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Interest rate convergence in the EMS prior to European Monetary Union[☆]

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Abstract

We analyze the convergence of interest rates in the European Monetary System (EMS) in a novel framework of changing persistence. Due to the specific historical situation in the EMS interest rate differentials were non-stationary before full convergence was achieved. After full convergence has taken place, interest rate differentials became stationary. The applied econometric approach allows us to estimate the exact dates of full convergence endogenously. Our empirical results suggest remarkable differences in the estimated convergence dates for Belgium, France, the Netherlands and Italy which are highly related to steps of European integration policies. We conclude that credibility of monetary policy is of paramount importance for establishing a monetary union successfully. This finding has significant implications for future member states of the EMU.

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1. Introduction

The recent financial crisis and the accompanying increase of interest rate spreads have again called the attention to the evolution of interest rate spreads. The question is not only relevant for the current members of European Monetary Union (EMU), but also for those new member countries who are obliged to join EMU in the long run. However, these cases suffer from short sample periods, which make the application of recently suggested econometric approaches difficult. It is therefore useful to take a look at the historical experiences from the European Monetary System (EMS) in the run-up to EU, where the situation was quite the opposite.

When analyzing the time series properties of the interest rate differentials in the EMS, a puzzle occurs. Whereas one would expect the interest rate differential to be stationary, empirical results show that the interest rates of the participants in the Exchange Rate Mechanism of the EMS were not cointegrated with the German one. At the time of its discovery, this fact challenged the German dominance hypothesis. The odd results can be explained by the specific historical situation of the EMS that has led to an ongoing process of financial and monetary integration, leading to the conclusion that these interest rate differentials are non-stationary.

Accordingly, as it is known that the process of integration came to an end with the launch of EMU, there must have been a switch from a non-stationary to a stationary process. The question arises of when this switch occurred, i.e., when full interest rate convergence has been achieved. This event did not necessarily coincide with the inauguration of EMU: one may also imagine that convergence was achieved before a country was announced to become a member of EMU. This is particularly the case if policy coordination was tight prior to the concrete preparations of EMU. Following the German dominance hypothesis, this basically means that a member state maintains a credible peg to the Deutsche mark. On the other hand, there may still be a lack of convergence even if a country has been announced as a future 2 member of EMU. This can be the case if there are doubts about the validity of the announcement. In this case one should find a convergence date between the official announcement of the country's entry and the actual entry. Our results will show that both cases occurred in the run-up to EMU. [Caporale, Kalyvitis, and Pittis \(1996\)](#) stress the importance of distinguishing between the process of convergence, during which we usually do not observe stationarity of interest rate differentials and "convergence as a state" ([Caporale et al., 1996](#), p. 696), i.e. a situation when convergence has been achieved. Following their line of arguments, the process of convergence is characterized by a declining and non-stationary interest rate differential, whereas convergence as a state implies that the interest rate differential is stationary. Therefore, a switch must have occurred from non-stationarity to stationarity over time, illustrating how monetary convergence has been achieved. A change in persistence is defined as a change in the degree of integration of a time series process, see [Leybourne, Taylor, and Kim \(2007\)](#). As the time series under consideration are interest rate differentials, changing persistence is clearly defined in our application: the point in time where the interest rate differential gets stationary, say at time T_B , full convergence has been achieved. Our contribution to the existing literature is threefold:

To the best of our knowledge, we are the first who investigate interest rate convergence by means of a changing persistence model, whereas most previous studies test for cointegration relations or stationarity of interest rate differentials over isolated subperiods. In contrast of imposing exogenous breakpoints (see for instance [Baum & Barkoulas, 2006](#); [Hassapis, Pittis, & Prodromidis, 1999](#); [Kirchgässner & Wolters, 1995](#); [Zhou, 2003](#)), we allow for endogenous estimation of the breakpoint. Thus, we do not only focus on the existence of a convergence process, but more importantly on the point in time where the break occurs. It turns out that the estimated breakpoints are

highly related to historical events of European integration. Furthermore, in comparison to sub-sample analysis with a restricted number of observations, the applied methods in this paper allow us to use the full sample instead and thereby obtaining more reliable results. Second, we apply a recently proposed test (Leybourne et al., 2007), that explicitly allows to test the null hypothesis that the process has constant persistence against the alternative of a change from a unit root to a stationary process over time. Third, while samples in earlier studies usually end in 1999, we include the first years during which EMU was in service. This enables us to include potential breakpoints up to the launch of EMU.

The paper proceeds as follows: Section 2 describes the components of the interest rate differential between EMS member countries. Section 3 briefly reviews the process of European monetary integration, while Section 4 describes the data and introduces the methodology. Section 5 presents the empirical results and Section 6 sums up our findings and concludes.

2. Interest rate linkages

Interest rate linkages are based on interest rate parity: if capital mobility is high, which was increasingly the case in the process of European monetary integration (Kenen, 1995), domestic and foreign financial assets with maturity k are – besides differences in the countries' default risk – substitutes for each other. This implies that the domestic interest rate equals the foreign interest rate, plus the forward premium on the foreign currency, i.e., covered interest parity:

$$i_t - i_t^* = f_t - s_t \quad (1)$$

where i_t and i_t^* are the domestic and foreign interest rates, the difference between forward rate f_t and spot rate s_t is the forward premium and it reflects the expected fluctuations of the exchange rate,¹ i.e., $E_t(\Delta s_{t+k})$ with $\Delta s_{t+k} = s_{t+k} - s_t$, and a risk premium $RP_t = f_t - E_t(\Delta s_{t+k})$, see Zhou (2003).

For the EMS, the risk premium RP_t itself can be decomposed in two components (Svensson, 1991): first, differences in country-specific default risks CR_t , second, the risk of realignment (Knot, 1998), to which we refer as the realignment risk RR_t . RR_t is a function of the probability of a change in the central parity and the expected magnitude of the change, and includes the possibility that the respective country leaves the ERM.

Based on these considerations, Eq. (1) evolves to the uncovered interest parity:

$$i_t - i_t^* = CR_t - RR_t + E_t(\Delta s_{t+k}) \quad (2)$$

As empirical results in the case of flexible exchange rates suggest that the risk premium is time-varying but stationary (see inter alia Fama, 1984; Wolff, 1987, recently Shively, 2000) one would expect the interest rate differential to be stationary, too.

However, the empirical literature found that the interest rate differential has not been stationary (see e.g. Caporale et al., 1996; Hassapis et al., 1999; Karfakis & Moschos, 1990; Katsimbris & Miller, 1993). This result was puzzling as one would expect an even stronger interest rate linkage in a system like the EMS (Baum & Barkoulas, 2006) due to better policy coordination since the early 1980s and an increasing degree of capital mobility. Although there is a lack of both, theoretical justifications and empirical evidence for a non-stationary risk premium in flexible exchange rates,

¹ For the EMS currencies this of course means fluctuations within the band, which could particularly after the widening to ± 15 percent in 1993 of substantial magnitude.

it may be non-stationary due to the specific historic situation in the EMS (for a discussion see Caporale & Pittis, 1993). There are basically two lines of arguments. First, the EMS has led to a higher degree of financial and monetary integration, but rather as an ongoing process (Willett, 2000) and not necessarily to the whole extent since its launch. This point is stressed by Frömmel and Menkhoff (2001, p. 302), who state that monetary integration “not only causes a once-for-all reduction in [exchange rate] volatility but can also create ongoing progress”. This ongoing reduction in exchange rate volatility then directly transfers to the risk premium, as $E_t(\Delta s_{t+k})$ is affected. Furthermore, the probability of realignments decreases with the increasing coordination in monetary policy and also induced “a monotonic convergence of the member states’ rates” (Hassapis et al., 1999, p. 48). This view is supported by Caporale and Pittis (1995). Knot, Sturm, and de Haan (1998) identify inflation differences, divergent fiscal policies and unemployment figures as sources for a lack of credibility, Arghyrou and Gadea (2012) stress the importance of macroeconomic incompatibility besides weakness of fiscal discipline for a lack of convergence. For a critical view on the debt-exchange rate relation see Nyahoho (2006).

Furthermore, Andersen and Chiriaeva (2007) argue that due to the limited abilities of monetary policy in a system of fixed exchange rates, the control of aggregate demand by fiscal policy is crucial. Thus, the credibility of fiscal policy – besides monetary policy – is a substantial requirement for the credibility of the peg and therefore for the convergence of interest rates according to Eq. (2).

There are several arguments to assume the convergence process follow a stochastic rather than a deterministic trend: first, according to the efficient market hypothesis (unexpected) news about the convergence process drive the interest rate differentials. Second, and related to the first argument, approaches from social and political sciences, such as historical institutionalism stress the importance of path-dependence and irreversibility in political and economic processes (Castaldi & Dosi, 2006), supporting the notion that “credibility has to be earned over time” (Hochreiter & Talas, 2004, p. 808). Third, the empirical literature is in favor of stochastic rather than deterministic trends in interest rate differentials (see particularly for the EMS Caporale & Pittis, 1993). However, as a robustness check we also estimated the breakpoints assuming a deterministic trend. The results do not substantially differ and are available from the authors on request.

Besides the argument of a trend-like convergence process in the EMS a second set of studies argues that the non-stationarity of the risk premium is due to structural breaks in the deterministic part of the time series process, which stem from the particular history of the EMS (Fountas & Wu, 1998; Katsimbris & Miller, 1993; Zhou, 2003).

3. Steps of European monetary integration

We start our analysis in August 1983, because the years 1982/83 are commonly accepted as the effective begin of the “new and hard EMS” (Artis & Taylor, 1994; Frömmel & Menkhoff, 2001) in terms of an improved coordination of monetary and fiscal policy. The further monetary integration has then led to a stepwise, discontinuous, rather than a continuous, trend-like convergence.

The final decision about the members has only been taken at the council of the EU on May 2 and 3, 1998 in Brussels and followed the advice given by the European Monetary Institute (EMI) in their convergence report dated from March 25, 1998.

Therefore one should expect the heterogeneous expectations on the members in the run-up to EMU to be reflected in the interest rate differential. As Germany was assumed to be surely a

member of the future EMU, it is straightforward and common to use it as a reference country and focus on the differentials to the German interest rate.

The history of European monetary integration should then be reflected in Eq. (2): a decline in interest rate differentials is observable, as with the degree of integration the risk of realignments (RR_t) as well as the risk of exchange rate movements $E_t(\Delta s_{t+k})$ decreases. One might further argue, that particularly with the higher fiscal discipline induced by the stability and growth pact even the differences in the default or country risk CR_t can be expected to have become smaller. Due to the disappearing risks of realignments and exchange rate movements when entering EMU, the interest rate differential should have become stationary. The question is, however, when this exactly happened. It must have been latest when markets accepted particular countries as members of EMU. This happened most likely between the ECOFIN meeting in Mondorf-Le-Bains in September 1997, and the summit in Brussels in May 1998, when the set of initial member countries was officially announced. However, one may imagine situations where convergence was already reached earlier, if a country fully credibly pegged its currency to the Deutsche mark, or later, if there were discussions in the course of 1998 about potential member countries even after the official announcement. We will later see that both cases occurred.

4. Data and methodology

4.1. Data

We focus on those countries that have been members of the EMS from the beginning of the sample period: Germany as the reference country, Belgium, France, Italy, and the Netherlands.² This narrow choice is mainly driven by the following reasons: for the econometric analysis it is of great importance that sample sizes are large enough to judge estimation and inference as reliable.³ Finally, our choice is influenced by the question whether data is potentially contaminated with outliers. These may heavily bias a structural break analysis. Applying these criteria, we are forced to exclude new member states and several other countries which joined the EMS later than the five listed above. Fig. 1 depicts the four interest rate differentials.⁴

In addition to the countries of interest we consider a control group to compare the results with some countries that did not join EMU. The control group consists of three countries with very different histories: Denmark took part in the exchange rate mechanism of the EMS from its very beginning in 1979, and is still (although now in EMS2). However, the DKK/DEM exchange rate was subject to several realignments between 1979 and 1987 and was substantially affected by the turmoil during the EMS crises⁵ particularly in the course of 1993. In contrast, the UK entered the EMS only in 1990 and when it was heavily hit by speculative attacks in September 1992 it left

² Due to lack of data availability, we do not include Ireland, although it was an initial member of the EMS and EMU. Luxembourg is not included as it formed a currency association with Belgium until 1999. In the following we therefore only refer to Belgium. For a case study on Austria and Greece see Hochreiter and Talas (2004).

³ It should also be stressed that data has to be trimmed when it comes to testing for structural breaks and related breakpoint estimation, see also Sections 4.2 and 5 and the Appendix. Data trimming becomes a critical issue for countries whose data is only available from the mid-nineties onwards: the true date of full convergence may be undetectable. Moreover, for the applied econometric procedures in this paper it is also essential that data does not contain missing values.

⁴ Unreported boxplots confirm that the selected data set does not contain outliers. Results are available from the authors upon request.

⁵ For excellent surveys on the EMS crisis see Kenen (1995) and Eichengreen (2002).

Fig. 1. Interest rate differentials from August 1983 to August 2007.

again. Thereafter, the DEM/GBP rate floated freely. The US, as a third phenotype, never had any relation with the EMS, thereby suggesting a different behavior.

In the empirical literature it is common to use short-term interest rates (see inter alia [Baum & Barkoulas, 2006](#) or [Zhou, 2003](#)).⁶ The choice of short term interest rates has the advantage that the default risk over short horizons is comparatively small in the case of EMS member countries and it does not play a dominant role in Eq. (2). We use treasury bill rates with a maturity of 3 months on a monthly basis. The data is obtained from the International Financial Statistics Database by the IMF, series ccc60C.ZF, where ccc is the respective country code.⁷ Thus, our analysis covers the interest rate differentials of seven countries versus Germany, whereby four countries form the heart of our analysis and three other countries serve as a control group to investigate the sensitivity of our findings.

Following the findings of several former studies, which state that the convergence process which led to a “new and hard EMS” did not start before the early 1980s (inter alia [Artis & Taylor, 1994](#); [Frömmel & Menkhoff, 2001](#)), we begin our analysis with the data of August 1983. In order to make sure that there is a sufficiently long period of EMU membership included in the sample, the end of the sample period is extended to August 2007. Hence, our sample consists of $T=289$ observations and covers a period of on-going monetary integration in Europe. Indeed, [Fig. 1](#) reveals that the evolution of interest differentials for the countries under consideration shows a decline from the start of our sample period. This decline seems to have ended prior to the launch of EMU, with the Dutch one being comparatively small from the beginning, whereas the other ones, particularly the Italian one, start from a high level.

⁶ Therefore, we do explicitly not aim to test for compliance of the Maastricht criteria of long term interest rate convergence.

⁷ For the Netherlands we rely on data from the Dutch central bank (3 months loans to local government).

4.2. Econometric methodology

We consider an autoregressive time series process $y_t = a + v_t$ with $v_t = \rho_t v_{t-1} + \varepsilon_t$, where ε_t is a stationary error term which is allowed to be autocorrelated, see [Leybourne et al. \(2007\)](#) for more details on the fairly general assumptions on the sequence ε_t . The time series process y_t contains a deterministic constant a . The autoregressive parameter ρ_t can be either characterized by (i) a one-time structural change or (ii) it is constant over time, i.e. $\rho_t = \rho$ for all $t = 1, 2, \dots, T$. In the latter case, it is of importance to further distinguish the cases $\rho = 1$ and $0 < \rho < 1$, which imply non-stationarity and stationarity of y_t , respectively. If $\rho = 1$, then y_t contains a unit root and is therefore a non-stationary $I(1)$ process. On the contrary, the stationarity condition in this simple model is given by $0 < \rho < 1$, y_t is then $I(0)$.

Next, we consider the case of changing persistence: if $\rho_t = 1$ for $t = 1, 2, \dots, T_B$ and $0 < \rho < 1$ for $t = T_{B+1}, T_{B+2}, \dots, T$, a decline in persistence takes place at the breakpoint T_B . The time series process switches from an $I(1)$ to an $I(0)$ process. In this sense, a change in persistence means a change in the degree of integration over time. [Leybourne et al. \(2007\)](#) propose a test for the unit root hypotheses against a change in persistence. They consider the following pair of hypotheses,

$$H_{11} : \rho = 1 \quad \text{for all } t$$

$$H_{10} : \begin{cases} \rho = 1 & \text{for } t = 1, 2, \dots, T_B \\ 0 < \rho < 1 & \text{for } t = T_{B+1}, \dots, T \end{cases}$$

For the purpose of exposition, we also write $T_B = [\tau T]$ in the following, where $[x]$ denotes the biggest integer smaller than x and $\tau \in (0, 1)$. The interpretation of H_{11} and H_{10} is as follows: the null hypothesis (H_{11}) states the time series y_t is integrated of order one throughout the sample, i.e., y_t is a unit root process for all t . On the contrary, the alternative hypothesis H_{10} states that there is a decline in the persistence of y_t at some unknown breakpoint $t = T_B$. In the context of unit roots and changing persistence, a third possibility plays an important role which is given by $H_{00} : 0 < \rho < 1$ for all t .

Under the validity of H_{00} , y_t follows an $I(0)$ process for all t and, trivially, neither H_{11} nor H_{10} can be true. The tests proposed by [Banerjee, Lumsdaine, and Stock \(1992\)](#), [Kim \(2000\)](#), [Kim, Belaire-Franch, and Amador \(2002\)](#), [Leybourne, Kim, Smith, and Newbold \(2003\)](#) and [Buseti and Taylor \(2004\)](#) have the major drawback that they may spuriously indicate a change in persistence even though there is none present in the data. Therefore, we concentrate on the recently proposed test by [Leybourne et al. \(2007\)](#) which overcomes this problem by suggesting a nonparametric CUSUM of squares-based test statistic. As discussed in [Leybourne et al. \(2007\)](#), their proposed test statistic R behaves conservatively under the validity of H_{00} . This means that the asymptotic size of R equals zero and that spurious rejections cannot occur. The relative breakpoint τ is assumed to be unknown and an estimator for τ is proposed in [Leybourne et al. \(2007\)](#). More details can be found in the Appendix.

For reasons of comparison and in order to check the robustness of the results we additionally consider breakpoint estimators proposed by [Kim et al. \(2002\)](#) and [Busetti and Taylor \(2004\)](#). Both estimators are applicable in our situation, although the related tests are not applicable because their null hypothesis is that y_t follows an $I(0)$ process for all t . This contradicts the existence of a non-stationary risk premia before the formation of EMU. For details regarding the breakpoint estimators, we refer the interested reader to [Kim et al. \(2002\)](#) and [Busetti and Taylor \(2004\)](#).

Table 1
CUSUM of squares-based test results.

Time series	BEL	FRA	GER	ITA	NET	DEN	UK	US
i_t	0.691	0.881	1.405	0.281	0.266	0.400	0.467	0.767
$i_t - i_t^{GER}$	6.217	3.376	–	6.706	2.555	2.422	0.590	0.401

Reported values are the CUSUM of squares-based unit root test statistics (R) applied to individual interest rates and the differentials. Critical values are given by $(cv_{10\%}, cv_{5\%}, cv_{1\%}) = (2.97, 4.16, 7.61)$ see [Leybourne et al. \(2007\)](#), Table 1.

5. Results

This section presents our empirical results. [Table 1](#) presents the results for the CUSUM of squares-based test proposed by [Leybourne et al. \(2007\)](#) and the corresponding critical values for de-meaned data which are taken from their Table 1 with $T=250$. In a first step, we apply the unit root test to the individual interest rates (first line of results in [Table 1](#)). In none of the eight cases evidence against the null hypothesis is found. From a statistical viewpoint it is premature to conclude that individual interest rates are $I(1)$ as the test behaves conservatively under H_{00} . This means that a non-rejection might be caused by an $I(0)$ or an $I(1)$ process without any change in persistence over time. Therefore, we apply the DF-GLS unit root test suggested by [Elliott, Rothenberg, and Stock \(1996\)](#) in order to test for $I(1)$ versus $I(0)$. This test is applicable to the individual interest rates since the results for the CUSUM of squares-based test clearly show that no change in persistence occurred.⁸ However, the unit root hypothesis is confirmed as the DF-GLS test does not reject the null hypothesis for all considered interest rates.⁹

As a second step, we apply the CUSUM of squares-based test to interest rate differentials in order to test for constant against changing persistence. The results (second line in [Table 1](#)) reveal that the hypothesis of constant persistence is rejected for three out of seven countries at a nominal significance level of 10 percent. For Belgium and Italy, the null hypothesis can be rejected in favor of the alternative even at the 5 percent level. For the Netherlands do we not find evidence against the hypothesis of constant persistence. This might be caused by the fact that the time series is stationary during the whole sample period since the test is conservative under H_{00} . If the interest rate differential between the Netherlands and Germany can be characterized as a $I(0)$ process for all considered time periods, then full interest rate convergence was already achieved before our sample starts. This possibility is further explored in the following. The results for the control group consisting of Denmark, United Kingdom and the US suggest that the persistence of these interest rate differentials is constant over time.¹⁰

Next, we consider the results for the convergence date estimates which are reported in [Table 2](#). This exercise is done for Belgium, France, Italy and the Netherlands but not for the countries in the control group as these do not exhibit a change in persistence. We compare the outcomes of three different breakpoint estimators, see Section 4.2. This is done in order to analyze the robustness of the results obtained by the LTK breakpoint estimator. Again, we use de-meaned data. In addition,

⁸ It is worthwhile to note that standard unit root test are ill-behaved when changes in persistence occur. As a change in persistence implies that there is a fraction of the sample where the process is stationary, the behavior of standard unit root tests depend entirely on the breakpoint. If the fraction of observations that belong to the stationary regime is small, rejections are not likely and vice versa. Hence, standard tests are not able to discriminate between H_{11} and H_{10} .

⁹ Detailed results are available from the authors upon request.

¹⁰ An application of the DF-GLS test to the interest rate differentials of the control group reveal that the interest rate differentials for the US and Denmark is $I(1)$, whereas it is $I(0)$ for the UK.

Table 2
Convergence date estimates for $i_t - i_t^{GER}$.

	LTK	KBA	BT
BEL	May 1995	May 1995	May 1995
FRA	March 1996	September 1996	May 1996
ITA	November 1998	December 1998	December 1998
NET	April 1993	October 1996	November 1987

LTK, KBA, BT refer to different breakpoint estimators proposed by [Leybourne et al. \(2007\)](#), [Kim et al. \(2002\)](#) and [Busetti and Taylor \(2004\)](#). Please note that the interest rate differential between the Netherlands and Germany is treated as stationary during the whole sample period.

we specify the interval of potential breakpoints as [1987:09, 1998:12]. This means that the earliest and the latest possible convergence dates in our analysis are September 1987 and December 1998, respectively. The earliest potential convergence date is therefore represented by the Basle–Nyborg agreement, aiming at strengthening the exchange rate mechanism of the EMS by providing credit facilities for intramarginal interventions and proposing a better policy coordination. The latest potential convergence date is the launch date of EMU, as by irrevocably fixing the exchange rate convergence in the spirit of Section 2 was achieved per definition. Even though we do not find evidence for changing persistence in the case of the Netherlands, we estimate a breakpoint for this time series as well simply for illustration. Clearly, the results for the Netherlands should be taken with a pinch of salt. Furthermore, we apply the DF-GLS unit root test for the full sample, the country-specific prebreak and the postbreak periods. Please note, that the DF-GLS unit root test results for the full sample should be taken with special care for Belgium, France and Italy since the test is not able to account for changes in persistence. The DF-GLS test is applied in order to verify the results obtained by the CUSUM of squares-based test and the outcomes of the breakpoint estimators. Individual pre- and postbreak periods are constructed according to the LTK breakpoint estimates, see [Table 2](#).¹¹

The outcomes of the breakpoint estimation exercise suggest that the convergence dates have been very different for the respective countries. In the case of *the Netherlands* it seems that there has been no change in persistence: we find the interest rate differential to be stationary through the whole sample period. Thus there is no statistical evidence for a switch from an $I(1)$ to an $I(0)$ process. This result is supported by the fact that the Dutch central bank followed the Bundesbank’s monetary policy for a long time and kept the Dutch guilder/Deutsche mark rate stable. There have only been two realignments of the guilder in the beginning of the EMS (1979–1983) before the Dutch central bank managed to keep the exchange rate stable and inflation differences to Germany low ([Klaster & Knot, 2002](#)). As a result of its policy the Netherlands continued to peg the guilder to the mark in the narrow ± 2.25 percent band, whereas the band was widened to ± 15 percent for all other currencies after the severe EMS crises in 1992 and 1993.

Accordingly the credibility of the peg was comparatively high, and there has been no realignment of the Dutch guilder since 1983, i.e., prior to our earliest potential break date 1987.¹² The Netherlands formed a de facto currency union with Germany long before the official launch of EMU.

¹¹ As the different breakpoint estimators deliver very similar results, this choice is not crucial. Results are reported in Table 3 of [Frömmel and Kruse \(2009\)](#).

¹² We also did the calculations with a sample period starting in April 1979. The results of which are available from the authors upon request. These, however, do not change significantly.

Table 3
DF-GLS unit root test results for $i_t - i_t^{GER}$.

Country	DF-GLS	Level	Decision	Lags	Obs	Sample
Full sample						
BEL	−0.282	–	$I(1)$	4	289	Aug1983–Aug2007
FRA	0.134	–	$I(1)$	4	289	Aug1983–Aug2007
ITA	0.272	–	$I(1)$	0	289	Aug1983–Aug2007
NET	−2.546	0.05	$I(0)$	0	289	Aug1983–Aug2007
Country-specific prebreak periods						
BEL	−0.731	–	$I(1)$	3	142	Aug1983–Apr1995
FRA	−0.211	–	$I(1)$	3	152	Aug1983–Feb1996
ITA	0.331	–	$I(1)$	0	184	Aug1983–Oct1998
NET	−1.687	0.10	$I(0)$	0	117	Aug1983–Mar1993
Country-specific postbreak periods						
BEL	−2.961	0.01	$I(0)$	0	147	May1995–Aug2007
FRA	−2.067	0.05	$I(0)$	3	137	Mar1996–Aug2007
ITA	−2.462	0.05	$I(0)$	3	105	Nov1998–Aug2007
NET	−2.173	0.05	$I(0)$	1	172	Apr1993–Aug2007

Country-specific pre- and postbreak periods are determined according to LTK breakpoint estimation results, see Table 2. DF-GLS is the Elliott et al. (1996) unit root test statistic, optimal lag length is chosen via AIC. Please note that the full sample analysis is only valid in the case of the Netherlands since this time series is the only one for which constant persistence is evident, see Table 1.

The unit root test results reported in Table 3 also suggest that the interest rate differential between the Netherlands and Germany has been stationary during the whole sample period. The DF-GLS test statistic is significant at conventional levels for the three considered samples. This outcome is in line with the results obtained by the CUSUM of squares-based unit root test, see Table 1. Moreover, this result is clearly in line with the history of Dutch monetary policy. Hence, we conclude that the short-term interest rates in the Netherlands and Germany have converged before our sample starts.

Although Belgium has some characteristics in common with the Netherlands as a small economy with a remarkable degree of openness, its monetary policy has been less credible and there have been seven realignments between 1979 and 1987. In 1990 Belgium gave up its two-tier exchange rate system and has since then adhered to the “franc-fort” policy, pegging the franc closely to the central parity and enhancing the convergence process. Our analysis indicates that this convergence process has come to an end in May 1995, see Table 2. This breakpoint estimate is remarkably stable across different estimators. Back then, a stable exchange rate had been the target of Belgium’s policy for some years and the government had made some successful efforts to bring down Belgium’s budget deficit by various measures between 1992 and 1994 (for details see Von Hagen, Hallett, & Strauch, 2001). The DF-GLS unit root test results for the pre- and postbreak periods confirm the change in persistence from non-stationarity to stationarity at the estimated breakpoint. Our impression of an achievement of convergence only in the 1990s roughly corroborates the results by Halikias (1994), who base his analysis on long-term interest rates.

Convergence was achieved slightly later in the case of France: the breakpoint estimators indicate a transition from an $I(1)$ to an $I(0)$ process between March and September 1996. The decline in persistence is supported by the results from our subsample analysis, see Table 3. Again, the later convergence date is in line with the history of the EMS: while the Netherlands and later Belgium as small open economies followed a strict exchange rate target, such a strategy is less

sustainable and thus less credible for a large country as France. This became obvious in 1993, when interest rate cuts in France rose suspicion that the stability-oriented policy might be in danger, a fact that was one of the reasons for the 1993 EMS crisis (Gros & Thygesen, 1998). Furthermore the French policy sent some conflicting signals regarding budget consolidation (Von Hagen et al., 2001). Accordingly the achievement of credibility took comparatively long in the case of France, although it was obvious that a European Monetary Union without France would not be possible. Thus, for the three countries (Netherlands, Belgium and France) membership in EMU was already accepted by markets when the EMI published its convergence report in May 1998.

In contrast, the convergence date for *Italy* is the last one set: the switch to a stationary interest rate differential occurred as late as November or December 1998, just before EMU was launched. It is worth noting that all breakpoint estimates are very close to each other. Results in Table 3 support this type of change in persistence at this date of convergence. This image of Italy as a late riser which most observers agree upon, is in line with the discussions about Italy's membership in EMU. Italy had huge problems meeting the convergence criteria and had to implement "emergency measures" (Von Hagen et al., 2001) such as a temporary Euro tax on income, limited until 1997 (EMI, 1998). These problems led to an ongoing debate on Italy's participation in EMU. Back in April 1998, a few weeks prior to the publication of the EMI's convergence report, the Dutch government regarded the Italian membership as critical (Deutsche Bundesbank, 1998a), a view that was shared by the influential Deutsche Bundesbank as well (Deutsche Bundesbank, 1998b). And even the EMI's convergence report itself left some room for doubts.¹³ The summing up of our approach provides results that are in line with the conclusions one would draw from a narrative approach.

As expected, the results for our control group substantially differ. There is no break in persistence at all, with the interest rate differentials for the US and Denmark being $I(1)$, whereas it is $I(0)$ for the UK. The non-existence of a change in persistence indicates that no convergence was reached for these countries during the sample period. In particular, interest rates have not converged between the US (and Denmark) and Germany, while the experience of the UK is different. The results therefore corroborate our results for the later EMU members.

6. Conclusions and policy implications

In this paper the convergence of short-term interest rates in the EMS is investigated by applying a recently proposed framework for changing persistence. Our approach allows estimating when the switch from non-stationary to stationary interest rate differentials has occurred, i.e. convergence (in the spirit of Caporale & Pittis, 1995) has been achieved. The convergence dates have been very different for the analyzed countries. It seems that the main factors driving interest rate convergence between the respective countries and Germany were the coordination of budgetary and monetary policy leading to stable exchange rates in the run-up to EMU.

Besides this historical perspective our results are important for both the current financial crisis and the accession of new members to EMU.

¹³ "Notwithstanding the efforts and the substantial progress made toward improving the current fiscal situation, there must be an ongoing concern as to whether the ratio of government debt to GDP will be 'sufficiently diminishing and approaching the reference value at a satisfactory pace' and whether sustainability of the fiscal position has been achieved." EMI (1998, p. 158).

Regarding the current crisis of the EMU, the literature stresses the role of fiscal coordination between member countries (Andersen & Chiriaeva, 2007; Demopoulos & Yannacopoulos, 2001; Issing, 2011; Marattin, Marzo, & Zagaglia, 2011) and it is exactly fiscal measures that we find to coincide with achieving convergence. In contrast to fiscal measures taken by the governments, we find policy announcements, such as the ECOFIN meeting in Mondof-Le-Bains, the EMI report from March 1998 and the meeting of the EU council in May 1998 less influential. This is an analogy to the view on the current crisis that “uncertainty about compliance of countries to respect deficit ceilings is important, more than whether they actually respect the SGP ceiling” (Ferré, 2008).

Our analysis, although dealing with a historical setting, provides useful policy implications: the 1998 evolution of interest rate convergence mirrors the situation in the European sovereign debt crisis that jeopardized the existence of EMU in the aftermath of the 2008 burst of the real estate bubble. While we observed a partly gradual, but mostly stepwise convergence of interest rates in the run-up to EMU, the 2009 crisis was characterized by divergent interest rates and widening spreads between the core members of EMU and the periphery. Again Germany was found to be in the center and again the literature suggests that fiscal policy was driving the process.

Our view that fiscal policy has played a dominant role in the run-up to EMU corroborates with similar results for the recent crisis (see e.g. Maltritz, 2012; Bernoth, von Hagen, & Schuknecht, 2012; Constantini, Fragetta, & Melina, 2014). Bernoth and Erdogan (2012) come to a similar conclusion, but only after the crisis has begun. They find evidence for time-variation in the importance of macroeconomic fundamentals and risk pricing as main determinants of government bond yield spreads. Constantini et al. (2014) consider a multi-country panel approach with possible breaks to study the determinants of spreads in the EMU. Beside fiscal imbalances, liquidity risks they find the membership to an optimal currency area to be of major importance. Closely related to our original approach, Sibbertsen, Wegener, and Basse (2014) consider the case of increasing persistence by using the test by Sibbertsen and Kruse (2009) and find some evidence for breaks between 2006 and 2008. They interpret their results in the light of increased sovereign credit risk and suggest a link to the debt crisis in the Euro Area.

Regarding the accession of new member countries our results suggest that convergence with the Euro area has to be achieved before the entry to the Euro system is determined and support the view by Bini-Smaghi and Del Giovane (1996). Again, as for the existing members of EMU the perception by market participants is more important than formal obligations and should therefore be in the focus of the political process. Markets expect national policies, in particular fiscal and budgetary policy, to coordinate. If markets doubt about this monetary integration will not take place.

Appendix.

The CUSUM of squares-based test proposed by Leybourne et al. (2007) is described in the following. Their test statistic R is given by

$$R = \frac{\inf_{\tau \in \Lambda} K^f(\tau)}{\inf_{\tau \in \Lambda} K^r(\tau)}$$

where $K^f(\tau)$ and $K^r(\tau)$ are CUSUM of squares-based statistics. They are based on the forward and reversed residuals of the data generating process as given below. In more detail, $K^f(\tau)$ and

$K^r(\tau)$ are given by $K^f(\tau) = \frac{1}{[\tau T]^2 \hat{\gamma}_0^f(\tau)} \sum_{t=1}^{[\tau T]} \hat{v}_{t,\tau}^2$ and $K^r(\tau) = \frac{1}{(T-[\tau T])^2 \hat{\gamma}_0^r(\tau)} \sum_{t=1}^{T-[\tau T]} \tilde{v}_{t,\tau}^2$. Here, $\hat{v}_{t,\tau}$ are the residuals from the OLS regression of y_t on a constant based on the observations up to $[\tau T]$.

This is $\hat{v}_{t,\tau} = y_t - \bar{y}(\tau)$ with $\bar{y}(\tau) = [\tau T]^{-1} \sum_{t=1}^{[\tau T]} y_t$. Similarly $\tilde{v}_{t,\tau}$ is defined for the reversed series

$z_t = y_{T-t+1}$. In addition, $\hat{\gamma}_0^f(\tau)$ and $\hat{\gamma}_0^r(\tau)$ are OLS variance estimators for $\Delta \hat{v}_{t,\tau}$ and $\Delta \tilde{v}_{t,\tau}$, respectively. Analogous expressions for the case of de-trending can be found in [Leybourne et al. \(2007\)](#).

The null hypothesis of a constant unit root process which translates to ‘no convergence’ in our application is rejected for large values of R in favor of the alternative which means ‘convergence’ at time $[\tau T] + 1$. Regarding the unknown breakpoint, [Leybourne et al. \(2007\)](#) prove the consistency of a breakpoint estimator under H_{10} which is given by $\hat{\tau}^r = \operatorname{arginf}_{\tau \in \Lambda} \frac{1}{(T-[\tau T])^2} \sum_{t=1}^{T-[\tau T]} \tilde{v}_{t,\tau}^2$

Note, that $\frac{1}{(T-[\tau T])^2} \sum_{t=1}^{T-[\tau T]} \tilde{v}_{t,\tau}^2$ is equal to the unstandardized backward statistic $K^r(\tau)$ (excluding the variance estimator $\hat{\gamma}_0^r(\tau)$). The simulation results in [Leybourne et al. \(2007\)](#) suggest that this estimator works well in small and moderate samples, see their Table VII.

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