1 Abstract

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

2 Introduction

The ECB defines price stability “as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2 %” (E. Castelnuovo 2003). (Emerson 1992) makes it clear, that a high inflation rate is also more variable and uncertain and in that way causes more relative price variability, leading to a less efficient price mechanism (p. 22). Thus to achieve a low inflation rate and low variability of inflation must be a key issue for the central bank.

To further justify the use of inflation volatility, we refer to (Rother 2004): “Among the harmful effects of inflation, the negative consequences of inflation volatility are of particular concern. High variability of inflation over time makes expectations over the future price level more uncertain. In a world with nominal contracts, this induces risk premia for long-term arrangements, raises costs for hedging against inflation risks and leads to unanticipated redistribution of wealth. Thus, inflation volatility can impede growth even if inflation on average remains restrained.”

The question of interest centers around the way in which a countries decision to join the EMU changed its inflation volatility. There are a number of reasons why the volatility of one of these nations should change indeed. Given that the country experienced quite volatile inflation rates, its efforts to meet the convergence criterias are likely to lead to a change in the volatility of their respective inflation rates, as has indeed been the case for a number of EMU countries, like Spain, Portugal, Italy and Greece.

3 Literature Overview

Theory unfortunately is quite unsure about whether or not the creation of a monetary union between two or more states is likely to reduce/increase the variability or even the level of the inflation rate. (R. Cooper 1998) 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). He creates a two country model for monetary policy analysis along the line of two models by (B. McCallum 1999) and (B. McCallum 2000) as well as (J. Gali 2005). The inflation is modeled by a hybrid Phillips curve (NKPC) specification and there are a number of different home country interest rate rules, like strict inflation targeting, flexible targeting, pegging to a currency and – monetary union. What he finds out via simulations of these different interest rate rules is that the standard deviation of the home CPI inflation rate can be substantially reduced by joining a monetary union. But monetary policy in a monetary union does not explicitly stabilize the output gap and inflation rate in case of national economic shocks. The effects of joining 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 guessed, theory has some troubles answering the question of this paper.
(G. Carporale 2009) estimate short-run and steady-state inflation uncertainty in 12 EMU countries and find a considerable degree of heterogeneity across EMU countries in terms of average inflation, its degree of persistence and both types of uncertainty. They use a time-varying model with a GARCH specification for the unconditional volatility of inflation and find some instability in the conditional volatility.
In a paper examining structural convergence of the inflation rates in EU counries, (E. Sarno 2003) 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 observeable. The same is also found by (G. Palomba 2007), they too find little evidence of similarity of short-run inflation dynamics.
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.
Inquiering into the convergence properties of inflation rates among countries of

the EMU, (F. Busetti 2007) find that from 1980-1997 there was convergence of inflation rates, but afterwards there is some diverging behavior.

4 Data

Inflation is measured as the logarithm of the monthly change in the HICP from 1.1990—3.2010, so $x_t = 100 \cdot ln(HICP_t/HICP_{t-1})$. Countries included are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Spain, Sweden, United Kingdom and the Euro area. The data are obtained from the OECD Statistics.

The countries can be divided into three different groups: the EMU countries (Portugal, Spain, Italy, Greece, France, Belgium, Netherlands, Germany, Austria, Ireland, Slovenia, Luxembourg and Finland), EU members without ERM II (Exchange Rate Mechanism): United Kingdom, Sweden, Poland, Czech Republic, Hungary. Denmark stands on its own as a member of the EU and the ERM II, but not yet a member of the EMU.

5 Methodology

5.1 Using a generalized logistic distribution (GL)

As allready stated, we now apply the general framework, as developed in (**?**) 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 our using of the GL distribution. Regarding the data at hand, it was not possible to use the already existing method developed in (K. Hornik 2007), since allmost all inflation rates, with the noteable exception of Greece, are not normally distributed and clearly exhibit asymmetric properties. Therefore, a somewhat more flexibel distribution had to be used. We needed a distribution exhibiting rather strong kurtosis and the property to be both left and right skewed. To this end we use a generalization of the logistic distribution as defined in (N.L.Johnson 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 b=1 the distribution simplifies to the logistic distribution, for b<1 it is skewed to the left and for b>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:

$$l(\delta, \theta, \sigma, \pi) = ln(\delta) - ln(\sigma) - \frac{1}{\sigma}(\pi - \theta) - (\delta + 1)ln(1 + \exp^{-\frac{\pi - \theta}{\sigma}}) \tag{5}$$

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

$$\psi(\pi_i, \delta) = \frac{\delta l(\delta, \theta, \sigma; \pi)}{\delta \delta} = \frac{1}{\delta} - ln(1 + \exp^{-\frac{\pi - \theta}{\sigma}}) \tag{6}$$

$$\psi(\pi_i, \theta) = \frac{\delta l(\delta, \theta, \sigma; \pi)}{\delta \theta} = \frac{1}{\sigma} - (\delta + 1) * \frac{\frac{1}{\sigma} \exp^{-\frac{\pi - \theta}{\sigma}}}{(1 + \exp^{-\frac{\pi - \theta}{\sigma}})} \tag{7}$$

$$\psi(\pi_i, \sigma) = \frac{\delta l(\delta, \theta, \sigma; \pi)}{\delta \sigma} = -\frac{1}{\sigma} + \frac{1}{\sigma^2}(\pi - \theta) - (\delta + 1) * \frac{\frac{1}{\sigma^2}(\pi - \theta) \exp^{-\frac{\pi - \theta}{\sigma}}}{(1 + \exp^{-\frac{\pi - \theta}{\sigma}})} \tag{8}$$

An enhancement to the allready 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 (K. Hornik 2007). the second part of the results - the dating procedure and the illustration of the denisties fitted for the subsamples (divided by the breaks) - ca be found in (I. Patnaik 2010).

5.2 Tests

5.2.1 Cramer-von Mises statistic - Nyblom Hansen Test

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

$$\frac{1}{n} \sum_{i=1}^{n} \|efp(\frac{i}{n})\|_2^2 \tag{9}$$

i.e. first the L_2 norm is used to aggregate over the components and then the mean of the resulting aggregated process is used as the test statistic. This can also be shown graphically as developed in

5.2.2 Kolmogorov-Smirnov Test

As a goodness of fit test, we use the Kolmogorov Smirnov Test for as given in (Massey 1951).

5.3 Densities

Another thing we wish to look at is the change in the moments of the distribution after a break occured and whether or not the subsample fit of the GL-distribution is prefereable to another. Allthough our interest centers on the variance of the respective inflation rate, skewness should not alltogether be ignored. If we observe - for example - a change in skewness from positive to negative from one regime to another, we could conclude that now we will observe higher values in the inflation rate since it shifted.

5.4 Expected Results

To give an idea what we would expect, 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), stage II (1995-1998) and stage III (1999-2002) which ended with the introduction of the Euro as legal tender. 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 "'Teuro"' argument (i.e. the claim that the Euro lead to a significant increase in prices following the year of its introduction). [Teuro besser formulieren, gibt es dafür einen internationalen Term?]

6 Results-very preliminary

Country	**glogist Breaks (dating unsure)**	**fxregimes Breaks**
Austria	1999,2008	no break
Belgium	2000	December 2000
Czech Republic	1998,2002	no break
Denmark	2001	no break
Finland	2000	no break
France	2005	no break
Germany	2000, 2005	no break
Greece	2005	no break
Hungary	1998,2000,2003 (not very clear)	April 1998
Ireland	2005	no break
Italy	1996,2001	April 1996, December 2000
Luxembourg	1999	December 1998
Netherlands	no break	no break
Poland	2001	April 2001
Portugal	1995	March 1994

Slovenia	2003,2005	no break
Spain	2000	December 2000
Sweden	1994	no break
United Kingdom	1994	no break

We find some similarity of a group of countries, Group I (Belgium, Spain and Italy), Group II (France, Greece and Ireland), Group III (Hungary and the Czech Republic) and Group IV (UK and Sweden). The other countries seem to be a group of their own.

6.1 Austria

The Double max test for Austria is insignificant, but the Cramér-von Mises test and the Supremum of LM statistcs test are both significant. This can be interpreted as a sign, that there was some change in the series as a whole, but that we are unsure wheter this happend with respect to location, scale or shape.

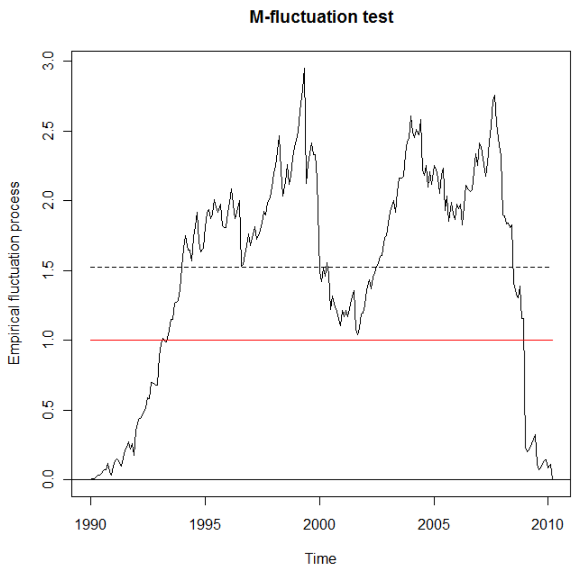

Figure 1: Cramér-von Mises test for Austria

Regarding the figure, we have two clear breaks, one in 1999 and another in 2008. [dating very unsure] The fxregimes procedure gives no breakdate. To give at least some intuition about the changes in variance [actually this is just scale, but can be adapted quickly] we forced 5 breaks into the Austrian inflation rates.

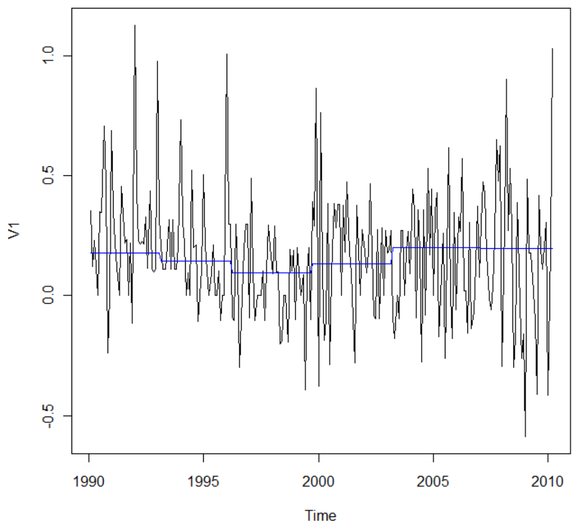

Figure 2: Variance Estimation in Austrian Inflation Rates with 5 Breaks

Only with some phantasy we can se some slight V shape (a decline in inflation volatility up to 2000, then an increase).

6.2 Belgium

Regarding the belgian inflation rates, all tests clearly indicate a break.

The fxregimes procedure indicates a breakpoint in December 2000.

6.3 Italy

In the italian case, there is clear evidence for two breaks.

If we compare the density of a whole and the denisties of the subsets of the data, we see a clear picture:

As we can see regarding the moments of the subsamples, we see a clear increase in variance (0.04, 0.01, 0.32), some smaller increase in the mean (0.41, 0.16, 0.18) and a interesting increas in decrease in skewness (0.96, 0.71, -0.26), which means that lower values of the inflation rate are quickly becoming less probable.

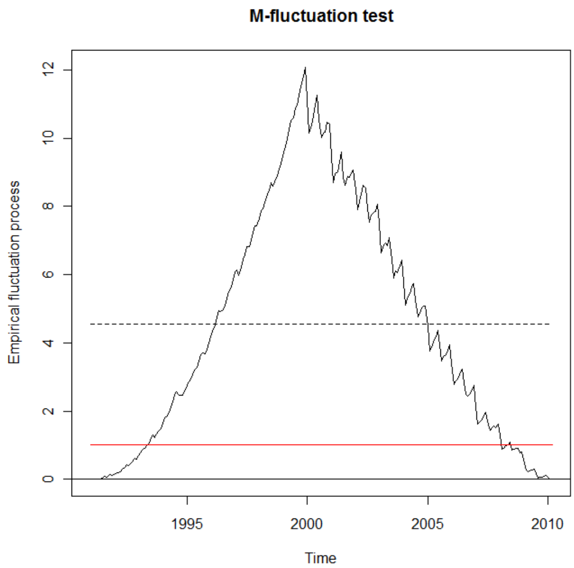

Figure 3: Cramér-von Mises test for Belgium

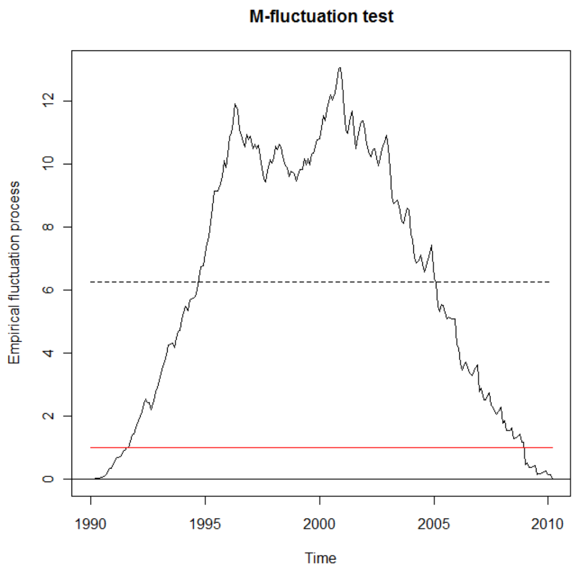

Figure 4: Cramér-von Mises test for Italy

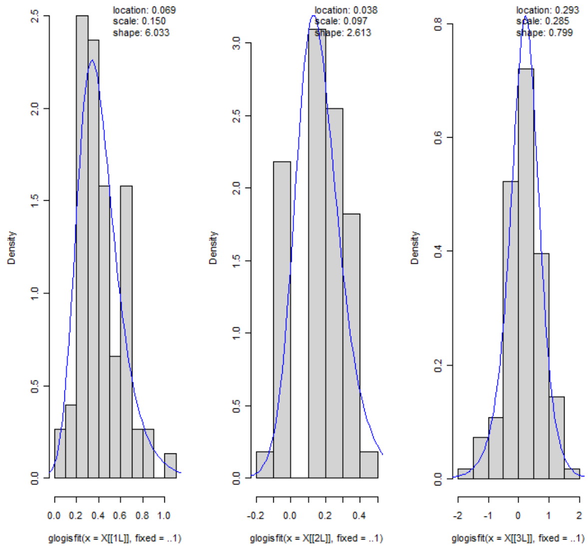

Figure 5: Parameters and Densities for subsamples

7 Literature

B. McCallum, T. Nelson. 1999. “Nominal income targanding in an open-economy optimizing model.” *Journal of Monandary Economics* 43:pp. 553578.

B. McCallum, T. Nelson. 2000. “Monetary policy for an open economy: an alternative framework with optimizing agents and sticky prices.” *Oxford Review of Economic Policy* 16(4):pp. 74–91.

E. Castelnuovo, S.Nicoletti-Altimari, D. Rodriguez-Palenzuela. 2003. “Definition of Price Stability, Range and Point Inflation Targets: The Anchoring of Long–Term Inflation Expectations.” *ECB Working Paper* 273.

E. Sarno, A. Zazzaro. 2003. “Structural Convergence of Macroeconomic Time Series: Evidence for Inflation Rates in EU Countries.” *Working Paper* .

Emerson, M. 1992. *One Market, One Money, An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union.*

F. Busetti, A. Harvey, L.Forni F.Venditti. 2007. “Inflation Convergence and

Divergence within the European Monandary Union." *International Journal of Central Banking* 3(2):pp. 95–121.

G. Carporale, A. Kotonikas. 2009. "The Euro and inflation uncertainty in the European Monandary Union." *Journal of International Finance and Money* 574:pp. 954–971.

G. Palomba, E. Sarno, A. Zazzaro. 2007. "Testing similarities of short-run inflation dynamics among EU countries after the Euro." *Working Paper* .

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

I. Patnaik, A. Shah, A. Zeileis. 2010. "Testing, monitoring, and dating in structural change in exchange rate regimes." *Computational Statistics and Data Analysis* 54:pp. 1696–1706.

J. Gali, T. Monacelli. 2005. "Monetary policy and exchange rate volatility in a small open economy." *Review of Economic Studies* 72:pp. 707–734.

K. Hornik, A. Zeileis. 2007. "Generalized M-fluctuation tests for parameter instability." *Statistica Neerlandica* 61(4):pp. 488–508.

Massey, F. 1951. "The Kolmogorov-Smirnov Test for Goodness of Fit." *Journal of the American Statistical Assosication* 45(253):pp. 68–78.

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

N.L.Johnson, S. Kotz, N. Balakrishnan. 1995. *Continuous Univariate Distributions, Volume 2.* Second edition ed. Wiley Series of Probability and Mathematical Statistics.

R. Cooper, H. Kempf. 1998. "Establishing a Montary Union." *NBER Working Paper* 6791.

Rother, P. 2004. "Fiscal Policy and Inflation Volatility." *ECB Working Paper* 317.