Universität Innsbruck

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
- Result Tables

Introduction

- Did EMU change inflation dynamics ?
- Economic Reasons

Data

- 21 Monthly HICP series, unadjusted
- Source: OECD Statistics

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 subindices:

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

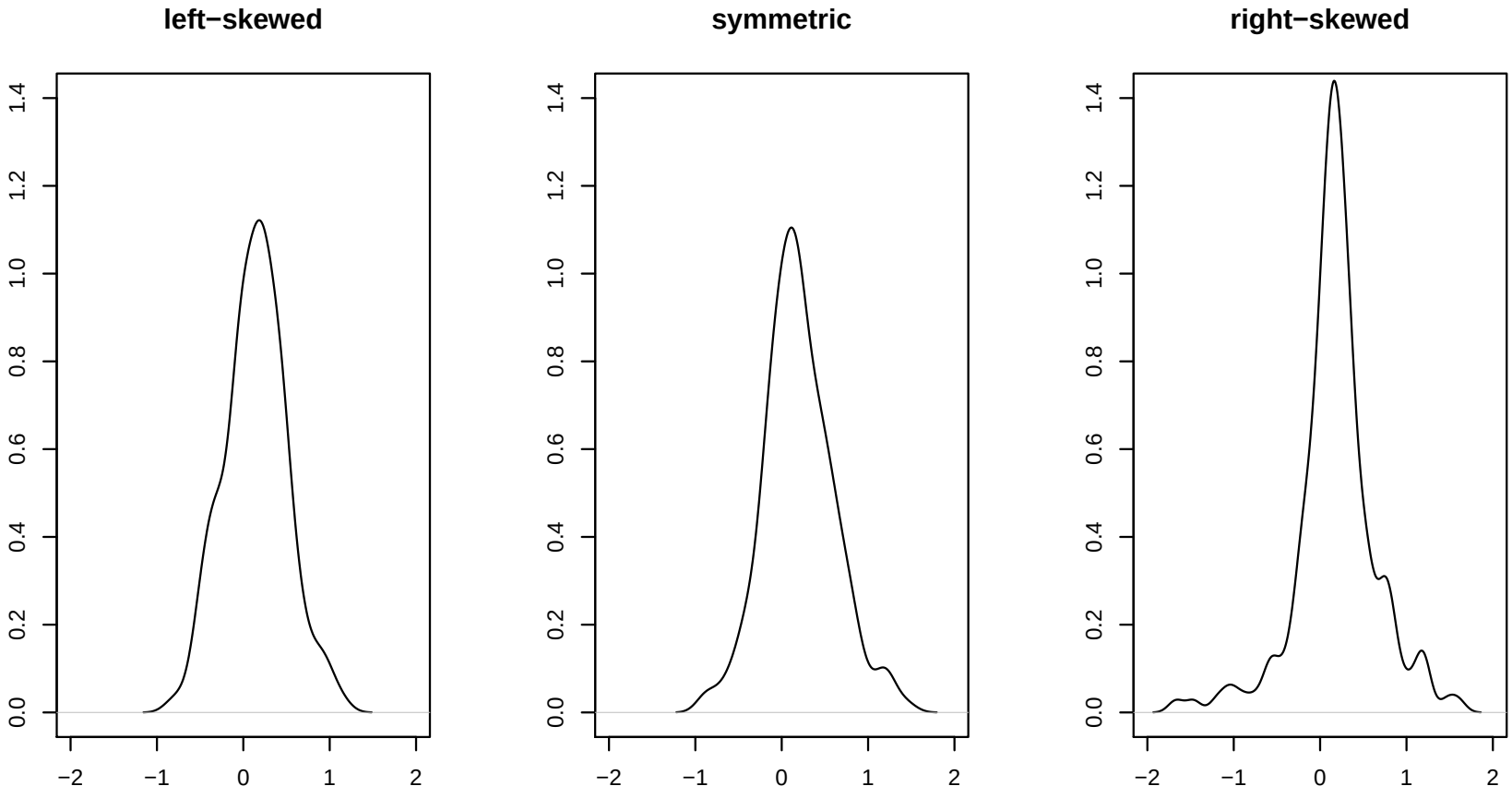
GL–Distribution

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). For $\delta = 1$ the distribution simplifies to the logistic distribution, for $\delta < 1$ it is skewed to the left and for $\delta > 1$ it is skewed to the right.

Some examples



First 3 Moments of the GL–Distribution

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

Scores

The resulting score functions s() are given by:

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

$$
\begin{aligned}
s(y,\sigma) &= \frac{\delta loglik(y|\theta,\sigma,\delta)}{\delta\sigma} \\
&= -\frac{1}{\sigma} + \frac{1}{\sigma^2}(y-\theta) - (\delta+1) \\
&\times \frac{\frac{1}{\sigma^2}(y-\theta)\exp^{-\frac{y-\theta}{\sigma}}}{(1+\exp^{-\frac{y-\theta}{\sigma}})}
\end{aligned}
$$

Testing Procedure

For the 3–dimensional parameter $\psi = (\theta, \sigma, \delta)$ we test:

$$H_0 : \psi_i = \psi_0 \ (i = 1, ..., n)$$

$$\underset{\psi \in \Psi}{argmin} \sum_{t=1}^{n} s(y_t, \psi) = \hat{\psi},$$

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

Under certain assumptions, a central limit theorem holds:

$$\sqrt{n}(\hat{\psi}) \xrightarrow{d} \mathcal{N}(0, A_0^{-1} B_0 A_0^{-1}), \tag{1}$$

efp

The empirical fluctuation process $efp(\cdot)$, defined as the decorrelated partial sum process of the empirical estimating functions, converges to a 3-dimensional Brownian bridge $W^0(\cdot)$ on the interval [0,1].

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

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

Test

We use Supremum of LM statistics:

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

and also supply a χ^2 goodness of fit test for the GL–distribution.

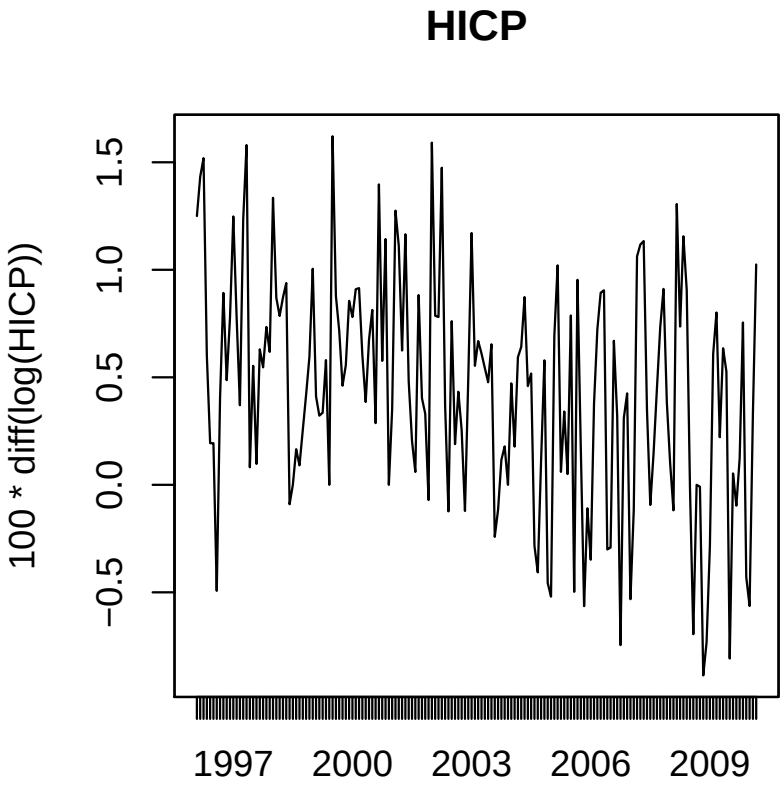
Breakpoint Estimation

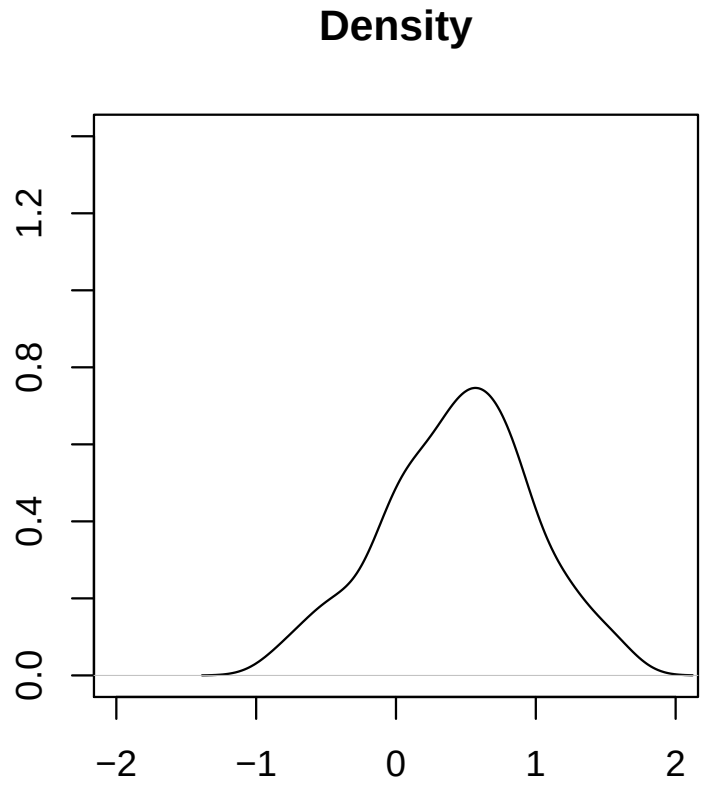
The partial log–likelihood is given by:

$$\sum_{b=1}^{B} \sum_{\tau=\tau_{b-1}}^{\tau_b} loglik(y_t|\theta^{(b)}, \sigma^{(b)}, \delta^{(b)})$$

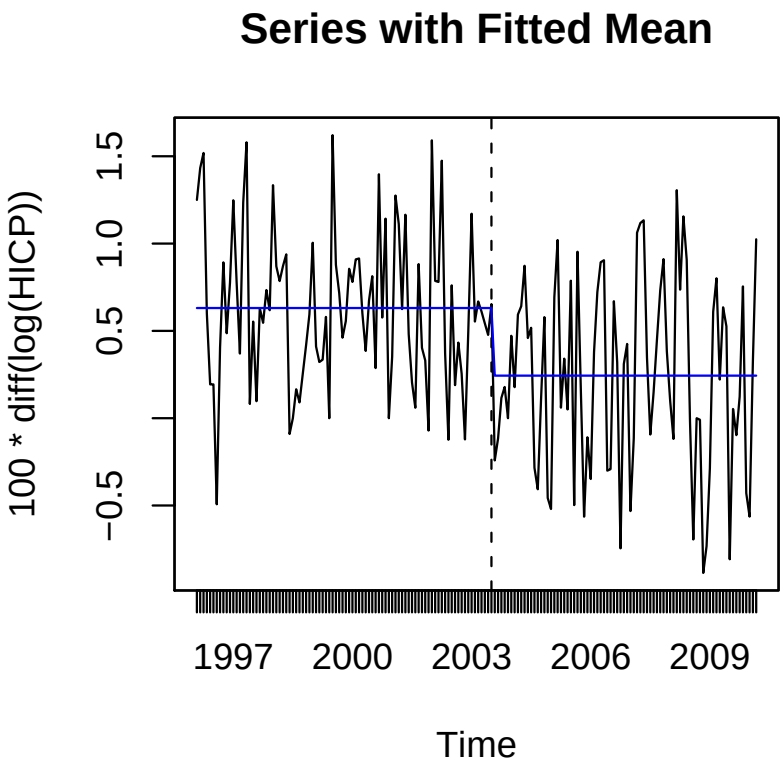
Breakpoint selection via modified BIC

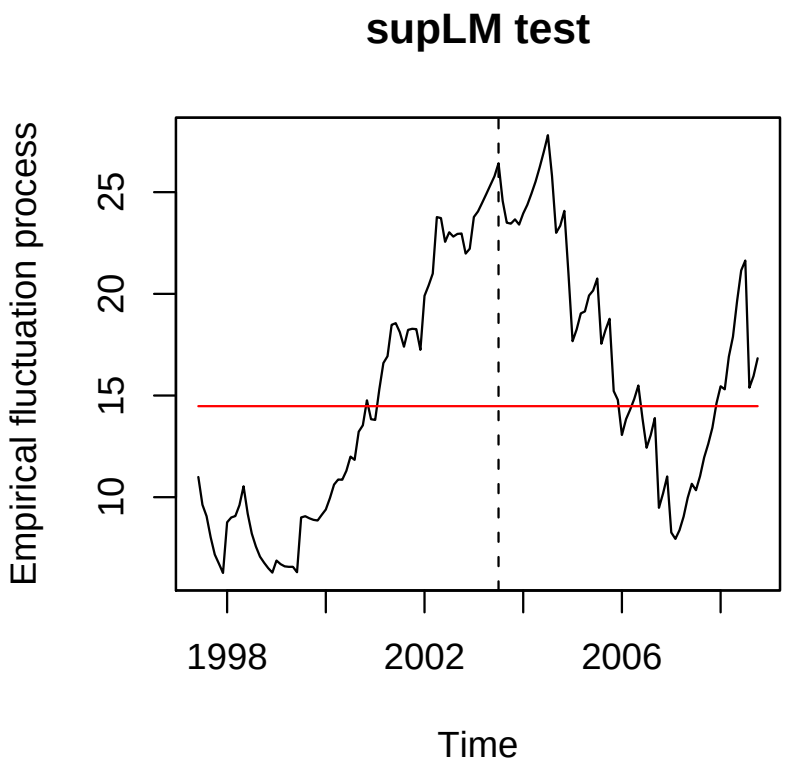
Slovenia


HICP
100 * diff(log(HICP))
−0.5
0.0
0.5
1.0
1.5
1997
2000
2003
2006
2009

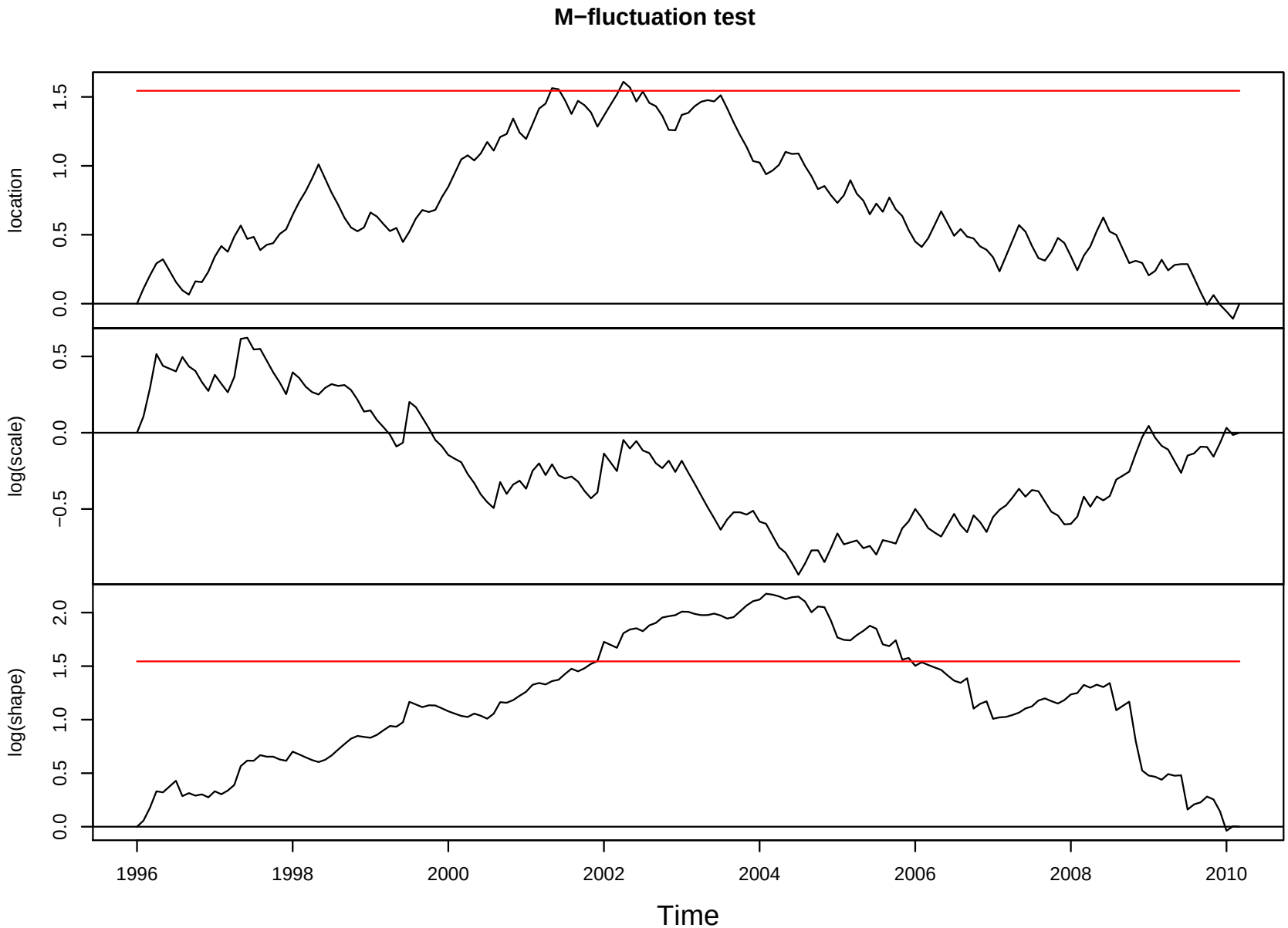

Density
0.0
0.4
0.8
1.2
−2
−1
0
1
2

Test

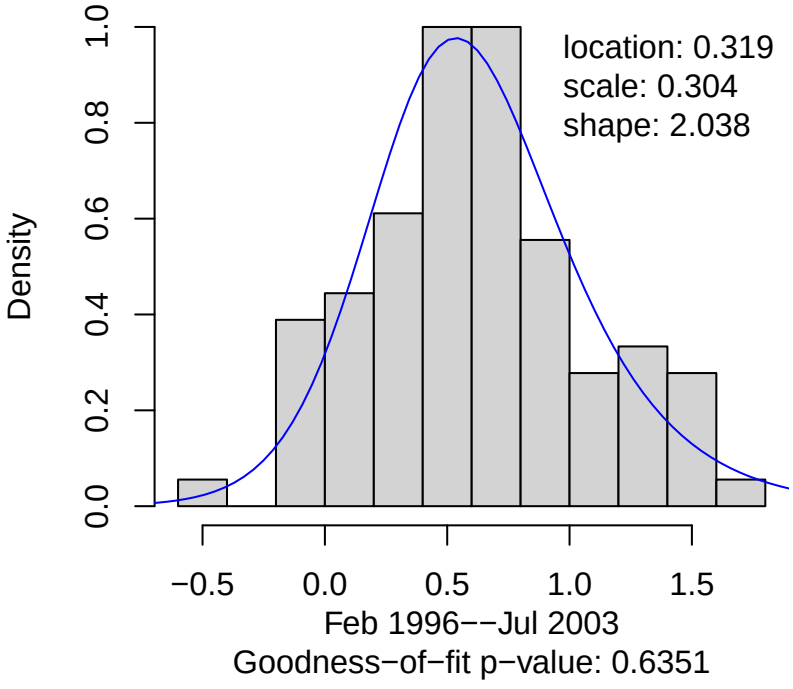

Series with Fitted Mean
100 * diff(log(HICP))
−0.5
0.5
1.0
1.5
1997
2000
2003
2006
2009
Time

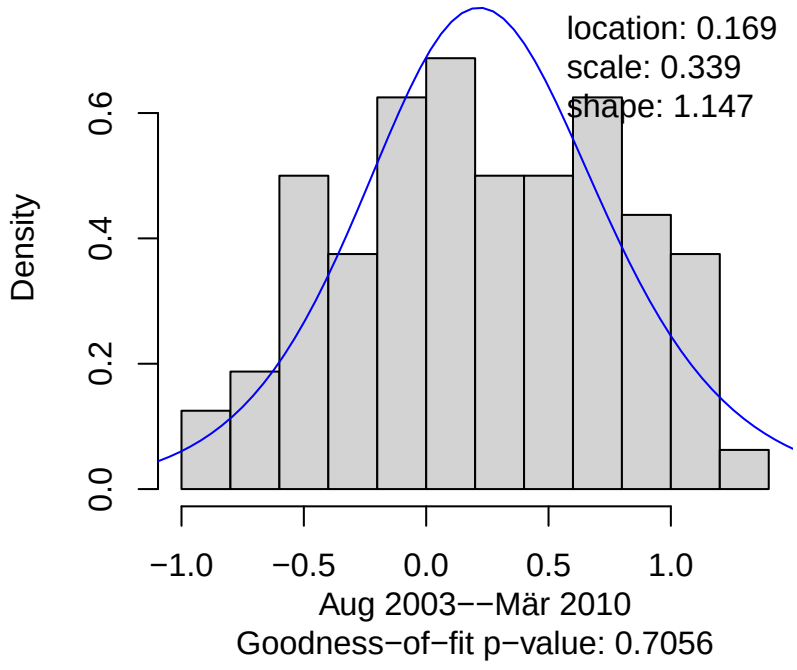

supLM test
Empirical fluctuation process
10
15
20
25
1998
2002
2006
Time

Moment changes



Goodness of fit Test





Slovenia

Economic Interpretation:

- had to reach Maastricht criteria
- reached goal in 2005
- from 2003 onwards much lower mean, but higher variance
- most reforms regarding financial sector introduced in 2003
- strong contraction in money supply (M1) starting in 2003

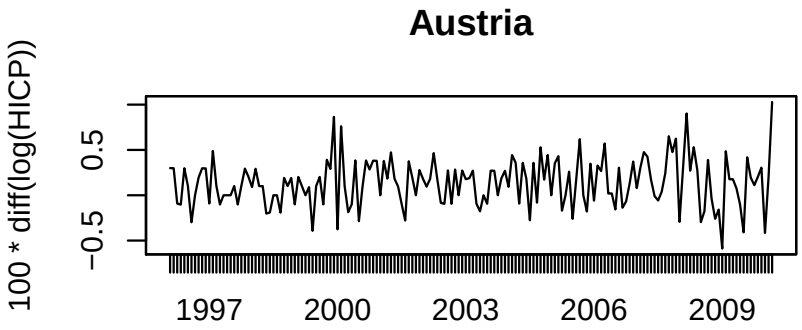
Result Table

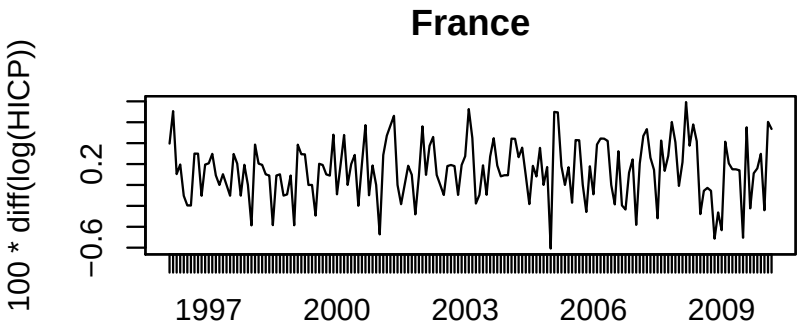
- 6 possible groups:
- Central countries: Austria, France, Germany
- Eastern countries: Czech Republic, Estonia, Hungary, Poland, Slovakia and Slovenia
- Ireland
- No change countries: Finland, Greece, Netherlands
- Northern counries: Denmark, Sweden, United Kingdom
- Southern countries: Italy, Portugal, Spain; with Belgium and Luxembourg

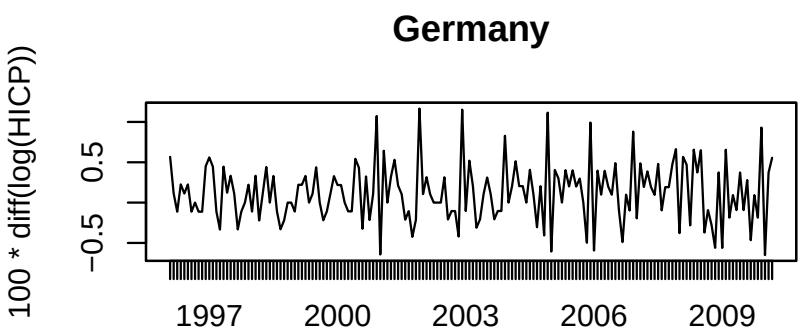
Central countries:

Country	Segment 1	Segment 2	Segment 3	ERM II/EMS	EURO
Austria	1990(2)–2007(9)	2007(10)–2010(3)	–	1995(1)	1999(1)
	mean: 0.1635 var: 0.05694 skew: 0.6056	mean: 0.1731 var: 0.16310 skew: 0.1691			
France	1990(2)–2004(12)	2005(1)–2010(3)	–	1979(1)	1999(1)
	mean: 0.1588 var: 0.05769 skew: 0.1965	mean: 0.1504 var: 0.13134 skew: -0.7942			
Germany	1995(2)–2000(5)	2000(6)–2004(12)	2005(1)–2010(3)	1979(1)	1999(1)
	mean: 0.08799 var: 0.06013 skew: 0.9219	mean: 0.14018 var: 0.16352 skew: 0.9920	mean: 0.14183 var: 0.18384 skew: -0.6625		

Central countries:



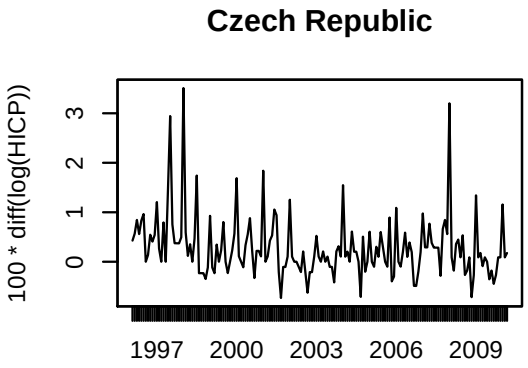


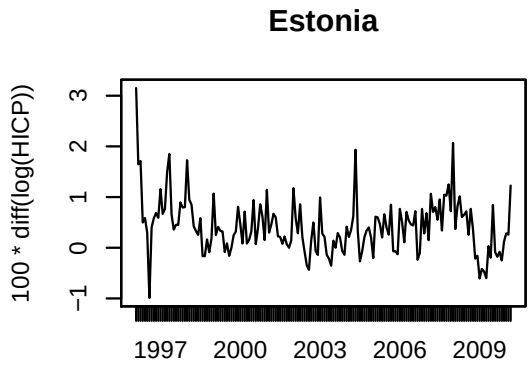


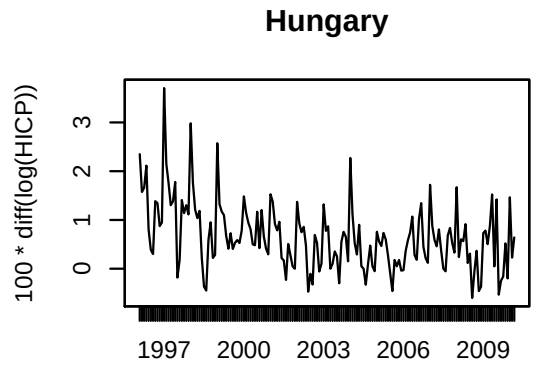
Eastern countries:

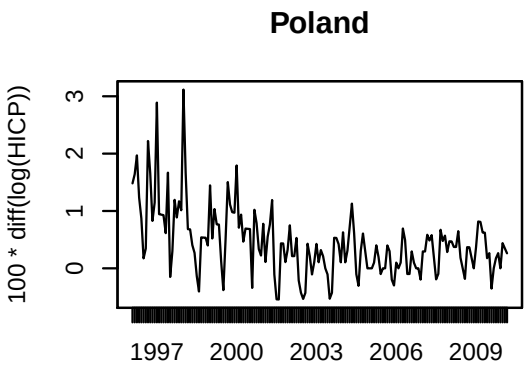
Country	Segment 1	Segment 2	Segment 3	ERM II/EMS	EURO
Czech Republic	1995(2)–1998(7)	1998(8)–2010(3)	–	no	no
	mean: 0.6969 var: 0.3363 skew: 1.139	mean: 0.1821 var: 0.2156 skew: 0.990			
Estonia	1996(2)–1998(3)	1998(4)–2010(3)	–	2004(6)	2011(1)
	mean: 0.8649 var: 0.4196 skew: 0.4041	mean: 0.3328 var: 0.2062 skew: 0.8016			
Hungary	1995(2)–1998(5)	1998(6)–2010(3)	–	no	no
	mean: 1.6064 var: 1.0243 skew: 0.8781	mean: 0.5068 var: 0.3161 skew: 0.7095			
Poland	1996(2)–2001(5)	2001(6)–2010(3)	–	no	no
	mean: 0.8548 var: 0.4212 skew: 0.6675	mean: 0.2024 var: 0.1232 skew: -0.3148			
Slovakia	1995(2)–1997(4)	1997(5)–2004(2)	2004(3)–2010(3)	2005(11)	2009(1)
	mean: 0.4799 var: 0.05768 skew: 1.139	mean: 0.5872 var: 0.44150 skew: 1.140	mean: 0.1865 var: 0.08903 skew: 1.139		
Slovenia	1996(2)–2003(7)	2003(8)–2010(3)	–	2004(6)	2007(1)
	mean: 0.6309 var: 0.2108 skew: 0.5883	mean: 0.2436 var: 0.3440 skew: 0.1426			

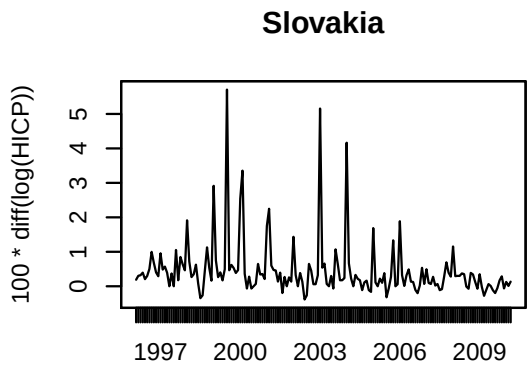
Central countries:

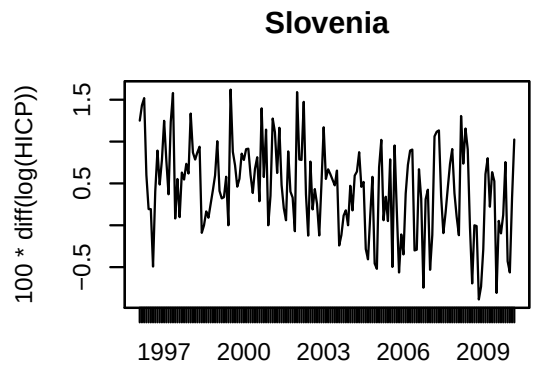








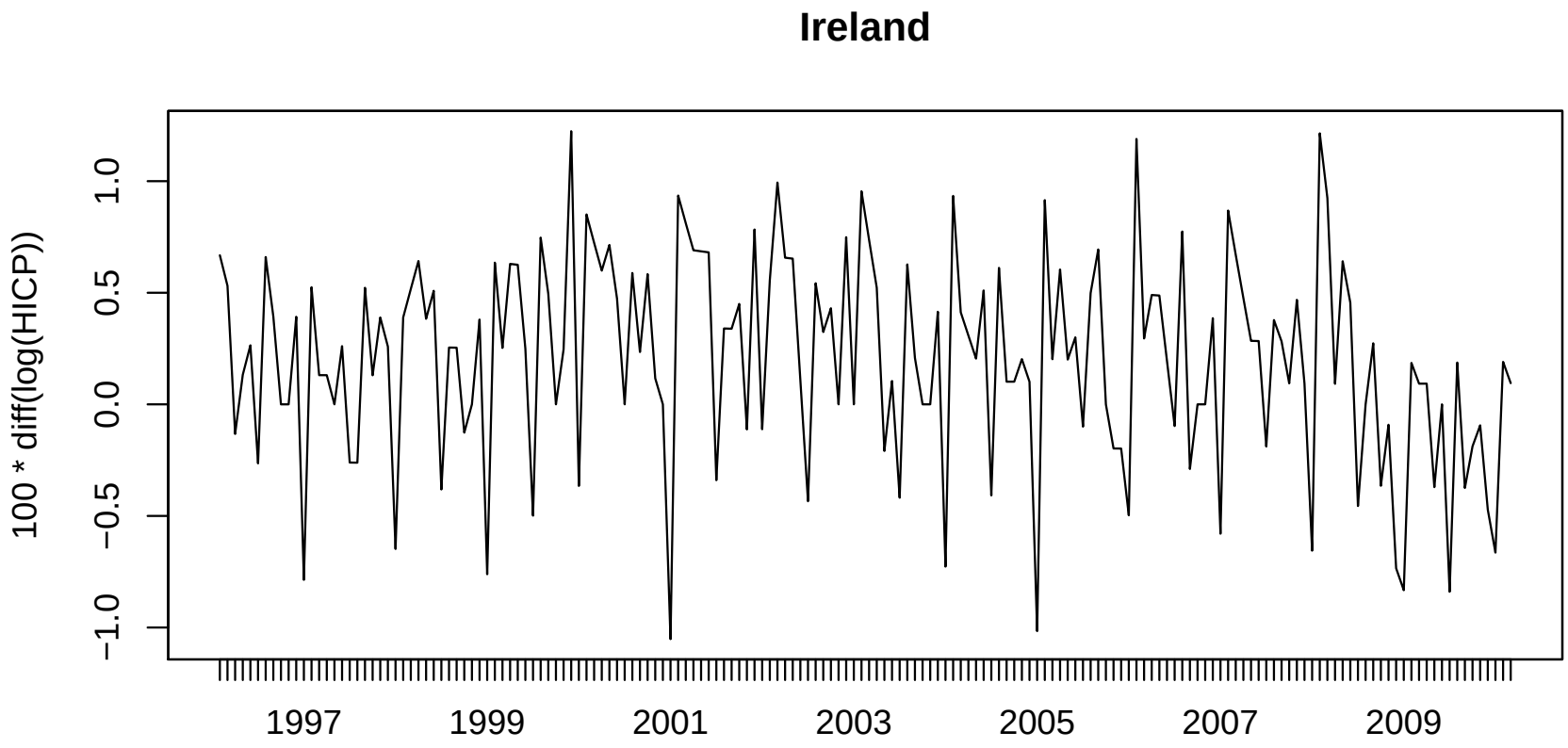




Ireland:

Country	Segment 1	Segment 2	Segment 3	ERM II/EMS	EURO
Ireland	1995(2)–2008(3)	2008(4)–2010(3)	–	1979(1)	1999(1)
	mean: 0.2546 var: 0.2045 skew: -0.6958	mean: -0.1313 var: 0.1836 skew: -0.9947			

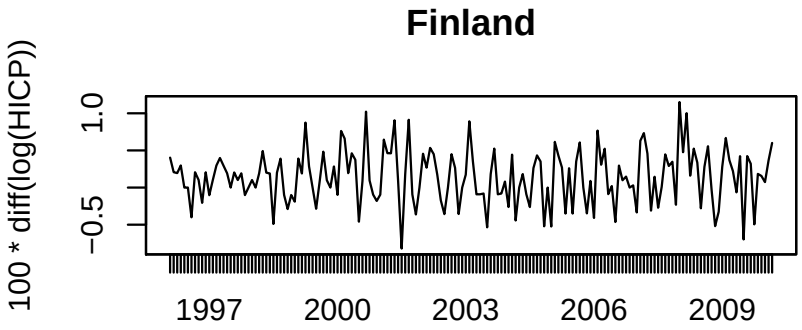
Ireland:

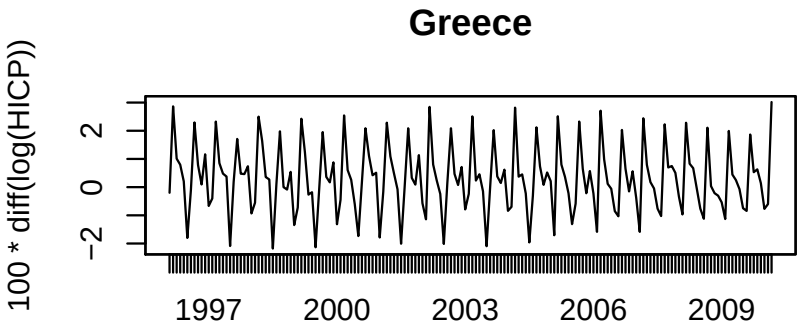

Ireland
100 * diff(log(HICP))
1.0
0.5
0.0
−0.5
−1.0
1997
1999
2001
2003
2005
2007
2009

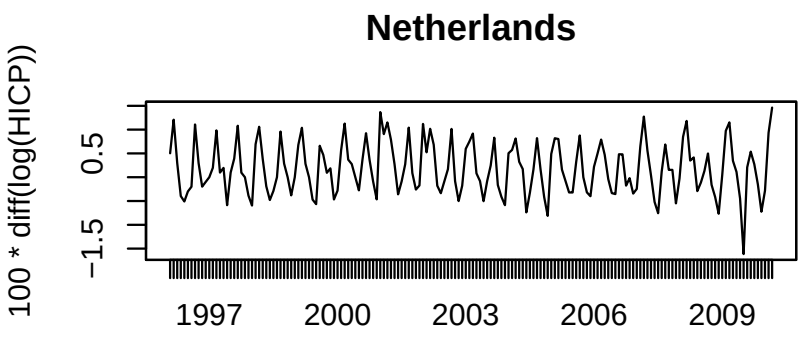
No change countries:

Country	Segment 1	Segment 2	Segment 3	ERM II/EMS	EURO
Finland	1990(2)–2010(3)	–	–	1996(10)	1999(1)
	mean: 0.1653 var: 0.1321 skew: 0.2798				
Greece	1995(2)–2010(3)	–	–	1999(1)	2001(1)
	mean: 0.3227 var: 1.48 skew: 0.4314				
Netherlands	1990(2)–2010(3)	–	–	1979(1)	1999(1)
	mean: 0.1854 var: 0.293 skew: 0.5984				

No change countries:



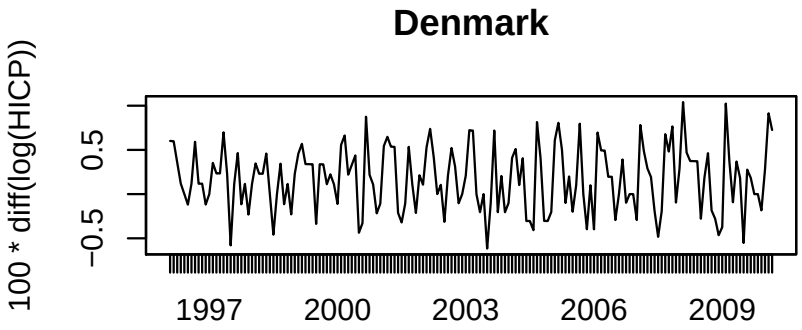


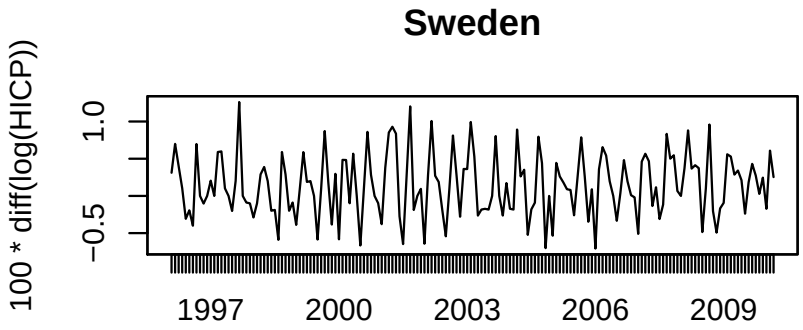


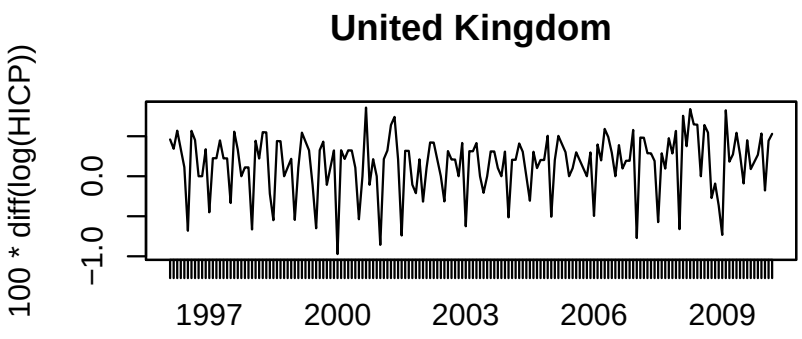
Northern countries:

Country	Segment 1	Segment 2	Segment 3	ERM II/EMS	EURO
Denmark	1990(2)–2000(6)	2000(7)–2010(3)	–	1999(1)	no
	mean: 0.1664 var: 0.09078 skew: -0.7425	mean: 0.1676 var: 0.18758 skew: 1.0471			
Sweden	1990(2)–1993(1)	1993(2)–2010(3)	–	no	no
	mean: 0.4748 var: 0.5715 skew: 1.1393	mean: 0.1552 var: 0.1848 skew: 0.5344			
United Kingdom	1990(2)–1992(4)	1992(5)–2010(3)	–	1990(10)	no
	mean: 0.5703 var: 0.3869 skew: 1.139	mean: 0.1615 var: 0.1490 skew: -1.265			

Northern countries:







Southern countries:

Country	Segment 1	Segment 2	Segment 3	ERM II/EMS	EURO
Belgium	1991(2)–1999(12)	2000(1)–2010(3)	–	1979(1)	1999(1)
	mean: 0.1459 var: 0.06401 skew: -0.03708	mean: 0.1768 var: 0.95401 skew: 0.50356			
Italy	1990(2)–1996(5)	1996(7)–2000(12)	2001(1)–2010(3)	1979(1)	1999(1)
	mean: 0.4135 var: 0.04129 skew: 0.9627	mean: 0.1676 var: 0.01997 skew: 0.7261	mean: 0.1819 var: 0.32117 skew: -0.2605		
Luxembourg	1995(2)–1998(12)	1999(1)–2010(3)	–	1979(1)	1999(1)
	mean: 0.08761 var: 0.01340 skew: 0.2606	mean: 0.22425 var: 0.53108 skew: -0.4836			
Portugal	1990(2)–1992(7)	1992(8)–2004(3)	2004(4)–2010(3)	1992(4)	1999(1)
	mean: 0.8519 var: 0.1718 skew: 1.1394	mean: 0.2700 var: 0.1052 skew: 0.8653	mean: 0.1605 var: 0.2559 skew: 0.5690		
Spain	1992(2)–1996(5)	1996(6)–2000(12)	2001(1)–2010(3)	1989(6)	1999(1)
	mean: 0.3724 var: 0.06960 skew: 1.13909	mean: 0.2001 var: 0.03988 skew: 0.01874	mean: 0.2225 var: 0.34215 skew: -0.36200		

Southern countries: