Structural Breaks in Inflation Dynamics within the European Monetary Union

Thomas Windberger, Achim Zeileis

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

Overview

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

Introduction and Data

- Did European Monetary Union (EMU) change inflation dynamics?
- Economic reasons
  - Former Council for Mutual Economic Assistance (COMECON) member states
  - Ex–Yugoslavia countries
  - Southern European countries
  - Central European countries
- 21 monthly unadjusted Harmonised Index of Consumer Prices (HICP) series
- Source: OECD Statistics
- 3 groups
  - EURO countries
  - EU members without Exchange Rate Mechanism II (ERM II)
  - ERM II countries

Model

- Some alternatives
  - ARIMA
  - GARCH
  - Multivariate models
- Our model
  - Investigate changes in mean, variance and skewness over time
  - Not interested in correlation structure

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

Estimate:

$$\underset{\phi \in \Phi}{argmin} \sum_{t=1}^{n} \log f(y_t|\phi) = \hat{\phi},$$

$$\sum_{t=1}^{n} s(y_t|\hat{\phi}) = 0$$

Assuming $\phi = (\theta, \sigma, \delta)$ is constant:

$$H_0 : \phi_i = \phi_0 \; (i = 1, ..., n)$$

Use empirical scores $s(y_t|\hat{\phi})$ for testing

Scores

3 components $(s_\theta, s_\sigma, s_\delta)$, with $\tilde{y} = \exp^{-\frac{y-\theta}{\sigma}}$

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

Empirical Fluctuation Process

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

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

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

- Functional Central Limit Theorem (FCLT) for $efp(\cdot)$
- W^0 converges to a 3–dimensional Brownian Bridge

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:

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

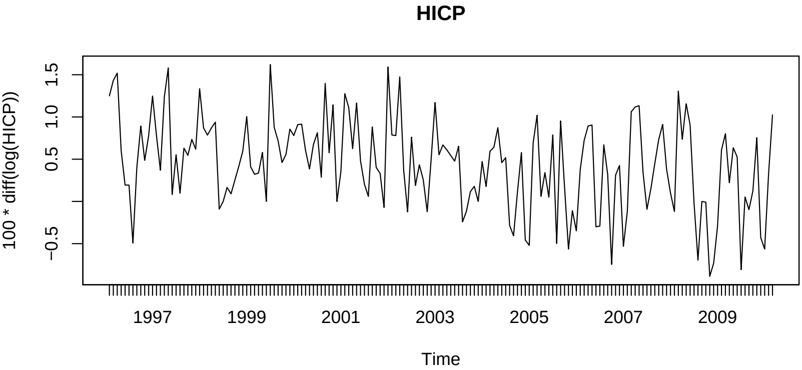
Breakpoint Estimation

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

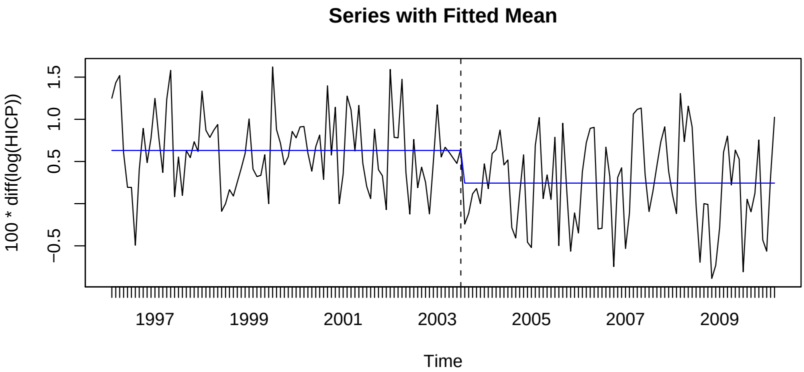
$$\sum_{b=1}^{B+1} \sum_{t=\tau_b+1}^{\tau_b} \log f(y_t | \theta^{(b)}, \sigma^{(b)}, \delta^{(b)})$$

- Estimate models with $B = 1, ...6$ breakpoints; select best via modified BIC

Slovenia

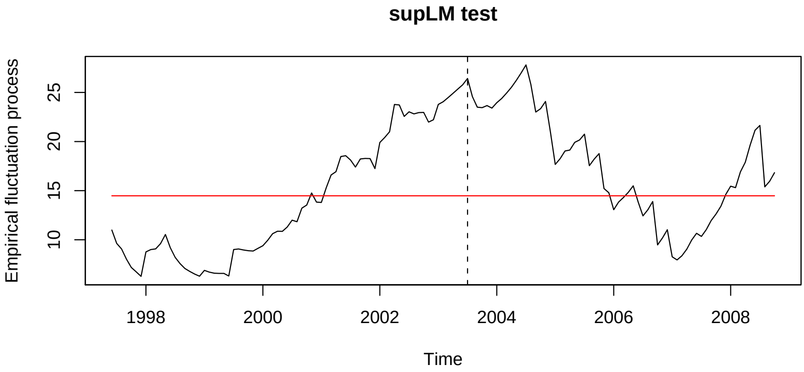

HICP
100 * diff(log(HICP))
1.5
1.0
0.5
−0.5
1997
1999
2001
2003
2005
2007
2009
Time

Slovenia

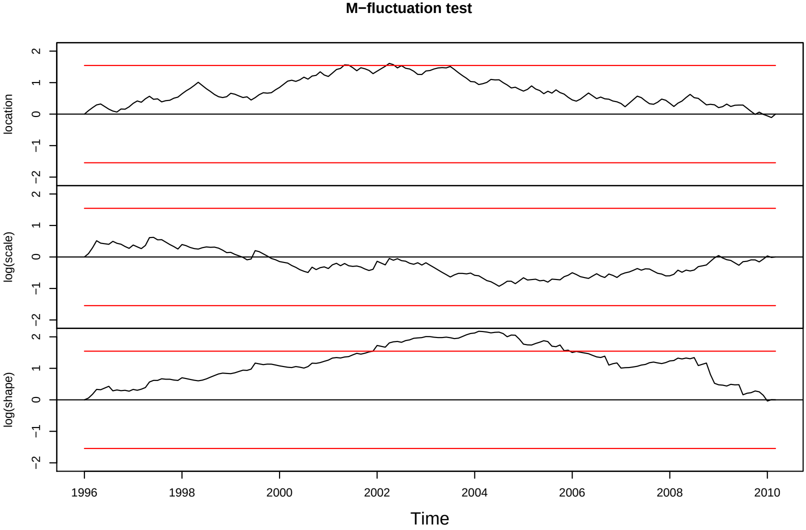


Country	Segment	Mean	Variance	Skewness
Slovenia	Feb 1996–Jul 2003	0.631	0.211	0.588
	Aug 2003–Mar 2010	0.244	0.344	0.143

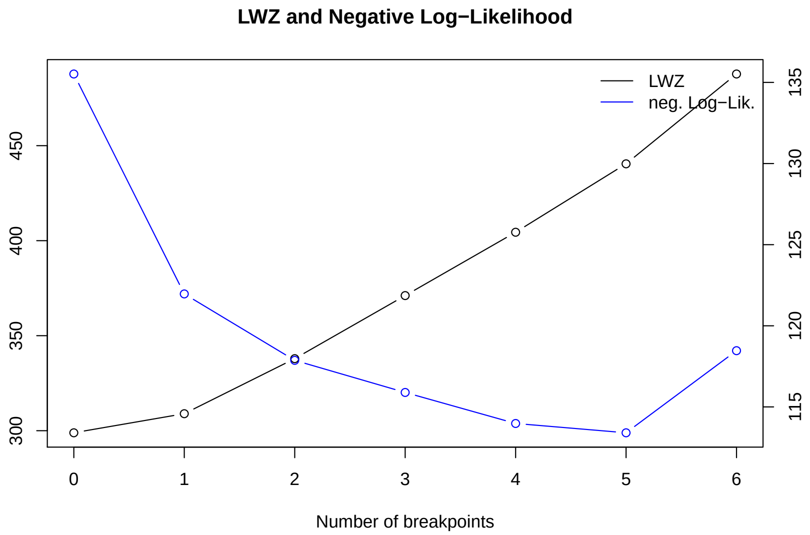
Slovenia–Test



Slovenia–Moment Changes



Slovenia–Breakpoint Selection



Slovenia–Fitted Model

Economic Interpretation:

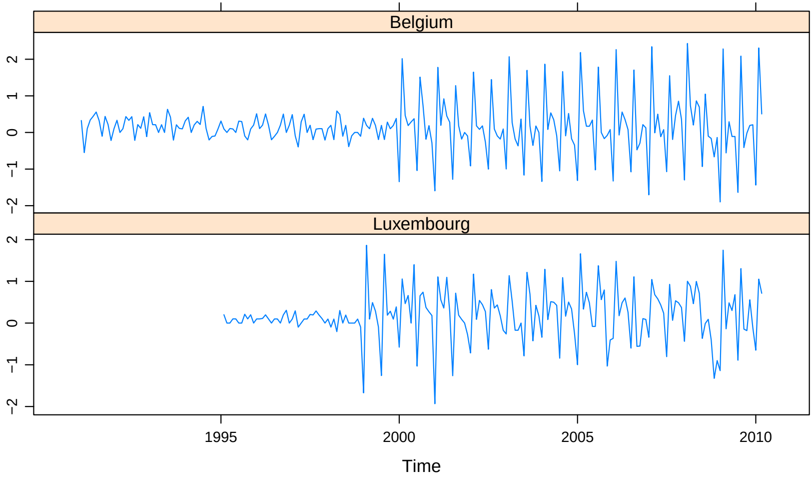
- had to reach Maastricht criteria
  - low inflation rate ($<$ 1.5 percentage points higher than average of 3 best performing)
  - deficit no higher than 3% of GDP
  - gross government debt $< 60\%$ of GDP
  - no devaluation in ERM II
- most reforms regarding financial sector introduced in 2003
- strong 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

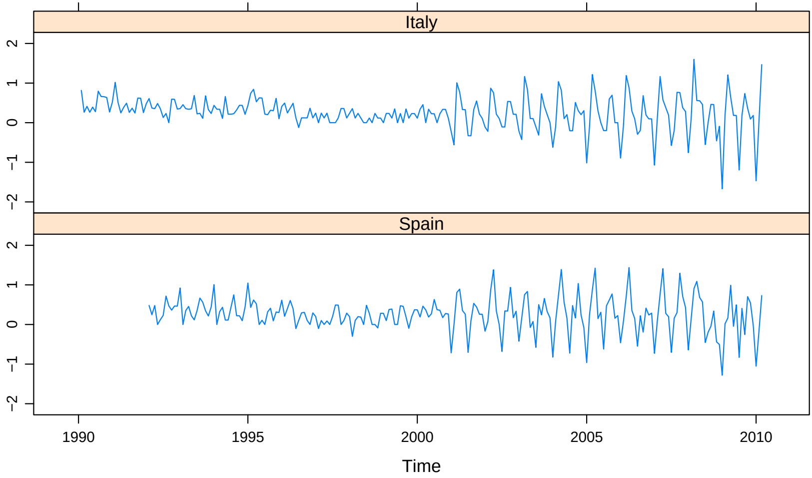
Belgium and Luxembourg



Belgium and Luxembourg

Country	Segment	Mean	Variance	Skewness
Belgium	Feb 1991–Dec 1999	0.146	0.064	-0.037
	Jan 2000–Mar 2010	0.177	0.954	0.504
Luxembourg	Feb 1995–Dec 1998	0.088	0.013	0.261
	Jan 1999–Mar 2010	0.224	0.531	-0.484

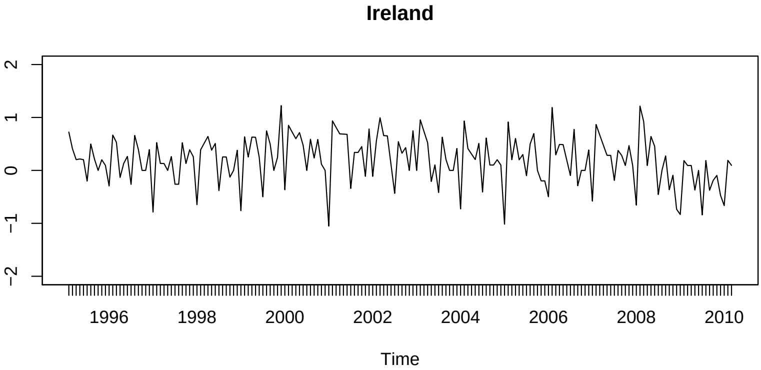
Italy and Spain



Italy and Spain

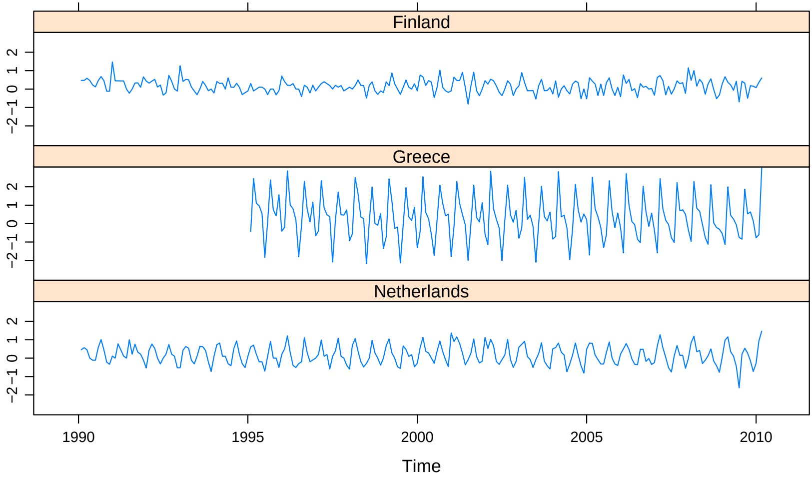
Country	Segment	Mean	Variance	Skewness
Italy	Feb 1990–May 1996	0.414	0.041	0.963
	Jun 1996–Dec 2000	0.168	0.020	0.726
	Jan 2001–Mar 2010	0.182	0.321	-0.261
Spain	Feb 1992–May 1996	0.372	0.070	1.139
	Jun 1996–Dec 2000	0.200	0.040	0.019
	Jan 2001–Mar 2010	0.223	0.342	-0.362

Ireland



Country	Segment	Mean	Variance	Skewness
Ireland	Feb 1995–Mar 2008	0.255	0.205	−0.696
	Apr 2008–Mar 2010	−0.131	0.184	−0.995

No Change Countries



No Change Countries

Country	Segment	Mean	Variance	Skewness
Greece	Feb 1995–Mar 2010	0.323	1.480	0.431
Netherlands	Feb 1990–Mar 2010	0.185	0.293	0.598
Finland	Feb 1990–Mar 2010	0.165	0.132	0.280

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_{iy}^t:

$$R_{iy}^t = \frac{(\prod_{j=1}^n p_{iyj}^t)^{1/n}}{(\prod_{j=1}^n p_{iyj}^0)^{1/n}}$$

Second step: sub–index for whole country R_i^t:

$$R_i^t = \sum_{y=1}^m R_{iy}^t G_y$$

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

Third step: weighted average of all included individual subindexes:

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

GL–right and left skewed