Structural Breaks in Inflation Dynamics within the European Monetary Union

Thomas Windberger, Achim Zeileis

`http://glogis.R-Forge.R-project.org/`

Overview

- Introduction
- Data
- Model
- Example
- Results
- Conclusion

Introduction

- Did EMU change inflation dynamics ?
- Economic Reasons
  - Former COMECON countries
  - Ex–Jugoslavia
  - Southern European countries
  - Central European countries

Data

- 21 monthly HICP series, unadjusted
- Source: OECD Statistics
- 3 groups
  - EURO countries
  - EU members withouth ERM II
  - Others

Model

- Actually some alternatives
  - ARIMA
  - GARCH
- Our model

Generalized Logistic Distribution (GL)

For series $y = 100 \cdot log(HICP_t / HICP_{t-1})$ we assume a GL–distribution given by:

$$f(y|\theta,\sigma,\delta) = \frac{\frac{\delta}{\sigma} \cdot \exp^{-\frac{y-\theta}{\sigma}}}{(1+\exp^{-\frac{y-\theta}{\sigma}})^{(\delta+1)}}$$

with location θ, scale σ and shape δ.
Moments:

$$\begin{aligned} E(y) &= \theta + \sigma(\psi(\delta) - \psi(1)) \\ VAR(y) &= \sigma^2(\psi'(1) + \psi'(\delta)) \\ SKEW(y) &= \frac{\psi''(\delta) - \psi''(1)}{(\psi'(1) + \psi'(\delta))^{\frac{3}{2}}} \end{aligned}$$

Framework

3–dimensional parameter $\phi = (\theta, \sigma, \delta)$:

$$H_0 : \phi_i = \phi_0 \ (i = 1, ..., n)$$
$$\underset{\phi \in \Phi}{argmin} \sum_{t=1}^{n} \log f(y_t|\phi) = \hat{\phi},$$
$$\sum_{t=1}^{n} s(y_t|\hat{\phi}) = 0$$

Empirical scores $s(y_t|\hat{\phi})$ to examine changes

Scores

3 components, $s() = (s_\theta, s_\sigma, s_\delta)$:

$$
\begin{aligned}
s_\theta(y|\theta,\sigma,\delta) &= \frac{\delta \log f(y|\theta,\sigma,\delta)}{\delta\theta} \\
&= \frac{1}{\sigma} - (\delta+1)\cdot\frac{\frac{1}{\sigma}\exp^{-\frac{y-\theta}{\sigma}}}{(1+\exp^{-\frac{y-\theta}{\sigma}})} \\
s_\sigma(y|\theta,\sigma,\delta) &= \frac{\delta \log f(y|\theta,\sigma,\delta)}{\delta\sigma} \\
&= -\frac{1}{\sigma} + \frac{1}{\sigma^2}(y-\theta) - (\delta+1) \\
&\times \quad \frac{\frac{1}{\sigma^2}(y-\theta)\exp^{-\frac{y-\theta}{\sigma}}}{(1+\exp^{-\frac{y-\theta}{\sigma}})}
\end{aligned}
$$

$$
\begin{aligned}
s_\delta(y|\theta,\sigma,\delta) &= \frac{\delta \log f(y|\theta,\sigma,\delta)}{\delta\delta} \\
&= \frac{1}{\delta} - \log(1+\exp^{-\frac{y-\theta}{\sigma}})
\end{aligned}
$$

Empirical Fluctuation Process

The empirical fluctuation process $efp(\cdot)$:

$$efp(t) = \hat{V}^{-1/2} n^{-1/2} \sum_{i=1}^{\lfloor nt \rfloor} s(y_t | \hat{\theta}, \hat{\sigma}, \hat{\delta}) \; (0 \leq t \leq 1),$$

$$efp(\cdot) \xrightarrow{d} W^0(\cdot)$$

Functional Central Limit Theorem (FCLT) for $efp(\cdot)$

Test

Supremum of LM statistics:

$$\sup_{t \in [0.1, 0.9]} \frac{\| efp(t) \|_2^2}{t(1-t)}$$

p–values can be computed from:

$$\sup_{t \in [0.1, 0.9]} \frac{\| W^0(t) \|_2^2}{t(1-t)}$$

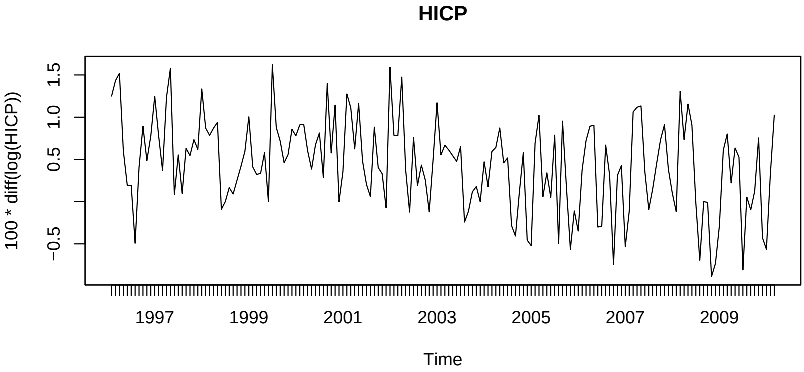
Breakpoint Estimation

- If instability detected, estimate $B \in [1, 6]$ breakpoints $\tau_1, ..., \tau_B$ via maximization of full segmented likelihood:

$$\sum_{b=0}^{B} \sum_{t=\tau_b+1}^{\tau_b} loglik(y_t | \theta^{(b)}, \sigma^{(b)}, \delta^{(b)})$$

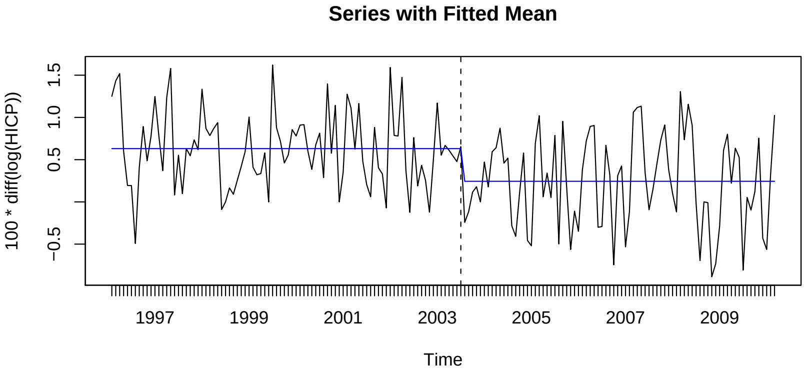
- Estimate models with B breakpoints; select best via modified BIC

Slovenia



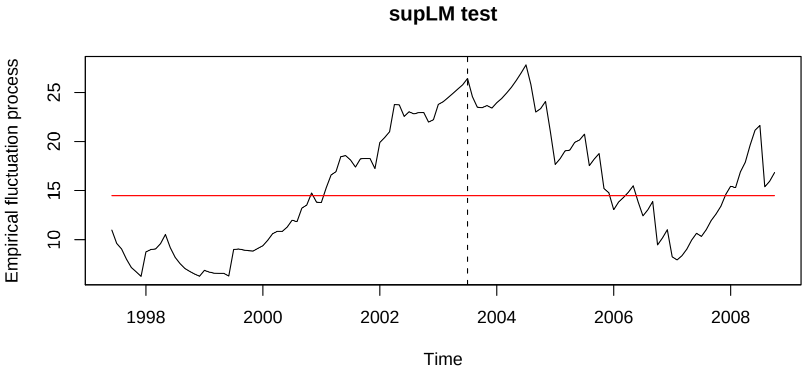
HICP
1.5
1.0
0.5
−0.5
100 * diff(log(HICP))
1997
1999
2001
2003
2005
2007
2009
Time

Slovenia



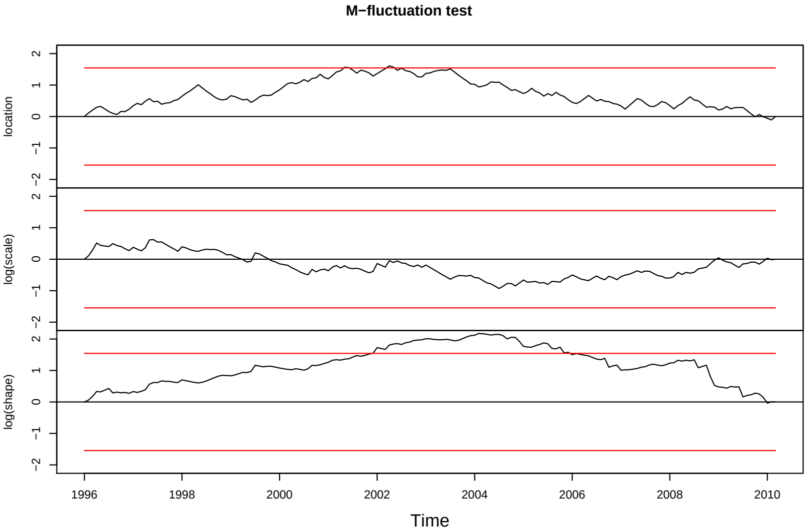
Series with Fitted Mean
100 * diff(log(HICP))
−0.5
0.5
1.0
1.5
1997
1999
2001
2003
2005
2007
2009
Time

Test

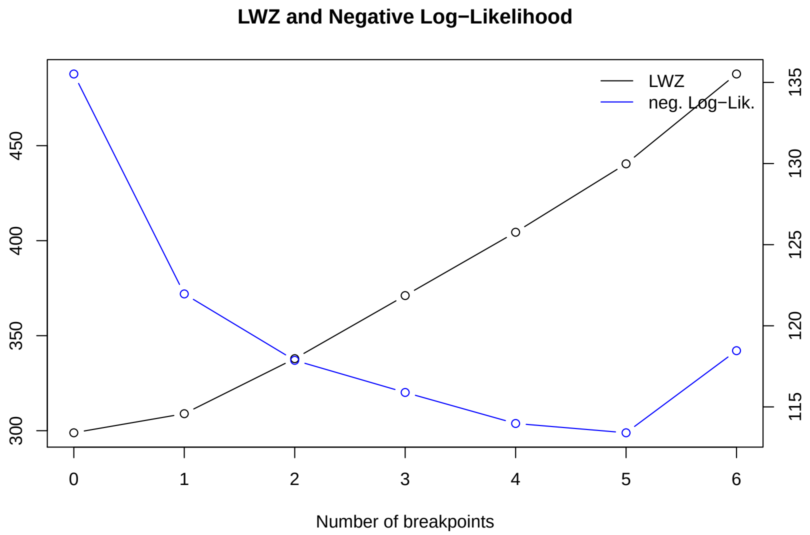


supLM test
Empirical fluctuation process
10
15
20
25
1998
2000
2002
2004
2006
2008
Time

Moment changes



Breakpoint Selection



Slovenia–Fitted Model

Economic Interpretation:

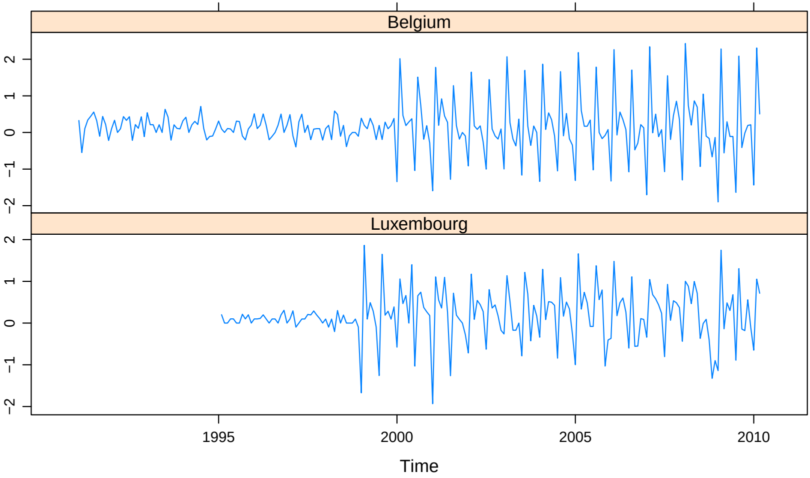
- had to reach Maastricht criteria
  - low inflation rate ($<$ 1.5 percentage points higher than average of 3 best performing)
  - deficit no higher than 3% of GDP
  - gross government debt $< 60\%$ of GDP
  - no devaluation in ERM II
- most reforms regarding financial sector introduced in 2003
- strong contraction in money supply (M1) starting in 2003
- from 2003 onwards much lower mean, but higher variance
- entered ERM II in June 2004; declared ready to join by ECB in May 2006

Results

Some countries follow very similar patterns

- Eastern countries: Czech Republic, Estonia, Hungary, Poland and possibly Slovakia
- Belgium and Luxembourg
- Italy and Spain
- Ireland
- No change countries: Finland, Greece, Netherlands
- Further results

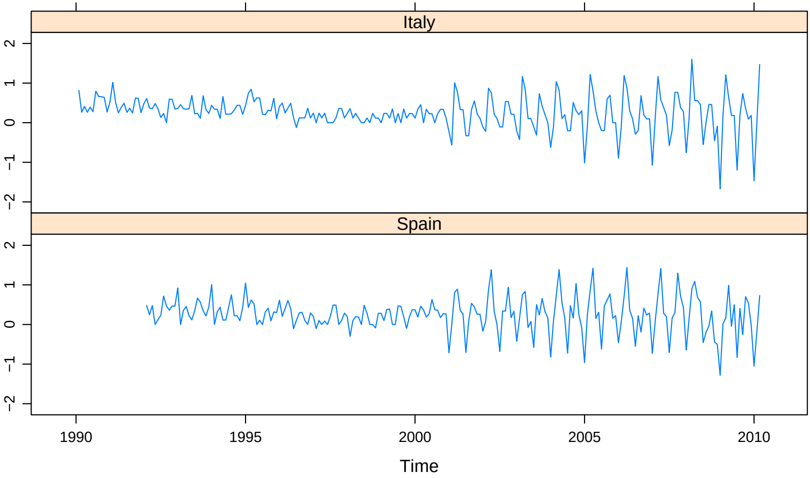
Belgium and Luxembourg



Belgium and Luxembourg

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
	Jän 1999–Mär 2010	0.224	0.531	−0.484			

Italy and Spain

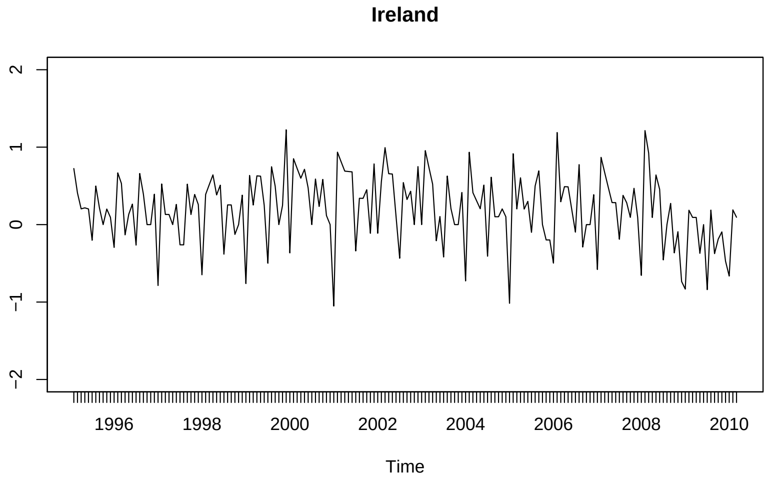


Italy and Spain

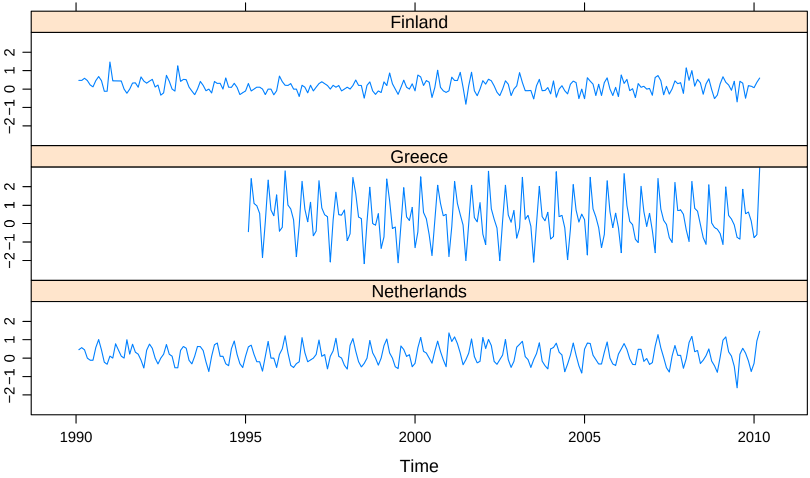
Country	Segment	Mean	Variance	Skewness	ERM	ERM II	EURO
Italy	Feb 1990–Mai 1996	0.414	0.041	0.963	Mär 1979	–	Jän 1999
	Jun 1996–Dez 2000	0.168	0.020	0.726			
	Jän 2001–Mär 2010	0.182	0.321	−0.261			
Spain	Feb 1992–Mai 1996	0.372	0.070	1.139	Jun 1986	–	Jän 1999
	Jun 1996–Dez 2000	0.200	0.040	0.019			
	Jän 2001–Mär 2010	0.223	0.342	−0.362			

Ireland

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			



No change countries



No change countries

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
Finland	Feb 1990–Mär 2010	0.165	0.132	0.280	Okt 1996	–	Jän 1999

Conclusion

- Stabilizing Effect of EURO
- Overall lowering in mean inflation rates
- Overall increase in volatility

HICP

First step: local sub–index of a specific price collected item R^t_{iy}:

$$R^t_{iy} = \frac{(\prod_{j=1}^n p^t_{iyj})^{1/n}}{(\prod_{j=1}^n p^0_{iyj})^{1/n}}$$

Second step: sub–index for whole country R^t_i:

$$R^t_i = \sum_{y=1}^m R^t_{iy} G_y$$

$$R_h^{t,T} = R_h^{12,T-1} \left[\frac{\sum_{i=1}^q w_i^T R_i^t / R_i^{12,T-1}}{\sum_{i=1}^q w_i^T} \right]$$

Third step: weighted average of all included individual subindices:

$$HICP_t = \sum_{i=1}^n \gamma_i R_h^{t,T}$$