Structural Breaks in Inflation Dynamics within the European Monetary Union

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Abstract

The aim of this paper is to shed some light on the effect of the European Monetary Union (EMU) on changing the dynamics of the inflation rates in its Member States.

Keywords: inflation rate, structural break, EMU.

1. Introduction

The European Central Bank (ECB) defines price stability "as a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) for the Euro area of below 2%"[1]. Emerson, Gros, Italianer, Pisani-Ferry, and Reichenbach (1992) emphasizes the fact that a high inflation rate is also more variable and uncertain and thus causes more relative price variability, leading to a less efficient price mechanism.

The question of interest centers around the way in which a countries decision to join the Economic and Monetary Union (EMU) changed its inflation rate dynamics. Theory unfortunately is quite unsure whether or not the creation of a monetary union between two or more states is likely to reduce or increase the variability or even the level of the inflation rate. Cooper and Kempf (2003) points out, that "a central bank under a monetary union will internalize the interdependence between countries and optimally choose a lower inflation rate" and he argues that a "central Bank governing the growth of money supply will optimally choose zero inflation." This is not the case with the ECB which targets at 2% so as to avoid the risk of deflation. It is thus not quite clear how a monetary union will affect the volatility and the level of the inflation rate.

An interesting approach to this question is taken by Holtemöller (2007). What he finds out via simulations of different interest rate rules is that the standard deviation of the home CPI inflation rate can be substantially reduced by joining a monetary union.

The effects of joining a monetary union on inflation rate variability depend on structural parameters like risk aversion, price flexibility, export demand elasticity, openness and shock correlations. Due to the fact that not all of these parameters are known and that their interaction as well has to be estimated, theory has some troubles establishing a sound theoretical model.

Caporale and Kontonikas (2009) estimate short-run and steady-state inflation uncertainty in 12 EMU countries and find a considerable degree of heterogeneity across EMU countries

[1]http://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html

in terms of average inflation and its degree of persistence. In a paper examining structural convergence of the inflation rates in EU countries, Palomba, Sarno, and Zazzaro (2009) try to answer the question if during the 1990s the inflation rate dynamics of EU countries become more similar. They find that convergence in time of inflation dynamics was only partly observable. In a paper studying core inflation and using an aggregated Euro Area inflation rate, Morana (2000) finds three regimes (roughly 1980—1984, 1984—1993 and 1993—2000) governing the core inflation rate.
Inquiring into the convergence properties of inflation rates among countries of the EMU, Busetti, Forni, Harvey, and Venditti (2007) find that from 1980—1997 there was convergence of inflation rates, but afterwards there is some diverging behavior.

2. Data

Inflation is measured as the logarithm of the monthly change in the HICP from 1.1990—3.2010. Countries included are Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, Spain, Sweden, and the United Kingdom.[2] The data is obtained from the OECD Statistics.[3]
The countries can be divided into three different groups: the EURO countries (Austria, Belgium, Estonia[4], France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and Slovenia)[5], EU members without ERM II (Exchange Rate Mechanism): the Czech Republic, Hungary, Poland, the United Kingdom and Sweden. Denmark stands on its own as a member of the EU and the ERM II, but not yet a member of the EMU.

[2] Latvia and Lithuania as well as Bulgaria and Romania are excluded due to data scarcity.
[3] http://www.oecd-ilibrary.org/content/data/data-00285-en
[4] although Estonia enters in 2011
[5] Cypria, Malta, Andorra, Monaco, San Marino and the Vatican are left out due their minor importance.

3. Methods

3.1. A Generalized Logistic Distribution

In econometrics, the logistic distribution is often used in income distributions and growth models. This is due to its longer tails and higher peak, which fits these problems somewhat better. The use of the generalized logistic distribution as we will use it in this paper is rather rare. Wong and Bian (2005) uses a GL distribution in a regression model with autocorrelated errors and assumes that they follow a GL distribution rather than a Student's t-distribution, as to model the fact that these are oftentimes leptokurtic and severely left or right skewed. A similar GL distribution is also used in Tolikas, Koulakiotis, and Brown (2007) who analyses extreme risk and value–at–risk in the German stock market, all though they don't use a shape parameter. Regarding inflation rates, the GL distribution is — to our best knowledge — only used in relationship with expected inflation. Batchelor and Orr (1988) use a logistic distribution (not its generalization) to model the distribution of mean expected inflation rates. We apply the general framework, as developed in Zeileis and Hornik (2007), to a more specific model, in this case by means of a GL distribution. Prior to that, we would like to give a short justification for the usage of the GL distribution. Regarding the data at hand, it was not possible to use the already existing method developed in Zeileis and Hornik (2007), since almost all inflation rates, with the notable exception of Greece, are not normally distributed and clearly exhibit asymmetric properties.

Therefore, a somewhat more flexible distribution had to be used. We needed a distribution exhibiting rather strong kurtosis and the property to be both left and right skewed. To serve this purpose, we use a generalization of the logistic distribution as defined in Johnson, Kotz, and Balakrishnan (1995). Its probability density is given by:

$$f(\pi|\theta, \sigma, \delta) = \frac{\frac{\delta}{\sigma} * \exp^{-\frac{\pi_i - \theta}{\sigma}}}{(1 + \exp^{-\frac{\pi_i - \theta}{\sigma}})^{(\delta+1)}} \tag{1}$$

with location (θ), scale (σ) and shape (δ). For δ=1 the distribution simplifies to the logistic distribution, for δ<1 it is skewed to the left and for δ>1 it is skewed to the right. The moments are given by:

$$E(\pi_i) = \theta + \sigma(\gamma(\delta) - \gamma(1)) \tag{2}$$

$$Var(\pi_i) = \sigma^2(\gamma'(\delta) + \gamma'(1)) \tag{3}$$

$$Skew(\pi_i) = \frac{\gamma''(\delta) - \gamma''(1)}{(\gamma'(\delta) + \gamma'(1))^{3/2}} \tag{4}$$

where $\gamma()$ is the digamma function and its derivatives.

The log-likelihood is given by:

$$\begin{aligned} l(\delta, \theta, \sigma, \pi) &= \log(\delta) - \log(\sigma) \\ &- \frac{1}{\sigma}(\pi - \theta) - (\delta + 1) \\ &* \log(1 + \exp^{-\frac{\pi - \theta}{\sigma}}) \end{aligned} \tag{5}$$

The resulting score function ($\psi()$) for the parameters (the derivatives of the log-likelihood) are given by:

$$\begin{aligned}
\psi(\pi_i, \delta) &= \frac{\delta l(\delta, \theta, \sigma; \pi)}{\delta \delta} \qquad (6)\\
&= \frac{1}{\delta} - \log(1 + \exp^{-\frac{\pi-\theta}{\sigma}})\\
\psi(\pi_i, \theta) &= \frac{\delta l(\delta, \theta, \sigma; \pi)}{\delta \theta} \qquad (7)\\
&= \frac{1}{\sigma} - (\delta + 1) * \frac{\frac{1}{\sigma}\exp^{-\frac{\pi-\theta}{\sigma}}}{(1 + \exp^{-\frac{\pi-\theta}{\sigma}})}
\end{aligned}$$

$$\begin{aligned}
\psi(\pi_i, \sigma) &= \frac{\delta l(\delta, \theta, \sigma; \pi)}{\delta \sigma} \qquad (8)\\
&= -\frac{1}{\sigma} + \frac{1}{\sigma^2}(\pi - \theta) - (\delta + 1)\\
* & \quad \frac{\frac{1}{\sigma^2}(\pi - \theta)\exp^{-\frac{\pi-\theta}{\sigma}}}{(1 + \exp^{-\frac{\pi-\theta}{\sigma}})}
\end{aligned}$$

An enhancement to the already existing R package **strucchange**, which currently does not support a generalized logistic distribution (GL) is provided with this paper. The asymptotic testing theory still holds for this generalization. [Beweis]
The first part of the results we are going to present here, i.e., the tests and the graphical illustration of the empirical fluctuation process can be found in Zeileis and Hornik (2007). the second part of the results - the dating procedure and the illustration of the densities fitted for the subsamples (divided by the breaks) - ca be found in Zeileis, Shah, and Patnaik (2010).

3.2. Tests

We use the Cramér von Mises type test as given in Zeileis and Hornik (2007). The test statistic is given by:

For the determination of the numbers of breakpoints, we use the Supremum of LM statistics test and we further investigate into the optimal number of breakpoints using the LWZ criterion, see Zeileis *et al.* (2010) for further details. To get an idea about the goodness of fit of the GL distribution for a given subsample we also report values of the χ^2 goodness of fit test.

4. Results

To help with the interpretation, we give a short overview over the history of the EMU. Following the Delors Plan with his 3 stages, we have: stage I (1990-1994) as a phase of liberalization, stage II (1995-1998) a phase of convergence and stage III (1999-2002) the transition period, which ended with the introduction of the Euro as legal tender and started with the Exchange Rate Mechanism II (ERM II) for Non–members and the irrevocable fixing of exchange rates of Member States. If the EMU had a significant effect upon inflation rate volatility we would expect to find a break either in the 90ies, reflecting the various waves of integration or after the introduction of the Euro due to the popular argument that the introduction of Euro paper money led to a considerable price increase.

Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Austria	Feb 1990–Sep 2007	0.163	0.057	0.606	Jän 1995	–	Jän 1999
	Okt 2007–Mär 2010	0.173	0.163	0.169			
Belgium	Feb 1991–Dez 1999	0.146	0.064	−0.037	Mär 1979	–	Jän 1999
	Jän 2000–Mär 2010	0.177	0.954	0.504			
CzechRepublic	Feb 1995–Jul 1998	0.697	0.336	1.139	–	–	–
	Aug 1998–Mär 2010	0.182	0.216	0.990			
Denmark	Feb 1990–Jun 2000	0.166	0.091	−0.742	Mär 1979	Jän 1999	–
	Jul 2000–Mär 2010	0.168	0.188	1.047			
Estonia	Feb 1996–Mär 1998	0.865	0.420	0.404	–	Jun 2004	Jän 2011
	Apr 1998–Mär 2010	0.333	0.206	0.802			
Finland	Feb 1990–Mär 2010	0.165	0.132	0.280	Okt 1996	–	Jän 1999
France	Feb 1990–Dez 2004	0.159	0.058	0.196	Mär 1979	–	Jän 1999
	Jän 2005–Mär 2010	0.150	0.131	−0.794			
Germany	Feb 1995–Mai 2000	0.088	0.060	0.922	Mär 1979	–	Jän 1999
	Jun 2000–Dez 2004	0.140	0.164	0.992			
	Jän 2005–Mär 2010	0.142	0.184	−0.662			
Greece	Feb 1995–Mär 2010	0.323	1.480	0.431	Mär 1998	Jän 1999	Jän 2001
Hungary	Feb 1995–Mai 1998	1.606	1.024	0.878	–	–	–
	Jun 1998–Mär 2010	0.507	0.316	0.709			
Ireland	Feb 1995–Mär 2008	0.255	0.205	−0.696	Mär 1979	–	Jän 1999
	Apr 2008–Mär 2010	−0.131	0.184	−0.995			
Italy	Feb 1990–Mai 1996	0.414	0.041	0.963	Mär 1979	–	Jän 1999
	Jun 1996–Dez 2000	0.168	0.020	0.726			
	Jän 2001–Mär 2010	0.182	0.321	−0.261			
Luxembourg	Feb 1995–Dez 1998	0.088	0.013	0.261	Mär 1979	–	Jän 1999
	Jän 1999–Mär 2010	0.224	0.531	−0.484			
Netherlands	Feb 1990–Mär 2010	0.185	0.293	0.598	Mär 1979	–	Jän 1999
Poland	Feb 1996–Mai 2001	0.855	0.421	0.668	–	–	–
	Jun 2001–Mär 2010	0.202	0.123	−0.315			
Portugal	Feb 1990–Jul 1992	0.852	0.172	1.139	Apr 1992	–	Jän 1999
	Aug 1992–Mär 2004	0.270	0.105	0.865			
	Apr 2004–Mär 2010	0.161	0.256	0.569			
Slovakia	Feb 1995–Apr 1997	0.480	0.058	1.139	–	Nov 2005	Jän 2009
	Mai 1997–Feb 2004	0.587	0.442	1.140			
	Mär 2004–Mär 2010	0.186	0.089	1.139			
Slovenia	Feb 1996–Jul 2003	0.631	0.211	0.588	–	Jun 2004	Jän 2007
	Aug 2003–Mär 2010	0.244	0.344	0.143			
Spain	Feb 1992–Mai 1996	0.372	0.070	1.139	Jun 1986	–	Jän 1999

	Jun 1996–Dez 2000	0.200	0.040	0.019			
	Jän 2001–Mär 2010	0.223	0.342	−0.362			
Sweden	Feb 1990–Jän 1993	0.475	0.572	1.139	–	–	–
	Feb 1993–Mär 2010	0.155	0.185	0.534			
UnitedKingdom	Feb 1990–Apr 1992	0.570	0.387	1.139	–	–	–
	Mai 1992–Mär 2010	0.162	0.149	−1.265			

4.1. Belgium and Luxembourg

On the basis of these results, we are able to trace out different groups. The first of this group consits of Belgium and Luxembourg. This may come as no surprise since both countries formed a monetary union prior even to the start of the European Rate Mechanism (ERM). While both countries enjoyed very stable inflation rates with low values of both mean and variance, this changed around the timing of the irrevocable fixing of the exchange rates. A causal connection to this events seems likely.

Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Belgium	Feb 1991–Dez 1999	0.146	0.064	−0.037	Mär 1979	–	Jän 1999
	Jän 2000–Mär 2010	0.177	0.954	0.504			
Luxembourg	Feb 1995–Dez 1998	0.088	0.013	0.261	Mär 1979	–	Jän 1999
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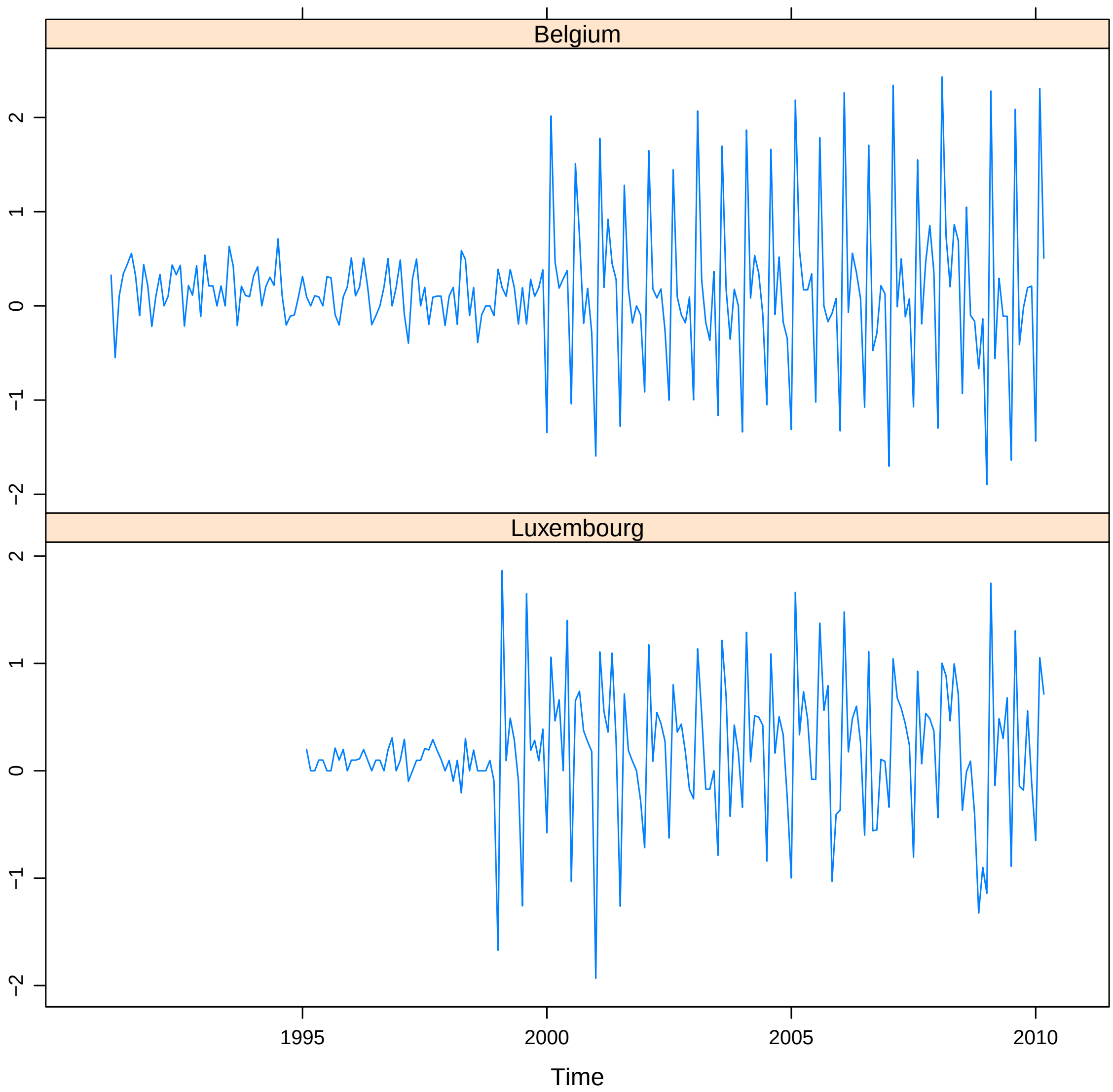

4.2. The Eastern Countries

The second of these groups are the Eastern European Countries, the Czech Republic, Estonia, Hungary, Poland, Slovakia and Slovenia. In all of these countries, the mean and the variance of their inflation rates declined in the later part of the 90ies. Most of them experienced a break in 1997/1998, with Poland, Slovakia and Slovenia somewhat later.

Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Estonia	Feb 1996–Mär 1998	0.865	0.420	0.404	–	Jun 2004	Jän 2011
	Apr 1998–Mär 2010	0.333	0.206	0.802			
Hungary	Feb 1995–Mai 1998	1.606	1.024	0.878	–	–	–
	Jun 1998–Mär 2010	0.507	0.316	0.709			
Poland	Feb 1996–Mai 2001	0.855	0.421	0.668	–	–	–
	Jun 2001–Mär 2010	0.202	0.123	−0.315			
Slovakia	Feb 1995–Apr 1997	0.480	0.058	1.139	–	Nov 2005	Jän 2009
	Mai 1997–Feb 2004	0.587	0.442	1.140			
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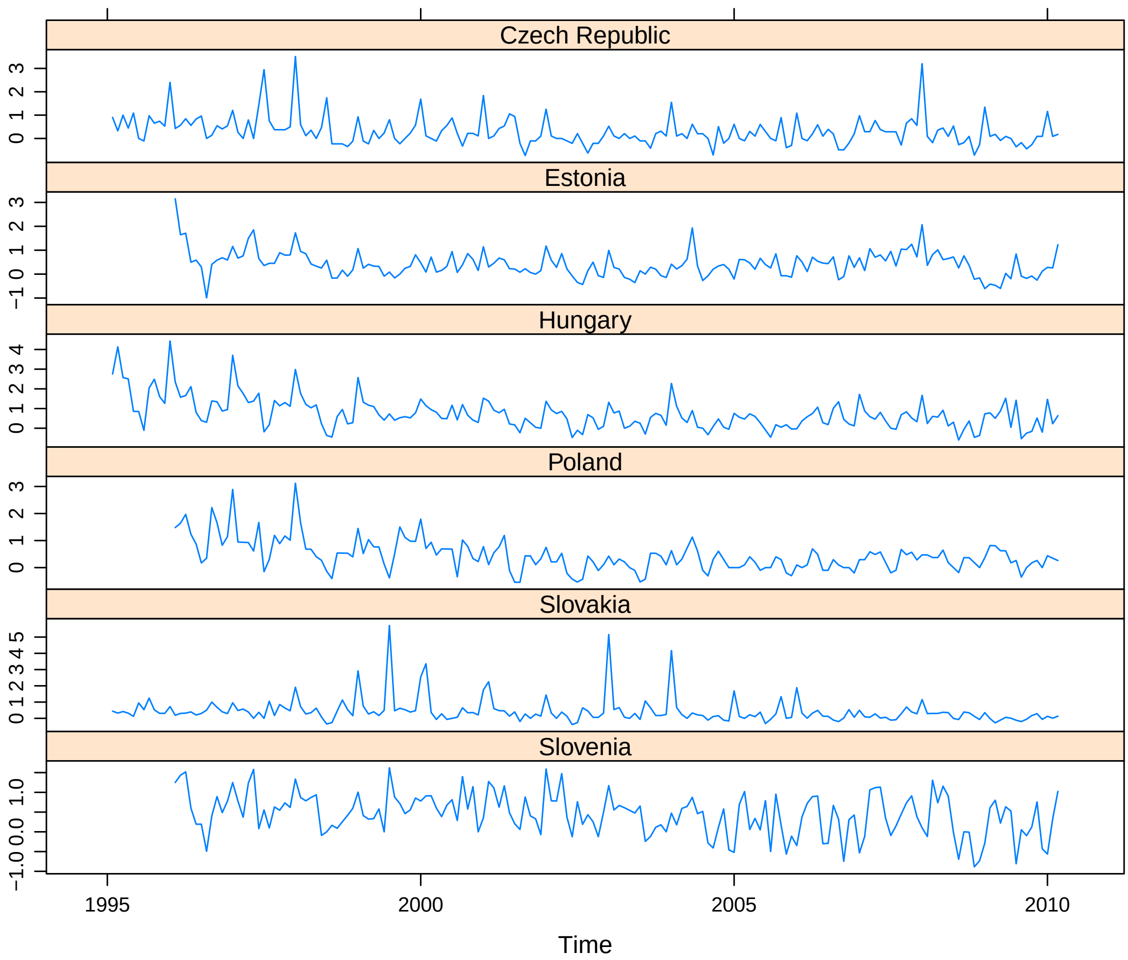
	Aug 2003–Mär 2010	0.244	0.344	0.143			



4.3. Italy and Spain

Another combination of countries with – this time – identical results are the two biggest southern European countries Italy and Spain. Both of them experienced high rates of inflation in the early 90ies. Afterwards, in the phase leading up to the monetary union, mean and variance were significantly reduced. This trend changed drastically soon after the fixing of the exchange rates leading to higher mean and much higher variances then ever before since the beginning of the HICP series.

Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Italy	Feb 1990–Mai 1996	0.414	0.041	0.963	Mär 1979	–	Jän 1999
	Jun 1996–Dez 2000	0.168	0.020	0.726			
	Jän 2001–Mär 2010	0.182	0.321	−0.261			
Spain	Feb 1992–Mai 1996	0.372	0.070	1.139	Jun 1986	–	Jän 1999
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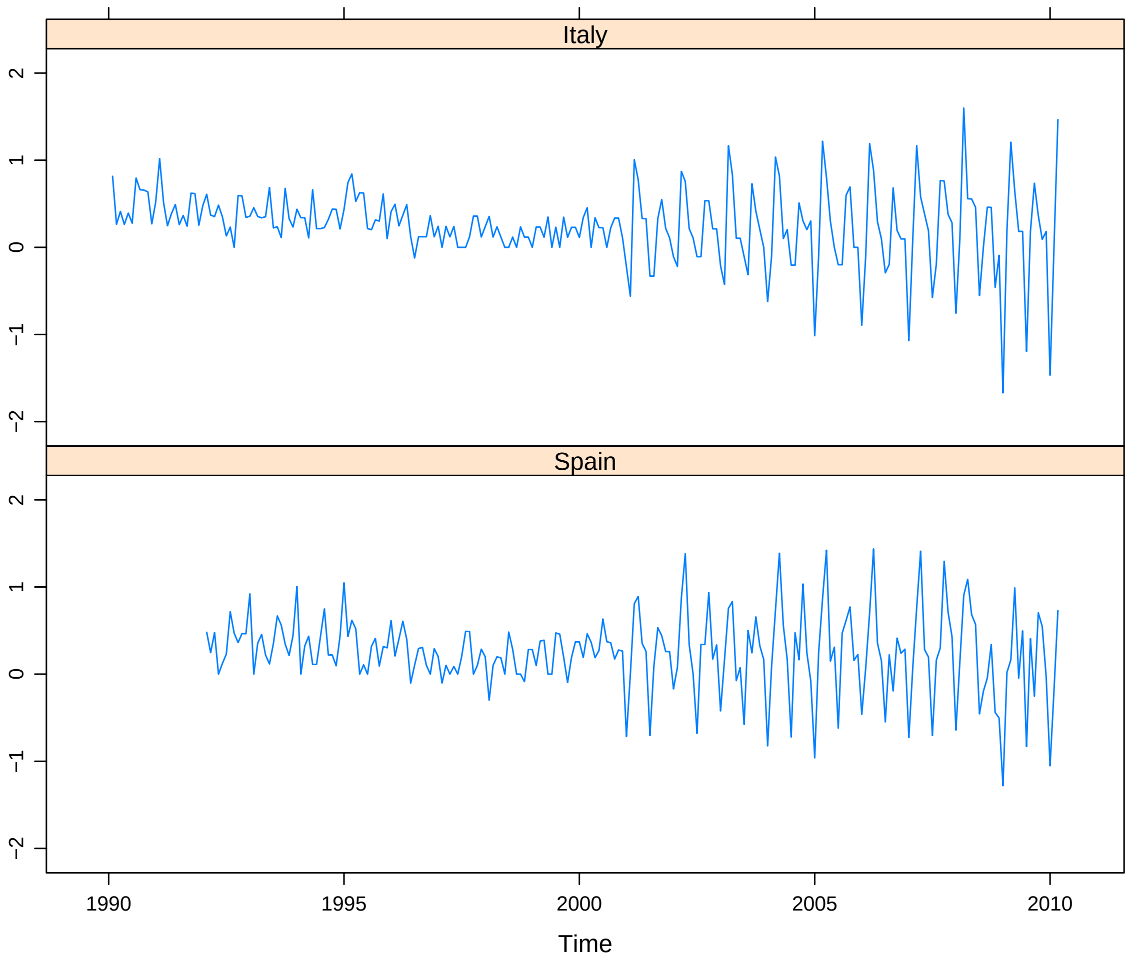
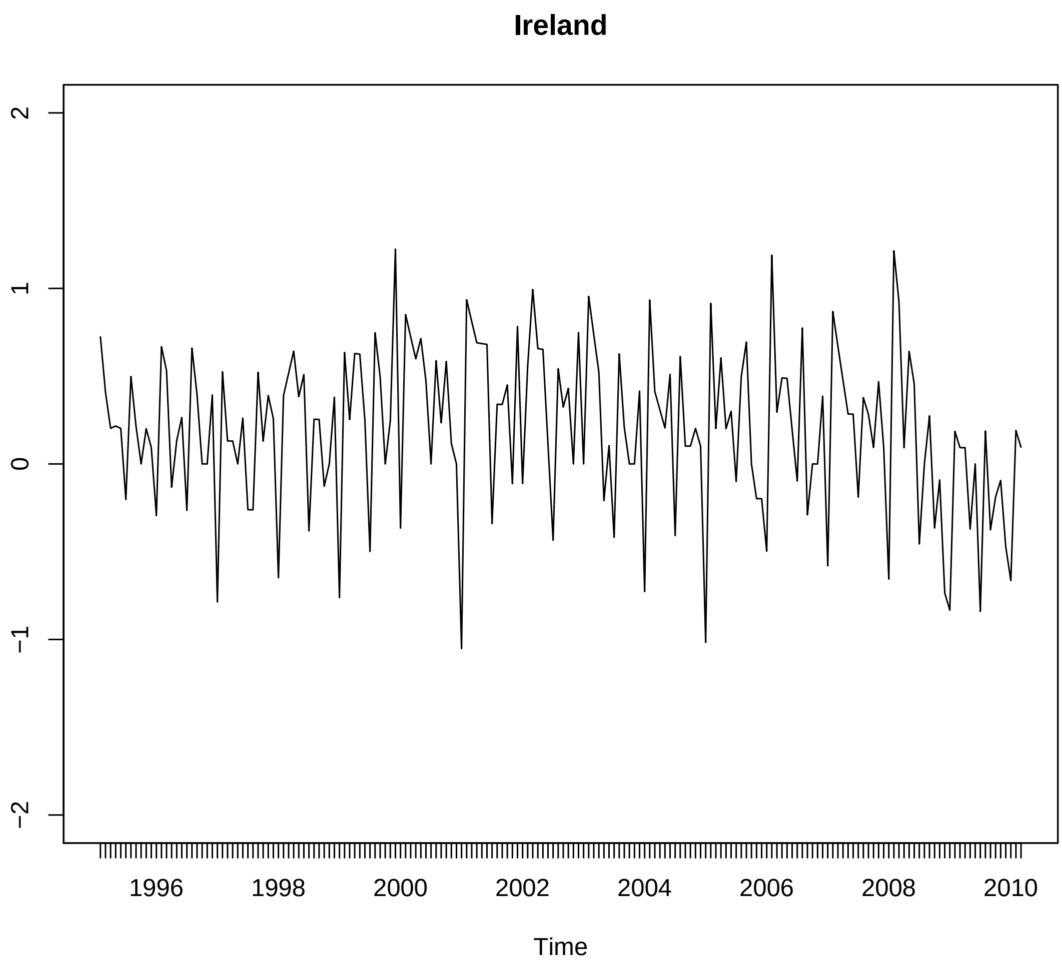


4.4. Ireland

Ireland can be considered a rather special case. It is the only economy where the effects of the ongoing financial crisis of 2008 are visible. We find a structural break in 2008 following the strong contraction of the Irish housing bubble and a beginning deflation.

Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Ireland	Feb 1995–Mär 2008	0.255	0.205	−0.696	Mär 1979	–	Jän 1999
	Apr 2008–Mär 2010	−0.131	0.184	−0.995			



4.5. No change countries

Another interesting group consists of 3 economically very different countries. In all of them we find no evidence of a structural change. Whereas the Netherlands and Finland are both on the lower side of the inflation margin, Greece exhibits some very strange behaviour. It has by far the highest variance of all series and seems to be completely different from all the others, just like some randomly generated series.

Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Greece	Feb 1995–Mär 2010	0.323	1.480	0.431	Mär 1998	Jän 1999	Jän 2001
Netherlands	Feb 1990–Mär 2010	0.185	0.293	0.598	Mär 1979	–	Jän 1999
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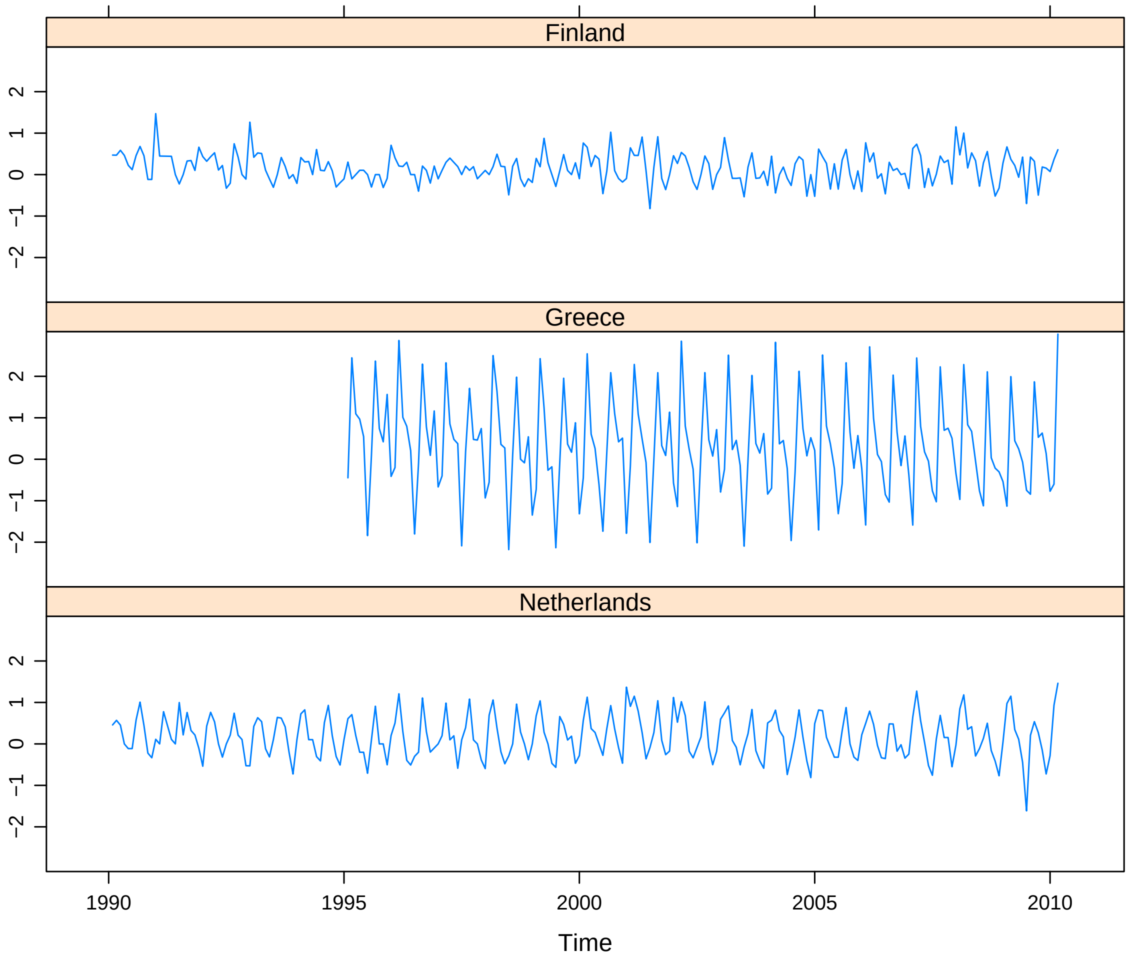
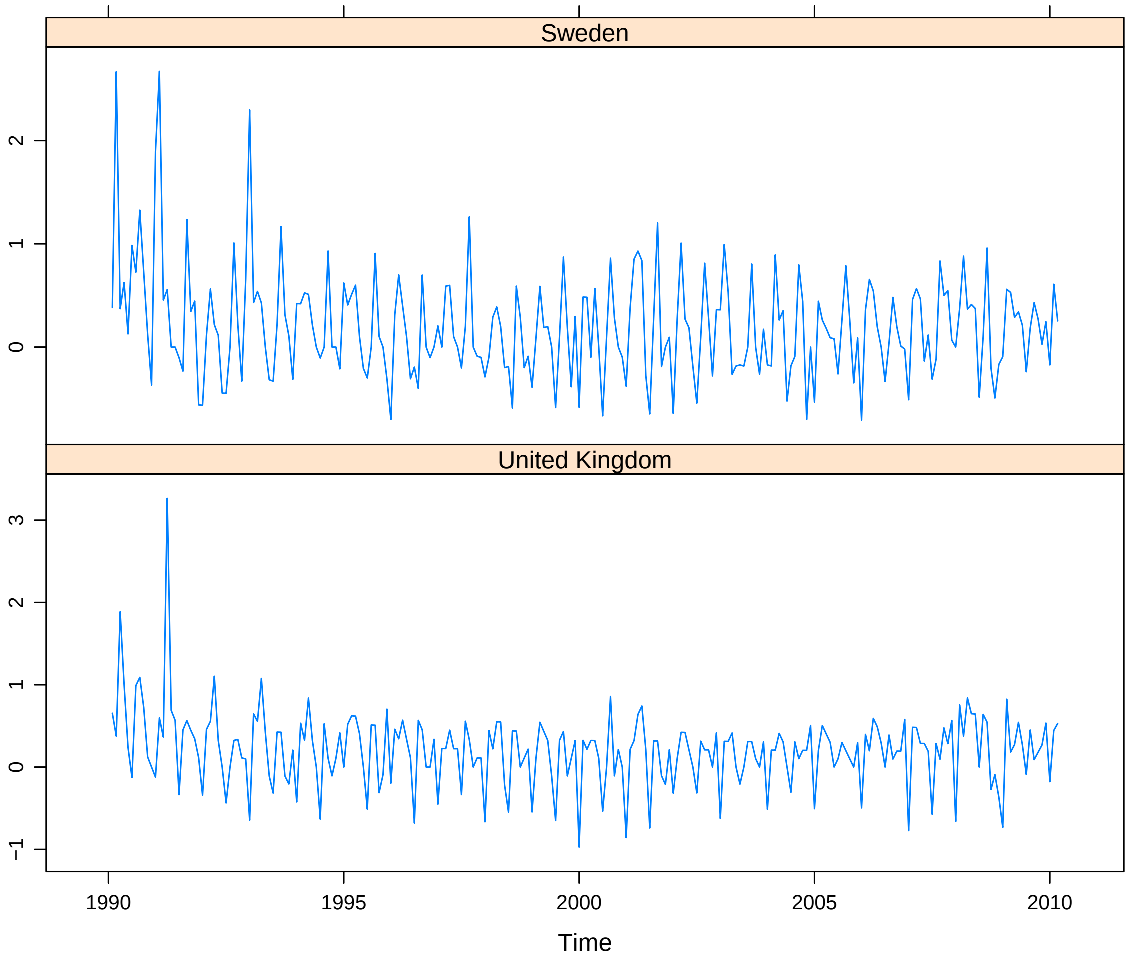


4.6. The Non–participating Countries

The last group with clear patterns can be seen with the two countries that decided not to be part of any European Monetary System[6], the United Kingdom and Sweden. Both have a clear break in the early 90ies, and both of these breaks can be traced back to crisis, the currency crisis of the United Kingdom with the "'Black Wednesday"' in September 1992 and the run on the Swedish currency in 1992.

Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Sweden	Feb 1990–Jän 1993	0.475	0.572	1.139	–	–	–
	Feb 1993–Mär 2010	0.155	0.185	0.534			
UnitedKingdom	Feb 1990–Apr 1992	0.570	0.387	1.139	–	–	–
	Mai 1992–Mär 2010	0.162	0.149	−1.265			



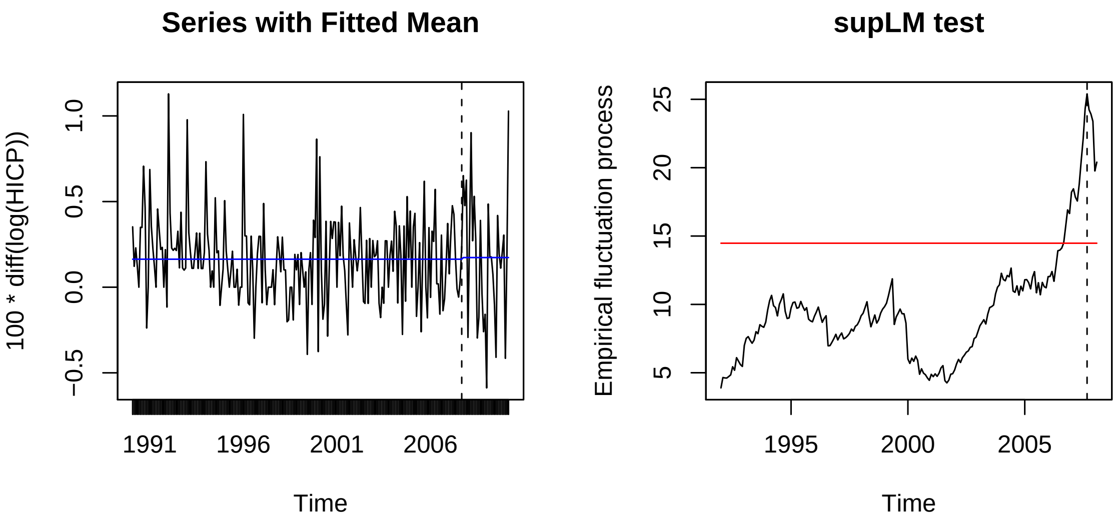
[6]If we ignore the short participating time of the United Kingdom in the EMS

4.7. The Other Countries

No clear message is available for: Denmark, France, Germany and Portugal.

Austria

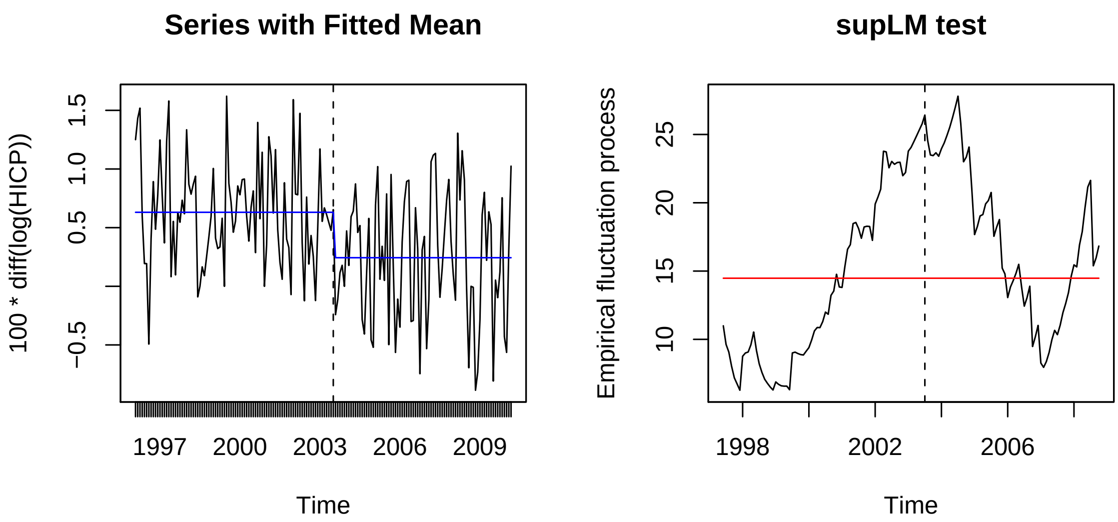
Lets consider a few countries in broader detail to get an idea about what happened. In Austria we see evidence of a change in the inflation rate, when the old regime ended in September 2007. The new regime is much more volatile, with an almost threefold increase in variance.



The reason for this is a strong increase in the yearly Austrian inflation rate following a heavy increase in oil price which was further amplified by a rise of mineral taxes. However, we fail to find any evidence for an incrase in mean or volatility of the Austrian rate following the introduction of the Euro paper money.

Slovenia

Lets consider Slovenia as the first Eastern European country that introduced the Euro. In August 2003 the new regime started with a much lower mean value (only a third now of its previous value) and interestingly enough, a higher volatility.



Slovenia is a good example of the benefits of an early Euro adoption. Its efforts to meet the criterias as set forth in the Maastricht treaty were successfull, actually Slovenia reached them in 2005. So from 2003 onwards inflation was lower but with a much higher variance. Regarding the dating in 2003, we have to keep in mind that this was the year where most of the financial reforms were introduced. Slovenia seems to be the only case where the introduction of the Euro was followed by an increase in yearly inflation, which faded away following the financial crises and its deflationary effects.

4.8. Alternative Explanations

Another possible explanation pattern could be the growth in the money supply. A drawback is the current lack of data[7]. But for some countries we can find some plausible findings. Regarding the case of Denmark, the M1 money supply started contracting in June 2000 (on a monthly base). In Estonia we find the highpoint in M3 expansion ending with March 1998, with much lower M3 growth rates afterwards. The same happended to Hungary in April and May 1998. In the Polnish case we find a severe contraction of the money supply in May 2001. Similar findings hold true for Germany as well.
In Spain we see a stronger increase in M1 in May and June 1996 (nothing for the other break, data scarceity). In Portugal we find a modest increase in year on year M1 money supply growth starting in July 1992. We find nothing peculiar for Slovakia and Hungary. In Estonia the M1 money supply starts to contract severely on a yearly base following March 1998. In Slovenia we find a contraction of the Money Supply in July 2003, with the whole year 2003 witnessing a sharp decrease in the year on year growth. Poland starts contracting the year on year M1 money supply after June 2000 with very low growth rates till January 2002.

Concerning monetary unions, it is interesting to notice that Belgium and Luxembourg, that constituted a monetary union prior to the European Monetary Union, did not experience the same timing in their break towards a higher mean and a significantly higher volatility regime.

With regard to the alleged benefit of monetary unions, the import of credibility to former high inflation countries (like Italy and Spain), did nothing to decrease their mean or volatility, rather to the contrary. Spain and Italy did have a – rather – low mean low volatility regime from 1996:6 to 2000:12 but then things changed towards higher volatility. It appears as if both countries tried to decrease inflation prior to the fixing of the exchange rates and let go afterwards.

Following the reasoning of a study by Duarte and Wolman (2008), high volatility of inflation rates within regions of a union may be explained a countries decision to lower the inflation differential by means of fiscal policy. This explanation might fit to Spain and Italy, both were above the the average EU inflation.

[7] hopefully to be solved

5. Conlcusion

References

Batchelor RA, Orr AB (1988). "Inflation Expectations Revisited." *Economica*, **55**(219), 317–331.

Busetti F, Forni L, Harvey A, Venditti F (2007). "Inflation Convergence and Divergence within the European Monetary Union." *International Journal of Central Banking*, **3**(2), 95–121.

Caporale GM, Kontonikas A (2009). "The Euro and inflation uncertainty in the European Monetary Union." *Journal of International Money and Finance*, **28**(6), 954–971.

Cooper R, Kempf H (2003). "Commitment and the Adoption of a Common Currency." *International Economic Review*, **44**(1), 119–142.

Duarte M, Wolman AL (2008). "Fiscal policy and regional inflation in a currency union." *Journal of International Economics*, **74**, 384–401.

Emerson M, Gros D, Italianer A, Pisani-Ferry J, Reichenbach H (1992). *One Market, One Money, An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union*. Oxford University Press.

Holtemöller O (2007). "The Effects of Joining a Monetary Union on Output and Inflation Variability in Accession Countries." *MPRA Paper*, (8633).

Johnson NL, Kotz S, Balakrishnan N (1995). *Continuous Univariate Distributions, Volume 2*. 2nd edition. John Wiley & Sons.

Morana C (2000). "Measuring Core Inflation in the Euro Area." *ECB Working Paper*, (36).

Palomba G, Sarno E, Zazzaro A (2009). "Testing Similarities of Short-Run Inflation Dynamics among EU-25 Countries after the Euro." *Empirical Economics*, **37**(2), 231–270.

Tolikas K, Koulakiotis A, Brown RA (2007). "Extreme Risk and Value-at-Risk in the German Stock Market." *The European Journal of Finance*, **13**(4), 373–395.

Wong WK, Bian G (2005). "Estimating Parameters in Autoregressive Models with Asymmetric Innovations." *Statistics & Probability Letters*, **71**(1), 61–70.

Zeileis A, Hornik K (2007). "Generalized M-Fluctuation Tests for Parameter Instability." *Statistica Neerlandica*, **61**(4), 488–508.

Zeileis A, Shah A, Patnaik I (2010). "Testing, Monitoring, and Dating Structural Changes in Exchange Rate Regimes." *Computational Statistics & Data Analysis*, **54**(6), 1696–1706.

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