            |
| <i>Germany</i>        | -0.4421**               | trend            | -0.6238*** | level            | -0.8284***           | trend            |
| <i>Greece</i>         | -0.0345                 | neither          | -0.0315    | neither          | -0.0460              | neither          |
| <i>Hungary</i>        | -0.2679***              | trend            | -0.3566*** | trend            | -0.4402***           | trend            |
| <i>Ireland</i>        | -0.0858***              | level            | -0.1914*** | trend            | -0.1849***           | trend            |
| <i>Italy</i>          | -0.6498***              | trend            | -0.2619**  | trend            | -0.2156              | trend            |
| <i>Latvia</i>         | -0.1285**               | trend            | -0.1729*** | trend            | -0.1808***           | trend            |
| <i>Lithuania</i>      | -0.1952***              | trend            | -0.1392*** | level            | -0.2006***           | trend            |
| <i>Luxembourg</i>     | -0.3020***              | level            | -0.1646*** | trend            | 0.9609*              | level            |
| <i>Malta</i>          | -0.4461***              | trend            | -0.2230*** | neither          | -0.4325***           | level            |
| <i>Netherlands</i>    | 0.9096***               | neither          | 0.9372     | neither          | 0.9193*              | neither          |
| <i>Poland</i>         | -0.1995***              | trend            | -0.0148    | neither          | -0.1848**            | trend            |
| <i>Portugal</i>       | -0.2652***              | level            | -0.3215*** | trend            | -0.3019***           | level            |
| <i>Romania</i>        | -0.2339**               | trend            | -0.4123*** | trend            | -0.3457***           | trend            |
| <i>Slovakia</i>       | -0.1077***              | level            | -0.1128*** | trend            | -0.0986***           | level            |
| <i>Slovenia</i>       | -0.2541***              | trend            | -0.2452*** | level            | -0.2020***           | neither          |
| <i>Spain</i>          | -0.2752***              | neither          | -0.0609*   | neither          | -0.1955***           | neither          |
| <i>Sweden</i>         | -0.1993***              | trend            | -0.2607*** | level            | -0.2771***           | trend            |
| <i>United Kingdom</i> | -0.2036**               | trend            | -0.3042*** | trend            | -0.2681**            | trend            |

Note: Results of the estimation for the crisis and the post-crisis period (2009–2016) based on seemingly unrelated regressions (SUR). Inflation differentials (ID) are based on the Harmonized Index of Consumer Prices (HICP) excluding food and energy prices measure. ADF denotes the Augmented Dickey-Fuller test; there are three versions of the ADF test: (i) the version without the intercept and without the time trend (denoted by neither), (ii) the version with the intercept but without the time trend (denoted by level), (iii) the version with the intercept and the time trend (denoted by trend). \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Figure A1: Inflation rate of Austria, Belgium, Bulgaria, Croatia, and three inflation benchmarks.

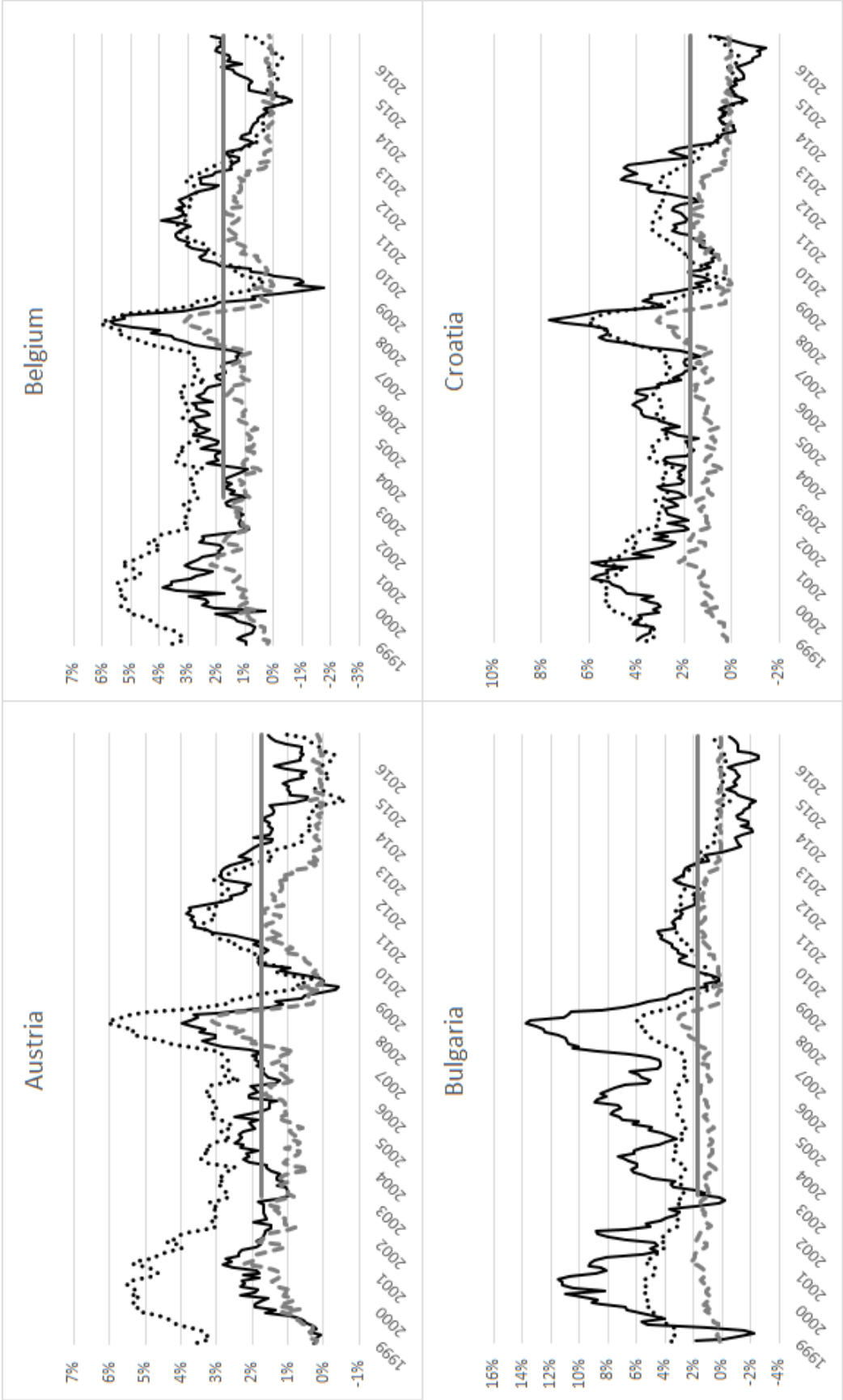


Figure A2: Inflation rate of Cyprus, the Czech Republic, Denmark, Estonia, and three inflation benchmarks.

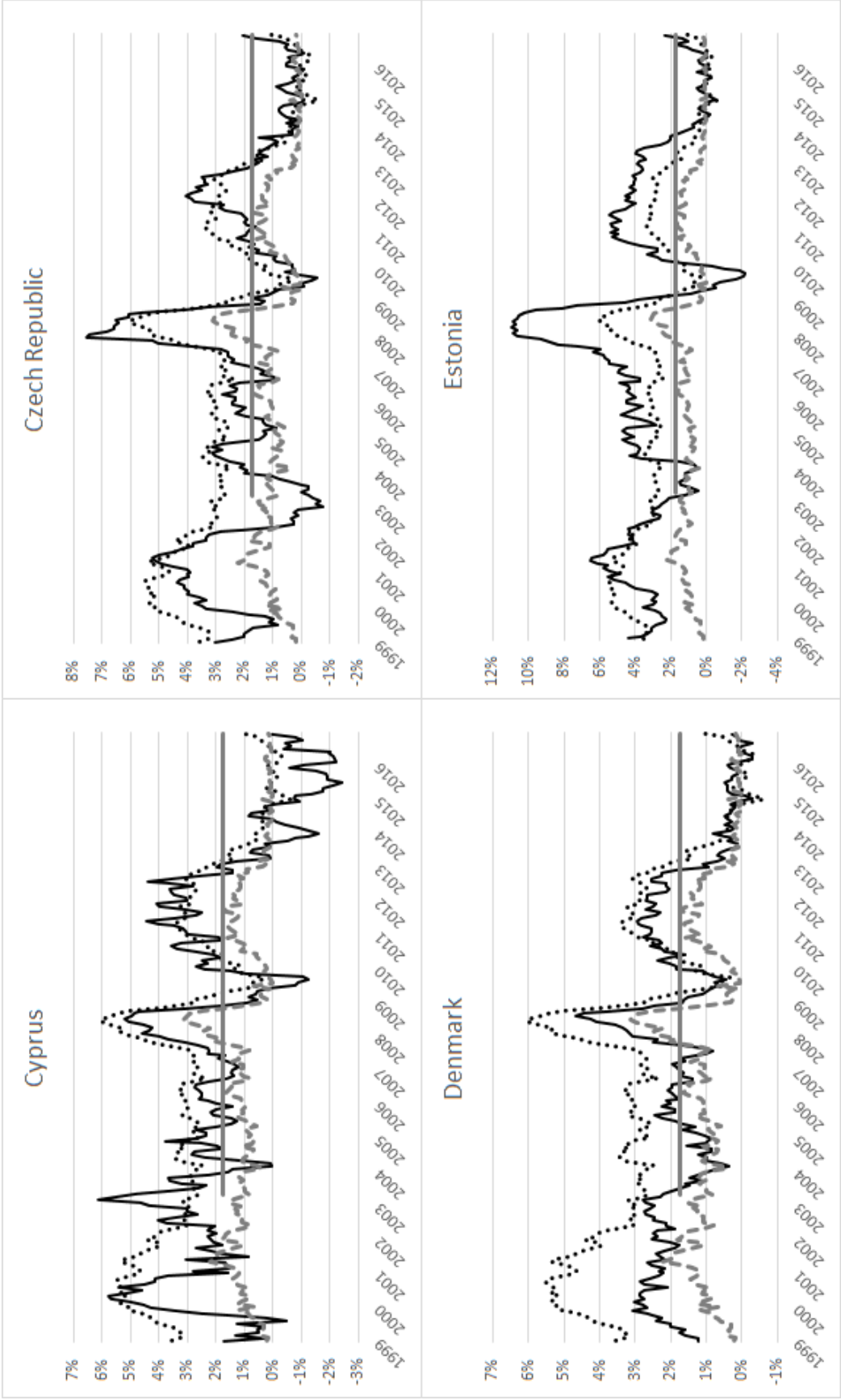


Figure A3: Inflation rate of Finland, France, Germany, Greece, and three inflation benchmarks.

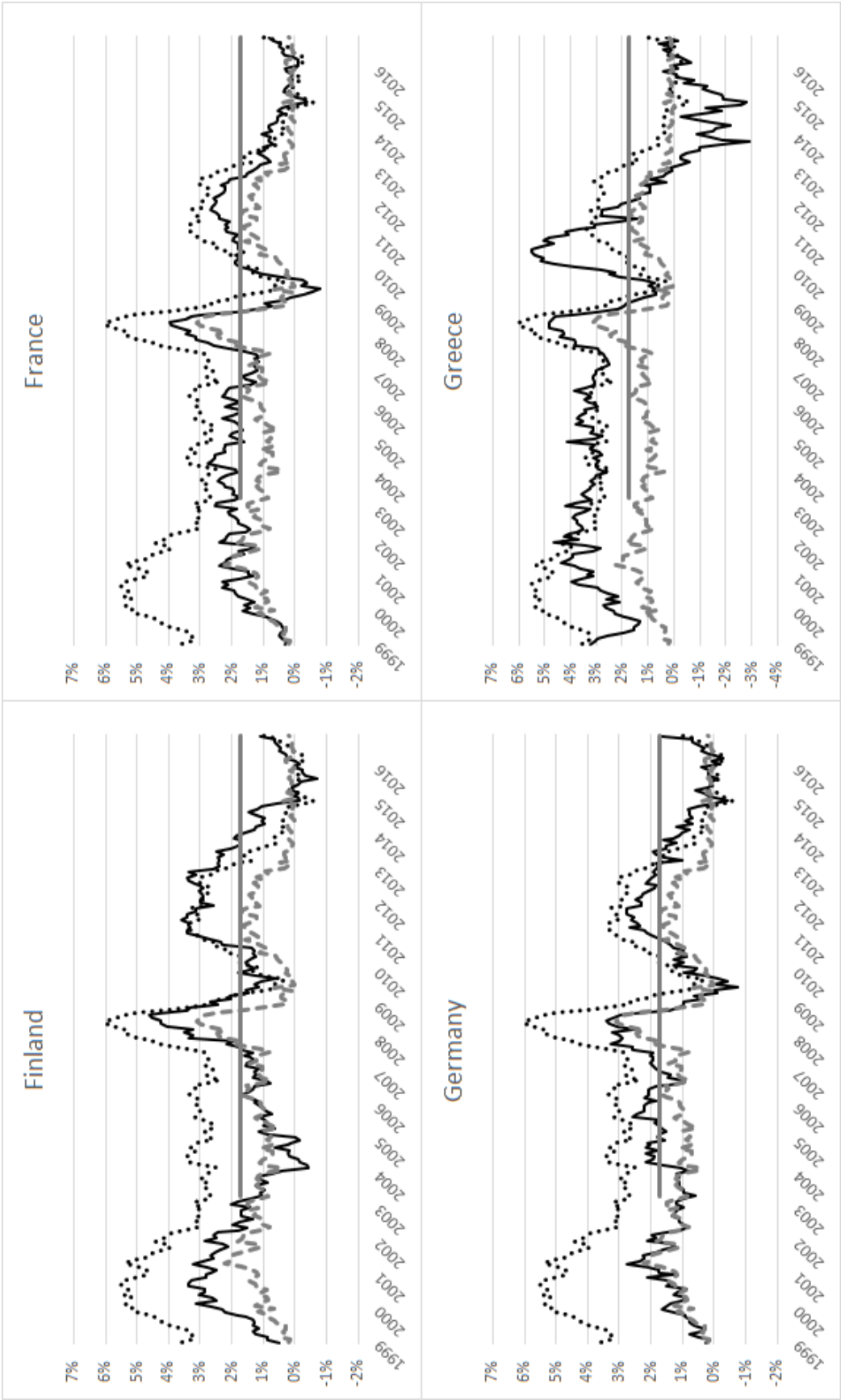


Figure A4: Inflation rate of Hungary, Ireland, Italy, Latvia, and three inflation benchmarks.

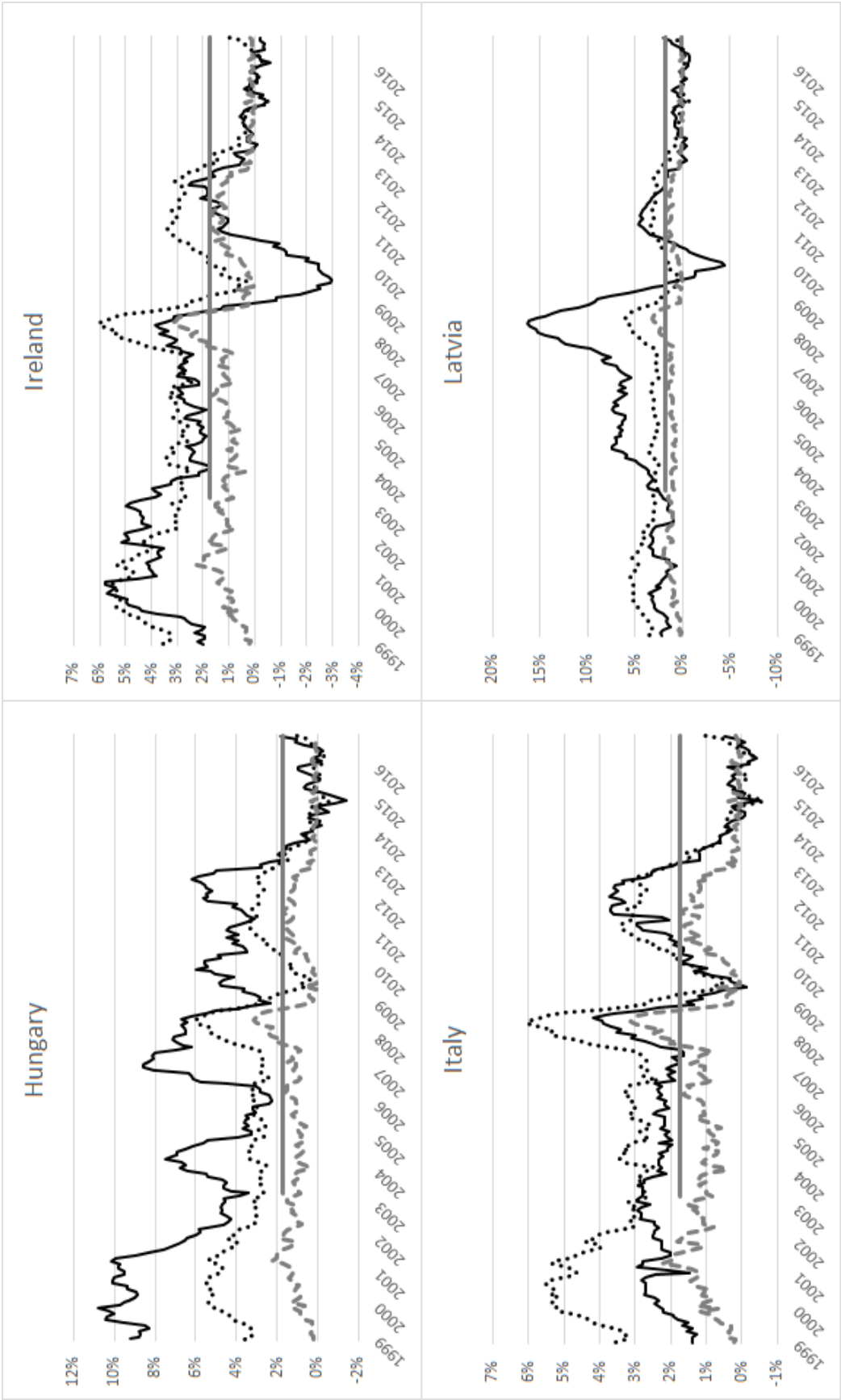


Figure A5: Inflation rate of Lithuania, Luxembourg, Malta, Netherlands, and three inflation benchmarks.

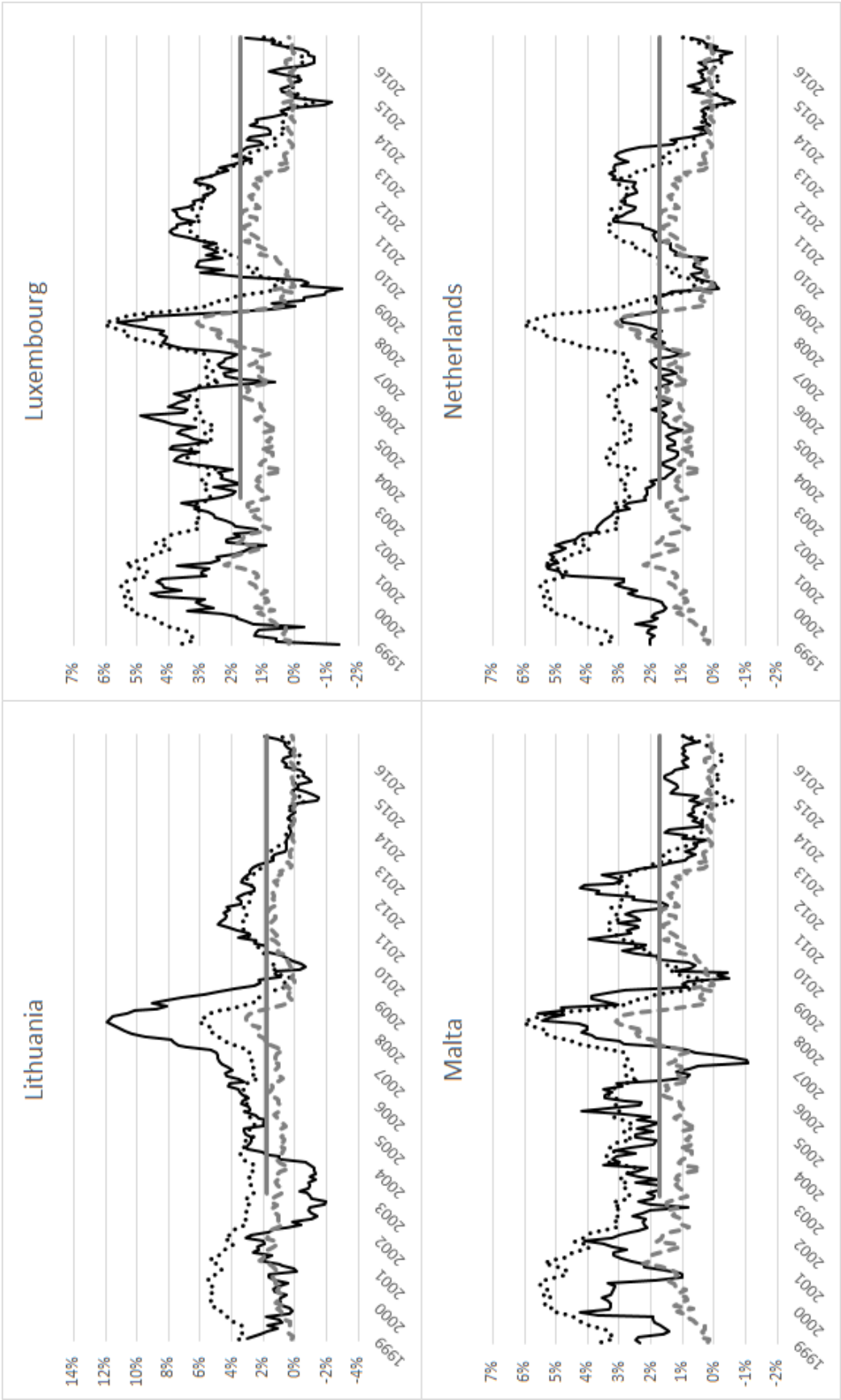




Figure A6: Inflation rate of Poland, Portugal, Romania, Slovakia, and three inflation benchmarks.

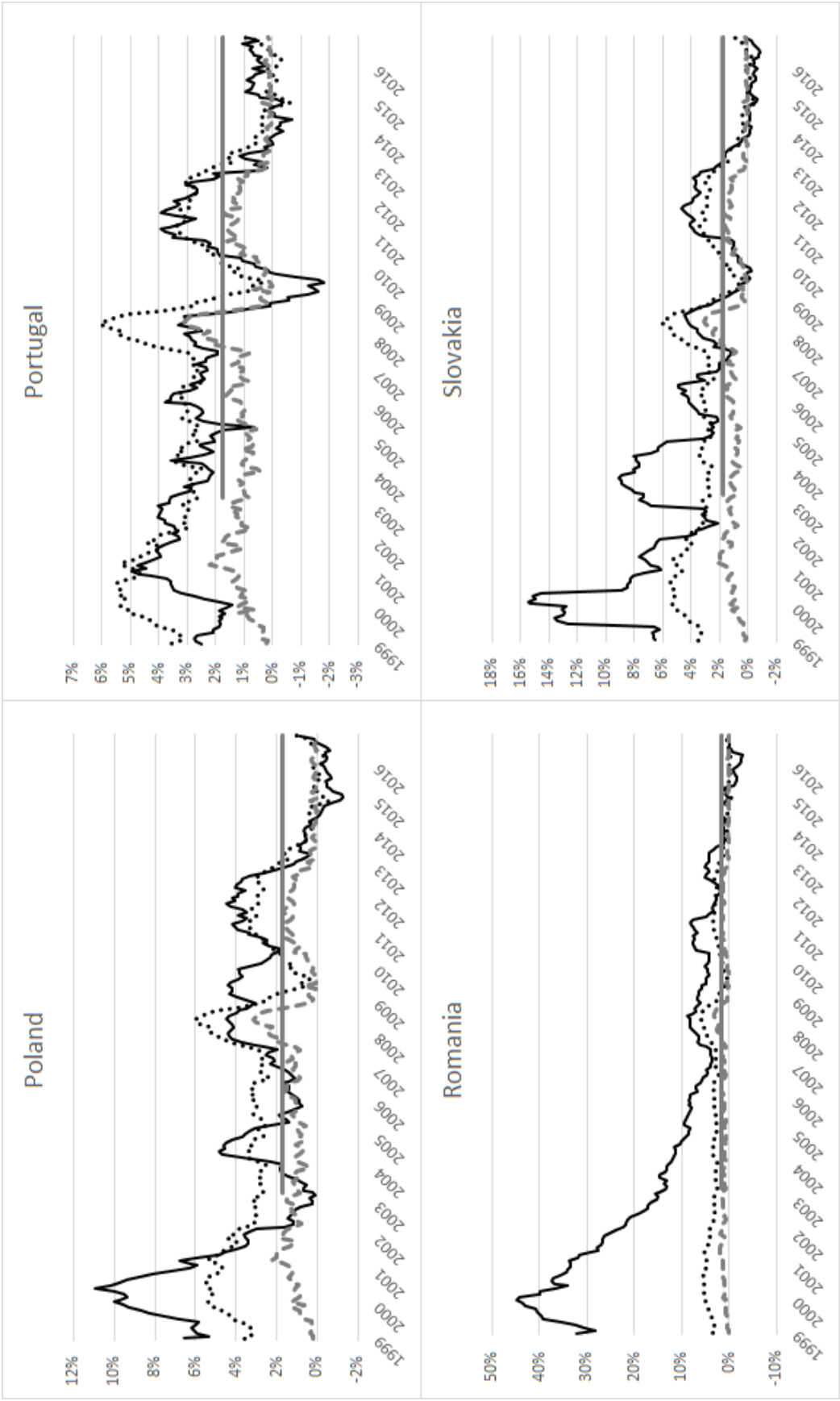
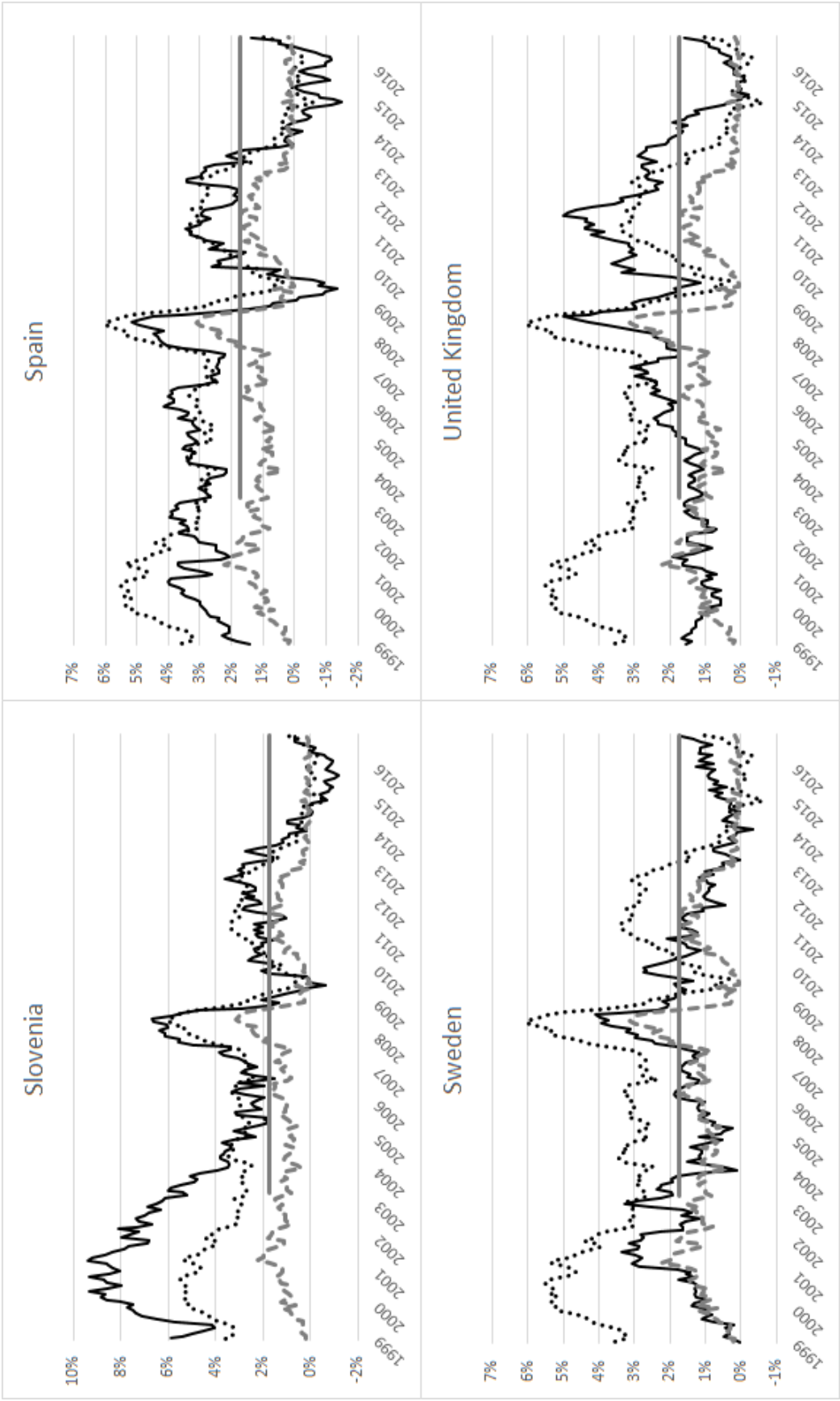


Figure A7: Inflation rate of Slovenia, Spain, Sweden, United Kingdom, and three inflation benchmarks.



**Table A1: Classification of dummy variables**

| Country               | Inflation targeting | Constraining exchange rate arrangement | Zero lower bound                    | Acquis communautaire <sup>d</sup> |
|-----------------------|---------------------|--|-------------------------------------|-----------------------------------|
| <i>Austria</i>        | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Belgium</i>        | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Bulgaria</i>       | N/A                 | 1999M01–2016M12                        | 2010M01–2016M12                     | 2000M05–2004M12                   |
| <i>Croatia</i>        | N/A                 | 1999M01–2016M12 <sup>a</sup>           | N/A                                 | 2006M06–2011M06                   |
| <i>Cyprus</i>         | 2008M01–2016M12     | 1999M01–2007M12 <sup>b</sup>           | 2013M05–2016M12                     | 1999M01–2002M12                   |
| <i>Czech Republic</i> | 1999M01–2016M12     | N/A                                    | 2012M07–2016M12                     | 1999M01–2002M12                   |
| <i>Denmark</i>        | N/A                 | 1999M01–2016M12                        | 2012M06–2016M12                     | N/A                               |
| <i>Estonia</i>        | 2011M01–2016M12     | 1999M01–2010M12                        | 2013M05–2016M12                     | 1999M01–2002M12                   |
| <i>Finland</i>        | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>France</i>         | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Germany</i>        | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Greece</i>         | 2001M01–2016M12     | 1999M01–2000M12                        | 2013M05–2016M12                     | N/A                               |
| <i>Hungary</i>        | 2001M06–2016M12     | 1999M01–2008M12 <sup>a</sup>           | N/A                                 | 1999M01–2002M12                   |
| <i>Ireland</i>        | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Italy</i>          | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Latvia</i>         | 2014M01–2016M11     | 1999M01–2013M11                        | 2014M01–2016M12                     | 2000M04–2002M12                   |
| <i>Lithuania</i>      | 2015M01–2016M12     | 1999M01–2014M12                        | 2015M01–2016M12                     | 2000M04–2002M12                   |
| <i>Luxembourg</i>     | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Malta</i>          | 2008M01–2016M12     | 1999M01–2007M12 <sup>c</sup>           | 2013M05–2016M12                     | 2000M05–2002M12                   |
| <i>Netherlands</i>    | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Poland</i>         | 1999M01–2016M12     | 1999M01–2000M12                        | N/A                                 | 1999M01–2002M12                   |
| <i>Portugal</i>       | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Romania</i>        | 2002M01–2016M12     | 1999M01–2002M12                        | N/A                                 | 2000M05–2004M12                   |
| <i>Slovakia</i>       | 2009M01–2016M12     | 1999M01–2008M12                        | 2013M05–2016M12                     | 2000M05–2002M12                   |
| <i>Slovenia</i>       | 2003M11–2016M12     | 1999M01–2006M12                        | 2013M05–2016M12                     | 1999M01–2002M12                   |
| <i>Spain</i>          | 1999M01–2016M12     | N/A                                    | 2013M05–2016M12                     | N/A                               |
| <i>Sweden</i>         | 1999M01–2016M12     | N/A                                    | 2009M04–2010M08;<br>2014M07–2016M12 | N/A                               |
| <i>United Kingdom</i> | 1999M01–2016M12     | N/A                                    | 2009M03–2016M12                     | N/A                               |

Note: Intervals show the period when a particular dummy variable takes the value of 1 and 0 otherwise. N/A shows that a dummy variable for a corresponding country takes a value of 0 over the entire sample period. The crises dummy that is not shown in the table takes the value of 1 from 2008M09 to 2012M07 for all countries based on von Hagen et al. (2011) and Afonso et al. (2017) and 0 otherwise. All dummy variables shown in the table were constructed following the classification of Kočenda and Varga (2017) unless stated otherwise: a IMF (2014), b Dreger et al. (2007), c Rawdanowicz (2006), d Böhmelt and Freyburg (2013).

**Table A2: Timing of structural breaks in the series of inflation differentials based on the results of the Bai and Perron test, inflation benchmark: cross-sectional average**

| Country               | Break 1 | Break 2 | Break 3 | Break 4 |
|-----------------------|---------|---------|---------|---------|
| <i>Austria</i>        | 2001M08 | 2004M09 | 2009M08 | 2012M12 |
| <i>Belgium</i>        | 2004M08 | 2009M12 | 2013M11 |         |
| <i>Bulgaria</i>       | 2009M01 |         |         |         |
| <i>Croatia</i>        | 2005M03 | 2009M11 | 2012M07 |         |
| <i>Cyprus</i>         | 2002M05 | 2009M10 |         |         |
| <i>Czech Republic</i> | 2003M12 | 2006M08 | 2009M03 | 2011M11 |
| <i>Denmark</i>        | 2009M02 |         |         |         |
| <i>Estonia</i>        | 2003M10 | 2008M01 |         |         |
| <i>Finland</i>        | 2012M04 |         |         |         |
| <i>France</i>         | 2001M12 | 2009M07 | 2013M08 |         |
| <i>Germany</i>        | 2004M04 | 2006M12 | 2009M08 | 2013M02 |
| <i>Greece</i>         | 2001M11 | 2006M09 | 2009M05 | 2012M01 |
| <i>Hungary</i>        | 2006M08 |         |         |         |
| <i>Ireland</i>        | 2001M08 | 2004M04 | 2007M12 | 2011M02 |
| <i>Italy</i>          | 2002M03 | 2006M04 | 2008M12 | 2011M08 |
| <i>Latvia</i>         | 2003M12 | 2006M09 | 2009M05 |         |
| <i>Lithuania</i>      | 2004M05 | 2009M09 |         |         |
| <i>Luxembourg</i>     | 2002M08 | 2006M08 | 2009M10 |         |
| <i>Malta</i>          | 2006M05 | 2008M09 | 2014M01 |         |
| <i>Netherlands</i>    | 2001M08 | 2008M12 | 2012M09 |         |
| <i>Poland</i>         | 2001M08 |         |         |         |
| <i>Portugal</i>       | 2007M08 | 2010M04 |         |         |
| <i>Romania</i>        | 2001M08 | 2004M04 | 2006M12 | 2011M6  |
| <i>Slovakia</i>       | 2004M12 |         |         |         |
| <i>Slovenia</i>       | 2003M12 |         |         |         |
| <i>Spain</i>          | 2002M03 | 2007M06 | 2010M02 | 2013M08 |
| <i>Sweden</i>         | 2001M08 | 2008M07 | 2011M03 |         |
| <i>United Kingdom</i> | 2002M02 | 2008M12 |         |         |

**Table A3: Timing of structural breaks in the series of inflation differentials based on the results of the Bai and Perron test, inflation benchmark: ECB target**

| Country               | Break 1 | Break 2 | Break 3 | Break 4 | Break 5 |
|-----------------------|---------|---------|---------|---------|---------|
| <i>Austria</i>        | 2006M11 | 2008M11 | 2010M11 | 2013M07 |         |
| <i>Belgium</i>        | 2006M11 | 2008M11 | 2010M11 | 2012M12 |         |
| <i>Bulgaria</i>       | 2007M04 | 2009M04 | 2013M06 |         |         |
| <i>Croatia</i>        | 2009M06 | 2013M09 |         |         |         |
| <i>Cyprus</i>         | 2006M11 | 2008M11 | 2010M11 | 2012M12 | 2014M11 |
| <i>Czech Republic</i> | 2007M01 | 2011M04 | 2013M04 |         |         |
| <i>Denmark</i>        | 2012M12 |         |         |         |         |
| <i>Estonia</i>        | 2008M12 | 2010M12 |         |         |         |
| <i>Finland</i>        | 2006M11 | 2008M11 | 2010M11 | 2012M12 | 2014M11 |
| <i>France</i>         | 2010M10 | 2012M11 |         |         |         |
| <i>Germany</i>        | 2008M11 | 2010M11 | 2012M12 | 2014M11 |         |
| <i>Greece</i>         | 2011M06 | 2013M06 |         |         |         |
| <i>Hungary</i>        | 2006M08 | 2008M08 | 2013M02 |         |         |
| <i>Ireland</i>        | 2009M01 | 2011M01 | 2013M02 |         |         |
| <i>Italy</i>          | 2008M12 | 2011M01 | 2013M03 |         |         |
| <i>Latvia</i>         | 2006M11 |         |         |         |         |
| <i>Lithuania</i>      | 2005M05 | 2007M05 |         |         |         |
| <i>Luxembourg</i>     | 2008M10 | 2010M10 |         |         |         |
| <i>Malta</i>          | 2007M09 | 2009M09 | 2013M02 |         |         |
| <i>Netherlands</i>    | 2009M03 | 2011M03 | 2013M09 |         |         |
| <i>Poland</i>         | 2007M08 | 2012M11 |         |         |         |
| <i>Portugal</i>       | 2008M10 | 2010M10 | 2012M12 |         |         |
| <i>Romania</i>        |         |         |         |         |         |
| <i>Slovakia</i>       | 2005M04 | 2008M12 | 2010M12 |         |         |
| <i>Slovenia</i>       | 2006M11 | 2008M11 | 2013M09 |         |         |
| <i>Spain</i>          | 2008M10 | 2010M10 | 2013M08 |         |         |
| <i>Sweden</i>         | 2007M10 | 2010M04 | 2012M10 |         |         |
| <i>United Kingdom</i> | 2008M03 | 2012M03 | 2014M08 |         |         |

**Table A4: Timing of structural breaks in the series of inflation differentials based on the results of the Bai and Perron test, inflation benchmark: Maastricht criterion**

| Country               | Break 1 | Break 2 | Break 3 | Break 4 | Break 5 |
|-----------------------|---------|---------|---------|---------|---------|
| <i>Austria</i>        | 2004M01 | 2010M12 | 2014M02 |         |         |
| <i>Belgium</i>        |         |         |         |         |         |
| <i>Bulgaria</i>       | 2002M05 | 2009M02 | 2013M06 |         |         |
| <i>Croatia</i>        | 2005M03 | 2009M06 | 2013M10 |         |         |
| <i>Cyprus</i>         | 2003M11 | 2013M03 |         |         |         |
| <i>Czech Republic</i> | 2002M04 | 2005M09 | 2008M12 | 2011M08 |         |
| <i>Denmark</i>        | 2003M06 | 2013M02 |         |         |         |
| <i>Estonia</i>        | 2002M06 | 2009M02 | 2014M01 |         |         |
| <i>Finland</i>        | 2002M08 | 2007M12 | 2010M12 | 2014M03 |         |
| <i>France</i>         | 2002M10 | 2006M02 | 2009M11 | 2014M04 |         |
| <i>Germany</i>        | 2004M02 | 2010M12 | 2014M04 |         |         |
| <i>Greece</i>         | 2012M01 |         |         |         |         |
| <i>Hungary</i>        | 2006M08 |         |         |         |         |
| <i>Ireland</i>        | 2003M10 | 2009M01 | 2011M09 |         |         |
| <i>Italy</i>          | 2002M04 | 2011M01 |         |         |         |
| <i>Latvia</i>         | 2003M12 | 2006M09 | 2009M05 |         |         |
| <i>Lithuania</i>      | 2007M01 |         |         |         |         |
| <i>Luxembourg</i>     | 2003M12 | 2009M10 |         |         |         |
| <i>Malta</i>          | 2013M01 |         |         |         |         |
| <i>Netherlands</i>    | 2002M02 | 2011M05 |         |         |         |
| <i>Poland</i>         | 2001M08 |         |         |         |         |
| <i>Portugal</i>       | 2007M07 | 2010M04 | 2012M12 |         |         |
| <i>Romania</i>        | 2001M12 | 2004M08 | 2011M06 |         |         |
| <i>Slovakia</i>       | 2004M12 |         |         |         |         |
| <i>Slovenia</i>       | 2003M08 |         |         |         |         |
| <i>Spain</i>          | 2008M04 | 2010M12 | 2013M08 |         |         |
| <i>Sweden</i>         | 2001M08 | 2004M04 | 2010M06 |         |         |
| <i>United Kingdom</i> | 2004M10 |         |         |         |         |

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