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INFLATION PERSISTENCE IN LUXEMBOURG A COMPARISON WITH EU15 COUNTRIES AT THE DISAGGREGATE LEVEL*

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Abstract

The aim of this paper is to analyse the degree of inflation persistence in Luxembourg using disaggregate price index data from the Harmonised Index of Consumer Prices. The degree of inflation persistence is then compared to estimates for the EU15 and for the euro area as well as for the individual member countries according to a unified approach. In order to assess the robustness of our estimates both a parametric and a non-parametric measure of inflation persistence is used. Overall, our results suggest a relatively low degree of inflation persistence in Luxembourg. For a large number of sub-indices we are not only able to reject the unit root hypothesis, but also we find a low degree of inflation persistence relative to other EU15 countries and relative to the EU15 and euro area aggregates. For Luxembourg as well as the other EU15 countries, our results suggest substantial heterogeneity in the degree of inflation persistence across sub-indices. We find some support for the presence of aggregation effects, both across indices and countries. Structural break tests for all EU15 countries suggest the presence of structural changes in the inflation process owing to the inception of the single monetary policy and/or to the modified treatment of sales.

Keywords: Inflation persistence, Mean reversion, Aggregation effect, Structural breaks

JEL Codes: E31, C21, C22, C14

I. INTRODUCTION

For monetary authorities and central banks, it is important to know how sluggishly inflation returns to its long-run equilibrium level after a disturbance, in order to assess the short-term impact of monetary policy decisions. A vast literature has emerged analysing the degree of inflation persistence[1]. One of the central issues is whether inflation persistence follows a unit root. Recent empirical evidence not only suggests that inflation has varied over time, but also that inflation is not an intrinsically persistent process.

As Levin & Piger (2004) demonstrated recently, a high degree of measured inflation persistence may be related to non-accounted breaks in the mean inflation rate, which may reflect changes in central banks' inflation target in the recent past. They show in a multi-country study that inflation persistence, as measured by the sum of autoregressive (ΣAR) coefficients, is well below unity for almost all inflation series and countries if the possibility of a structural break in the mean level of the inflation is taken into consideration and conclude that inflation persistence is not an intrinsic feature of industrial economies. Benati (2004) subsequently provided evidence for 20 OECD countries plus the euro area for the post WWII era. He allows for multiple structural breaks in inflation and reports that persistence estimates are generally characterised by a significant amount of uncertainty – sometimes to the extent that it is often impossible to make strong statements of persistence for a specific series and/or sample period. He, too, concludes that high inflation persistence is not a robust feature of the data.

For the euro area and its individual member states, the empirical evidence points towards inflation persistence being remarkably invariable, despite numerous changes in monetary policy regimes that took place – and in contrast to recent U.S. evidence (e.g. Cogley & Sargent, 2002). Marques (2004) reports little variation in the euro area inflation persistence over time, while the U.S. inflation shows persistence parameter instability when using conventional structural break tests. For both the U.S and the euro area, however, inflation persistence drops considerably when a time-varying mean of inflation is introduced. In addition, the parameter instability in the case of the U.S. inflation series vanishes. O'Reilly & Whelan (2004) also report a stable but relatively high degree of inflation persistence in the euro area in the period between 1970 and 2002, despite allowing for endogenous structural breaks. Batini (2002) finds that the inflation persistence has only marginally varied in the euro area over the last 30 years. She argues that this result is due to a statistical averaging effect, rather than aggregation. However, she finds important differences among the four major euro area countries. Benigno & López-Salido (2002) also report a considerable degree of cross-country heterogeneity, which may have implications for the optimal monetary policy.

The above-mentioned studies focus on aggregate inflation data, while using disaggregate inflation data may prove a useful way to identify the key drivers of aggregate inflation persistence. A disaggregate analysis may uncover inflation persistence differences and allow a classification according to sectors and/or to expenditure weights. This is the approach followed by Clark (2003) who presents results for more than 150 sub-indices of the U.S. consumer price index. He reports three main results; first, the average persistence of disaggregate inflation series is below aggregate inflation persistence. Most of the disaggregate inflation series exhibit a low degree of inflation persistence, but those with a high degree of persistence tend to represent a higher fraction of consumer spending. Second, the level of inflation persistence seems to be similar across different sectors (durable goods, non-durable goods and services). Third, the estimated inflation persistence is lower in magnitude if a shift in mean inflation is taken into account.

[1] For a review see for example Levin & Piger (2004) or Benati (2004).

The aim of this paper is to analyse the degree of inflation persistence in Luxembourg using disaggregate price index data from the Harmonised Index of Consumer Prices (HICP). The degree of inflation persistence is then compared to estimates for the EU15 and for the euro area as well as for the individual member countries according to a unified approach. This approach is motivated by the seemingly high degree of aggregate inflation persistence in the euro area during the last economic downturn[2] and the theoretical finding that aggregate persistence is predominantly driven by the most persistent disaggregate components (e.g. Altissimo & Zaffaroni, 2003; Zaffaroni, 2004). This paper provides estimates of the degree of inflation persistence at the most disaggregate level of the HICP in Luxembourg. In estimating the degree of inflation persistence in Luxembourg and in comparing it to those of other EU15 countries a unified approach is adopted. We use officially published data series from Eurostat. They are readily available, of good quality and to a large extent harmonised across EU15 countries. We aim to identify the main drivers of inflation persistence in Luxembourg, to assess the strength of inflation persistence relative to other EU15 countries, the EU15 and the euro area as well as to highlight major discrepancies between them.

In order to assess the robustness of our estimates both parametric and non-parametric measures of inflation persistence are used. The primary measure of inflation persistence is based on the ΣAR coefficients resulting from univariate estimations[3]. As auxiliary inflation persistence indicator we use a non-parametric measure of mean reversion proposed by Marques (2004), which provides a valuable robustness check, in particular in light of the short sample period. We consider two possibilities of structural breaks in the inflation process of consumer prices in order to avoid spuriously high inflation persistence estimates: First, we allow for an exogenous break at the start of EMU Stage III. Second, we analyse the effects of an essential modification to the HICP data collection methodology by several national statistical institutes including Statec, namely the inclusion of sales prices.

[2] See for example ECB president Jean-Claude Trichet's introductory statement at the press conference on 6 November 2003.

[3] We do not wish to engage in discussions about the pro and cons of different parametric indicators. A detailed discussion on different inflation persistence measures (based on impulse response function, the largest autoregressive root, the spectral density at frequency zero and the half life) can for example be found in Marques (2004).

II. DATA, VARIABLES AND ESTIMATION METHODOLOGY

The underlying price index data are publicly available and taken from the Eurostat *New Cronos* database. The database comprises the HICP for the individual EU15 countries. Throughout the paper the country abbreviations adopted by Eurostat will be used. These are: be-Belgium, dk-Denmark, de-Germany, gr-Greece, es-Spain, fr-France, ie-Ireland, it-Italy, lu-Luxembourg, nl-The Netherlands, at-Austria, pt-Portugal, sf-Finland, sv-Sweden and uk-The United Kingdom, plus EA-euro area and EU–European Union[4]. The data covers the period from January 1995 to December 2003. Our results are based on q-o-q inflation rates at quarterly frequency. While we also provide results for intermediate aggregations of the HICP, which will be used to analyse the presence of aggregation effects, we will concentrate the presentation on the 94 most disaggregated HICP sub-indices.

Data problems and other challenges

The disaggregate approach allows better locating the drivers of inflation persistence in the aggregate series. It also allows ranking countries and sectors but the availability of data is poorer at the disaggregate level than for the full HICP. In general, the publication of harmonised EU15 price indices at the disaggregate level dates back to January 1995. For some of the most disaggregate sub-indices, the *New Cronos* series start at an even later stage[5]. In addition, Statec as well as many other national statistical institutes changed the methodology of compiling the HICP. An important modification relates to the decision by Statec to adopt end-of-season sales from January 2000 onwards. Eventually, other national statistical institutes adopted end-of-season sales prices at different points in time.

In order to assure best-possible comparability of our estimates between Luxembourg and the other countries, we adopt a unified approach. With regard to the univariate regressions, the lag length is individually determined for each price index. We chose to report least squares estimates and do not attempt to correct the downward bias of the least squares coefficients in using median unbiased estimates (e.g. Andrews, 1993; Andrews & Chen, 1994). This is motivated by the predominant share of estimated coefficients residing in the range between 0.00 and 0.75, within which the bias is generally not considered to be particularly worrisome.

Research Methodology

a. Univariate Estimations

The ΣAR coefficients are used as the primary measure of inflation persistence. For each sub-index i of the Luxembourg HICP we estimate the following equation:

$$\pi_{i,t} = c_i + \sum_{k=1}^{K} \beta_{i,k} \pi_{i,t-k} + \sum_{l=2}^{4} D_{i,l} + \varepsilon_{i,t}, \text{ with } \rho_i = \sum_{k=1}^{K^*} \beta_{i,k},$$

[4] Throughout the paper the mention of EU is synonymous with EU15.

[5] The same may hold for other EU15 countries as well. In the case of France and the UK for example, data on the most disaggregated HICP sub-indices start in January 1996 only, thereby not leaving sufficient degrees of freedom to explore the presence of structural breaks in the inflation series due to EMU stage III.

where $\pi_{i,t}$ refers to the quarterly inflation rate in quarter t for the HICP sub-index i and $\rho_{i,j}$ to the ΣAR autoregressive coefficients with K^* representing the optimal lag length according to the Schwarz information criterion (1978). The maximum allowed lag length (K) is 4 quarters. $D_{i,l}$ denote quarterly fixed effects to take account of seasonality. The associated t-statistics are based on heteroskedasticity consistent standard errors. Furthermore, we investigate the presence of a structural break in the inflation process with respect to the modified treatment of sales prices in the HICP and alternatively due to the dawn of EMU Stage III. As the dates of the potential breaks are well defined, there is no need for using procedures that test for structural breaks at unknown date. Instead, we perform overall structural break tests à la Chow, as in Batini (2002) or Levin & Piger (2004). Additionally, the source of the overall structural breaks is explored by applying Wald-tests separately to the ΣAR coefficients and to the intercept.

b. Mean Reversion

We complement the analysis by a non-parametric measure of inflation persistence based on the concept of mean reversion. Following Marques (2004), we define $\gamma = 1\text{-}n/T$ as an alternative measure of inflation persistence, where n reflects the number of times the inflation series crosses its mean during an interval with $T+1$ observations. Given the short sample period under consideration, we assume the mean to be constant. The constant mean is defined as the average of the q-o-q inflation rate[6]. As shown by Marques (2004), a value of $\gamma=0.5$ indicates the absence of serial correlation, while values close to 0 and 1 indicate negative and positive serial correlation, respectively. In theory, there should be close correspondence between the two inflation persistence indicators.

In our case, the use of a secondary indicator of inflation persistence serves three purposes. First, the concept of mean reversion is non-parametric in nature. Thus, the methodology is independent of the common assumptions underlying parametric estimation methods. Second, it represents a very intuitive way to analyse inflation persistence and allows us to obtain results even for those HICP sub-indices for which only few observations are available. Third, the secondary indicator provides a robustness check for the parametric estimates. In addition, this non-parametric measure has a couple of benefits over the common inflation persistence estimate ρ. First, it does not require the specification and estimation of a model and thus is expected to be robust against potential model misspecifications. Second, given its non-parametric nature it is also expected to be less sensitive to the presence of outliers univariate estimates based on OLS. An additional property of the measure proposed by Marques (2004) is that the degree of persistence of the whole sample period is approximately equivalent to a weighted average of persistence of two consecutive sub-periods.[7]

[6] The assumption of a time varying mean approximated by Hodrick-Prescott filter with λ=1600 does not change the results in any substantial way.

[7] However, both parametric and non-parametric measures are affected by the uncertainty surrounding the measurement of the mean level of inflation (e.g. Dias & Marques, 2004).

III. RESULTS BASED ON THE FULL SAMPLE

Inflation persistence based on ΣAR coefficients

First, we estimate the persistence of the different sub-indices without allowing for structural breaks. The results referring to these estimations will henceforth be referred to as "restricted" or "constrained". The average and the median of ρ across the most disaggregated sub-indices of the Luxembourg HICP are 0.03 and 0.09 respectively. The (unweighted) average and median across all EU15 countries are 0.13 and 0.21. The median ρ for the EU15 and the euro area aggregates are 0.30 and 0.40, respectively. At the disaggregate level, therefore, it seems that the degree of inflation persistence in Luxembourg is very low in absolute terms, but also trifling relative to the other EU15 member countries (see Table 1).[8] Similar to a large number of other countries, the median ΣAR coefficients across the HICP sub-indices in Luxembourg is larger than its mean, indicating that the distribution is left-skewed with some sub-indices displaying rather high degree of inflation persistence.

Table 1: Summary statistics of inflation persistence parameter ρ per country, restricted model

Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	93	0.27	0.34	-0.29	0.02	0.30	0.54	0.74
EA	Euro Area	93	0.30	0.42	-0.45	0.12	0.40	0.59	0.76
be	Belgium	78	0.15	0.41	-0.56	-0.09	0.26	0.44	0.68
dk	Denmark	84	0.01	0.58	-1.02	-0.08	0.16	0.29	0.55
de	Germany	90	0.29	0.39	-0.33	0.14	0.34	0.53	0.73
gr	Greece	81	0.11	0.46	-0.76	-0.06	0.17	0.44	0.72
es	Spain	77	0.18	0.51	-0.71	0.01	0.27	0.49	0.74
fr	France	88	0.29	0.69	-0.54	0.08	0.28	0.54	0.83
ie	Ireland	87	0.23	0.31	-0.33	0.12	0.25	0.42	0.65
it	Italy	84	0.22	0.49	-0.71	0.05	0.34	0.54	0.72
lu	Luxembourg	77	0.03	0.41	-0.81	-0.12	0.09	0.27	0.64
nl	Netherlands	82	0.18	0.42	-0.60	0.00	0.27	0.44	0.68
at	Austria	83	0.04	0.58	-0.73	-0.08	0.18	0.33	0.51
pt	Portugal	86	0.22	0.36	-0.40	0.02	0.32	0.45	0.68
sf	Finland	87	-0.05	0.54	-1.20	-0.11	0.08	0.23	0.50
sv	Sweden	83	0.09	0.32	-0.47	-0.11	0.10	0.29	0.61
uk	United Kingdom	80	0.02	0.49	-0.85	-0.14	0.11	0.31	0.53
	All	1433	0.16	0.48	-0.69	-0.03	0.22	0.44	0.70

Note: The estimated parameters are taken at face value and are not treated as zeros in case of statistical

Figure 1 presents selected percentiles of the distribution of the estimated inflation persistence parameter ρ for Luxembourg and the other EU15 countries. We find that for almost 1 out of 2 sub-indices of the Luxembourg HICP the inflation persistence measure ρ falls into the range of $0 \leq \rho \leq 0.5$. Whereas the median ρ is very low compared to other euro area countries (except for Finland, where the median ΣAR coefficients is lower than in Luxembourg), we find broadly similar figures for the non-euro area countries. This similarity extends to the 75th percentile. Figure 1 highlights a relatively small fraction of sub-indices in Luxembourg with a high degree of inflation persistence, implying a large difference between the 75th and the 90th percentile (0.25 relative to 0.16 on average across all EU15 countries). This is also confirmed by the relatively large discrepancy between the 90th and the 95th percentile of the distribution of the ΣAR coefficients in Luxembourg.

[8] Detailed tables with results are available from the authors upon request.

Figure 1: Percentiles of inflation parameter ρ, restricted model

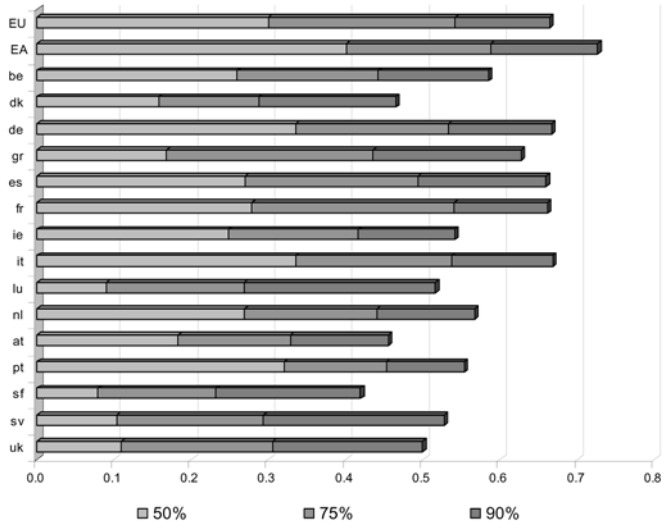
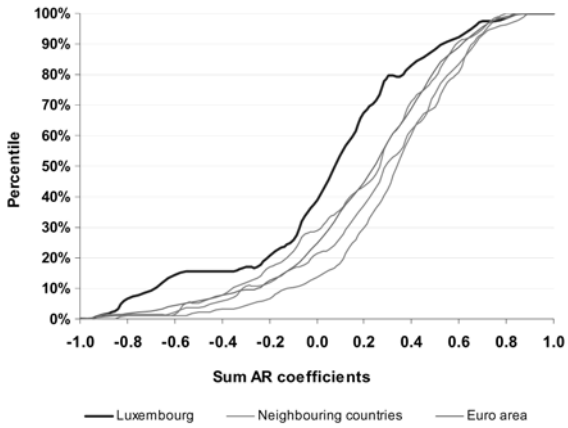


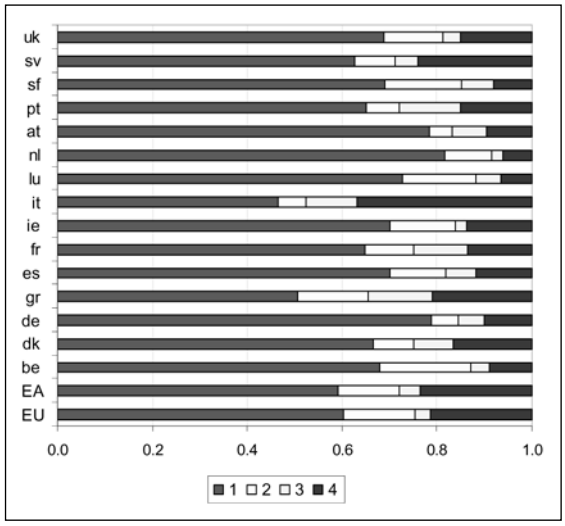
Figure 2 presents the cumulative distribution of the ΣAR coefficients for Luxembourg, its neighbouring countries and for the euro area. For a considerable number of all country index combinations, the persistence parameter ρ is negative, despite the use of quarterly dummies. This may, in part, reflect the impact of end-of-season sales for different indices. Again, it seems that the degree of inflation persistence of the sub-indices of the Luxembourg HICP, in general, is low relative to its neighbouring countries and relative to the euro area in total.

Figure 2: Cumulated distribution of inflation parameter ρ, restricted model



With regard to the optimal lag length, we find that a lag of one quarter is the predominant outcome for the sub-indices of the Luxembourg HICP (approximately 75 percent). The predominance of the 1-quarter lag applies to all countries and country aggregates (Figure 3).

Figure 3: Optimal lag length in quarters, per country, restricted model



One of the key questions in the context of inflation persistence is whether the inflation process follows a unit root. We therefore subject the estimated ρ coefficients to an ADF test, based on $(\rho_{i,k,t-1})$ / s.e.$_{i,k,t}$.[9] Table 2 summarises the results for various critical values. The null hypothesis of a unit root is rejected in 87 percent of cases at the 10 percent level or better. At the 5 percent level of confidence, this share is still 83 percent, while, for almost 3 out of 4 sub-indices of the Luxembourg HICP, we are able to reject the unit root hypothesis at the 1 percent level of confidence. These rejection frequencies provide strong evidence against unit roots for the majority of sub-indices of the Luxembourg HICP. In addition, the rejection rates are relatively high compared to other EU15 countries and higher than those reported by Clark (2003) for the U.S. The ADF test suggests that the idea of inflation exhibiting a unit root does not apply to the large majority of the sub-indices considered in our sample, even despite not allowing for any structural breaks in the mean inflation rate. Some indices, however, appear to exhibit unit roots. As the persistence of aggregate inflation is determined primarily by the properties of the most persistent components, aggregate inflation may nevertheless be characterised by substantial persistence.

Table 2: Unit root test, per country and significance level, in %, restricted model

Level of Significance	EU	EA	BE	DK	DE	GR	ES	FR	IE	IT	LU	NL	AT	PT	SF	SV	UK	All
P-value<0.1	75.3	72.0	70.5	79.8	73.3	80.2	84.4	67.0	77.0	84.5	87.0	80.5	89.2	84.9	90.8	89.2	86.3	80.5
P-value<0.05	71.0	61.3	65.4	70.2	71.1	72.8	75.3	55.7	72.4	76.2	83.1	75.6	85.5	80.2	83.9	85.5	77.5	74.1
P-value<0.01	53.8	46.2	53.8	52.4	60.0	61.7	57.1	40.9	55.2	61.9	72.7	61.0	73.5	57.0	73.6	80.7	65.0	60.2

Note: The critical values are calculated according to MacKinnon (1991) and not adjusted for varying lag lengths.

[9] Here we are only concerned with ρ<1 and ignore the fact that some estimates return ρ<-1. This is the case for about 30 ΣAR coefficients.

Inflation Persistence Based on Mean Reversion

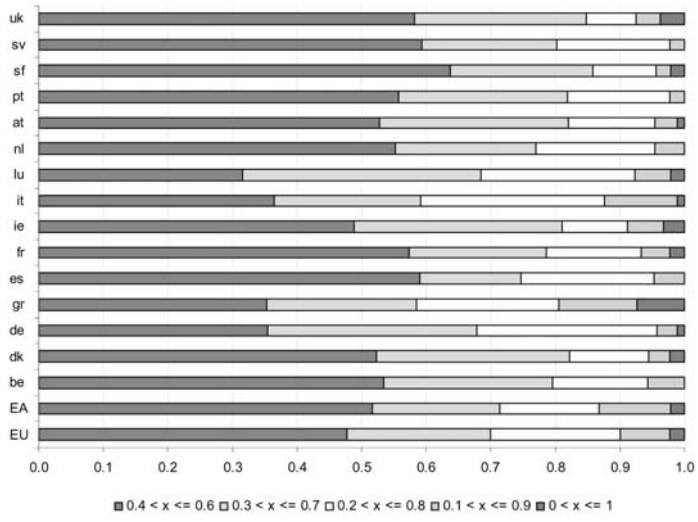
Table 3 presents the summary results with regard to the mean reversion coefficient γ. Our results suggest that, on average, the mean reversion coefficient obtained for the sub-indices of the Luxembourg HICP is relatively close to the expected value under the hypothesis of zero inflation persistence. The mean and the median of γ are 0.55 and 0.59 respectively. The distribution of the mean reversion coefficient γ, however, points to a large degree of heterogeneity across sub-indices within the Luxembourg HICP, as a large fraction of indices reveal a degree of mean reversion at either side of the scale. For example, for 1 out of 3 sub-indices γ falls into the interval ((0.0, 0.3] ∪ (0.7, 1.0]) suggesting that a significant degree of both negative and positive serial correlation is present in the case of some sub-indices (see Figure 4)[10]. This ratio is relatively high compared to that of other EU15 countries, in particular to that of non-euro countries and – to a lesser extent – that of smaller euro area countries.

Table 3: Summary statistics of mean reversion coefficient γ, per country

Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	94	0.52	0.20	0.06	0.50	0.56	0.65	0.78
EA	Euro Area	94	0.56	0.19	0.14	0.50	0.56	0.68	0.83
be	Belgium	88	0.57	0.14	0.35	0.50	0.56	0.68	0.79
dk	Denmark	92	0.51	0.17	0.18	0.43	0.50	0.64	0.74
de	Germany	93	0.63	0.12	0.44	0.56	0.62	0.71	0.79
gr	Greece	88	0.53	0.25	0.00	0.50	0.56	0.72	0.83
es	Spain	83	0.58	0.12	0.44	0.50	0.56	0.68	0.79
fr	France	92	0.55	0.18	0.10	0.50	0.57	0.65	0.80
ie	Ireland	92	0.55	0.18	0.09	0.50	0.59	0.65	0.76
it	Italy	88	0.62	0.15	0.36	0.53	0.64	0.74	0.82
lu	Luxembourg	92	0.55	0.18	0.23	0.41	0.59	0.68	0.82
nl	Netherlands	89	0.56	0.15	0.29	0.50	0.57	0.65	0.76
at	Austria	91	0.56	0.15	0.32	0.50	0.59	0.64	0.75
pt	Portugal	88	0.57	0.12	0.37	0.50	0.56	0.65	0.75
sf	Finland	92	0.51	0.15	0.29	0.44	0.53	0.59	0.72
sv	Sweden	88	0.55	0.15	0.30	0.47	0.56	0.65	0.74
uk	United Kingdom	83	0.46	0.18	0.07	0.43	0.50	0.57	0.67
	All	1527	0.55	0.17	0.21	0.50	0.56	0.67	0.79

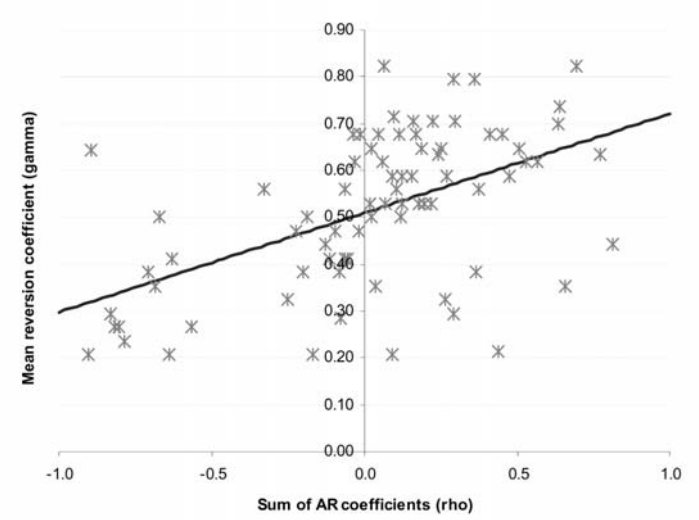
Note: Only the most disaggregated sub-indices are included.

Figure 4: Distribution of mean reversion coefficient γ, per country



[10] As shown by Marques (2004), the critical values of the mean reversion coefficient γ may be derived according to the following property $((\gamma\text{-}0.5)/(0.5/\sqrt{T})) \curvearrowright N(0;1)$, where T+1 is the number of observations. The interval given by $0.3 < x \leq 0.7$ in figure 4 illustrates the "uncritical" interval for the mean reversion coefficient γ assuming a number of 30 observations.

Figure 5: The relationship between mean reversion coefficient γ and ΣAR coefficients - sub-indices of the Luxembourg HICP -



How do these results compare to those obtained by univariate estimation techniques? We analyse to what extent the estimated ΣAR coefficients and the mean reversion indicator γ are correlated (or not). As Dias & Robalo Marques (2004) have shown, there is a monotonic relationship between γ and ρ if the data is generated by an AR(1) process, while for higher order processes this relationship breaks down. As most of our ρ estimates refer to AR(1) processes, we would a priori expect an approximate monotonic relationship between the two indicators. The correlation coefficient between ρ and γ is 0.53 (see Figure 5). The corresponding figure across all country-index combinations from the EU15 countries is 0.42[11]. Thus, a higher ΣAR coefficients generally coincides with a lower frequency of mean reversion. Nevertheless, a given value of the mean reversion parameter γ may yield a wide range of ΣAR coefficients ρ (and vice versa). In the case of the sub-indices from the Luxembourg HICP, for example, for frequently mean-reverting indices (say, $\gamma \approx 0.2$) we find ρ parameters ranging from –0.9 to +0.4 approximately. A simple linear regression approximately matches the values indicating zero persistence according to both indicators (i.e. $\rho = 0$, $\gamma = 0.5$). The explanatory content of the regression is quite low though ($R^2 = 0.28$). The fit provided by a regression using all EU15 country index combinations is $R^2 = 0.18$.

Aggregation effects

The results in the previous section suggest that most disaggregate inflation series are characterised by a low to moderate degree of persistence. However, the estimated parameters vary substantially across indices, and in addition, some indices seem to exhibit unit roots. These results are particularly relevant as heterogeneity in the persistence across stationary disaggregate inflation series may imply a non-stationary inflation process at the aggregate level (e.g. Granger, 1980; Chambers, 1998). Hence, this may imply that the aggregate inflation process is characterised by substantial persistence, in particular as the persistence of aggregate series is primarily determined by the properties of its most persistent components (e.g. Altissimo & Zaffaroni, 2003; Zaffaroni, 2004).

[11] The correlation coefficient increases to 0.63, however, if we restrict the correlation analysis to indices estimated with an AR(1) process and residing within $r \in [-1; 1]$.

In this section, we analyse to what extent inflation persistence is affected by simple aggregation. Clark (2003) has shown for U.S. data that persistence of aggregate inflation series is typically larger than the weighted persistence of the disaggregate inflation series ("positive aggregation effect" hereafter). Furthermore, differences in persistence between the aggregate series and the weighted persistence of the disaggregate series increase with the level of disaggregation.

Table 4 presents the results of the aggregation exercise for different disaggregation levels. The exercise is based on the respective euro area HICP weights (we also used the national HICP weights, but this does not change our results fundamentally. For the ΣAR coefficients, the results do not seem to support the presence of a positive aggregation effect in Luxembourg. Aggregating from level 1 (comprises max. 12 different sub-indices) to the full HICP (level 0) yields a negative aggregation effect. Aggregating from the lowest level of aggregation (comprises max. 94 sub-indices) to the full HICP (level 0) does not indicate a positive aggregation effect for Luxembourg either.

These results are in contrast to the findings for the majority of the EU15 countries, for which we generally find evidence of a positive aggregation effect. Aggregating from level 1 (comprises max. 12 different sub-indices) to the full HICP (level 0), we are able to detect a positive aggregation effect for 10 out of 17 countries. Aggregating from level 2 (comprises max. 39 sub-indices) to the full HICP (level 0), a positive aggregation effect is discernible for 12 out of 17 countries, while aggregating from the lowest level of aggregation 3 (comprises max. 94 sub-indices) to the full HICP (level 0) yields a positive aggregation effect for 11 out of 17 countries.

With regard to the mean reversion coefficient γ, the results are supportive in the case of Luxembourg, but less supportive for the other EU15 countries. For Luxembourg, a positive aggregation effect is detectable regardless of whether we aggregate from level 1, 2 or 3 to level 0, while such an effect can only be detected for more than 50 percent of the countries when aggregating from level 2 to level 0. Furthermore, and in contrast to Clark (2003), our results for both Luxembourg and the other countries do not suggest that the aggregation effect becomes larger as the level of disaggregation is increased (see Table 4 for more details).

Table 4: Difference in weighted persistence estimates, according to level of aggregation

Aggr. Level	EU15	EA	be	dk	de	gr	es	fr	ie	it	lu	nl	at	pt	sf	sv	uk
ΣAR																	
0	0.40	-0.14	-0.33	0.21	-0.16	0.51	-0.50	0.49	0.38	0.23	-0.17	0.28	0.43	0.31	0.07	0.06	0.32
Using EA HICP weights																	
1	0.32	0.26	-0.05	0.11	0.11	0.06	0.04	0.17	0.31	0.28	0.20	0.19	0.12	0.15	-0.01	0.14	0.14
2	0.31	0.25	0.13	0.06	0.26	0.12	0.16	0.14	0.19	0.08	0.04	0.19	0.10	0.19	-0.05	0.08	0.01
3	0.35	0.31	0.15	0.08	0.28	0.16	0.16	0.29	0.25	0.16	0.13	0.20	0.12	0.22	-0.07	0.17	0.14
Using National HICP weights																	
1	0.32	0.26	-0.05	0.13	0.10	0.12	0.05	0.20	0.30	0.25	0.17	0.17	0.08	0.13	0.03	0.13	0.19
2	0.31	0.25	0.16	0.08	0.24	0.25	0.21	0.20	0.23	-0.03	0.07	0.17	0.12	0.34	0.03	0.06	0.15
3	0.35	0.31	0.15	0.08	0.29	0.18	0.19	0.32	0.20	0.05	0.11	0.18	0.08	0.26	0.01	0.18	0.16
γ																	
0	0.41	0.47	0.44	0.38	0.38	0.06	0.35	0.41	0.62	0.47	0.62	0.32	0.56	0.56	0.47	0.18	0.12
Using EA HICP weights																	
1	0.42	0.48	0.53	0.47	0.51	0.40	0.53	0.47	0.53	0.57	0.55	0.45	0.52	0.53	0.47	0.50	0.44
2	0.43	0.46	0.49	0.39	0.52	0.42	0.42	0.45	0.42	0.49	0.46	0.43	0.45	0.45	0.41	0.41	0.34
3	0.53	0.56	0.58	0.48	0.64	0.52	0.53	0.55	0.53	0.61	0.55	0.52	0.55	0.54	0.50	0.51	0.43
Using National HICP weights																	
1	0.42	0.48	0.52	0.48	0.52	0.40	0.53	0.48	0.53	0.55	0.54	0.44	0.50	0.53	0.48	0.51	0.45
2	0.43	0.46	0.52	0.47	0.48	0.50	0.38	0.50	0.54	0.54	0.47	0.415	0.48	0.63	0.50	0.40	0.37
3	0.53	0.56	0.59	0.50	0.65	0.48	0.55	0.57	0.54	0.60	0.55	0.54	0.55	0.57	0.52	0.53	0.46

Note: HICP weights for euro area in 2002. National HICP weights in 2002. Sum of weights vary across countries and aggregation levels, as estimates were not possible for all indices.

Clark (2003) also demonstrated for the U.S. that the weighted median, the weighted average and the weighted 75th percentile are typically larger than their non-weighted counterparts. This result also holds for Luxembourg, as the weighted average, the weighted median and the weighted 75th percentile of the ΣAR coefficients exceed their unweighted counterparts (see Table 5 and Table 6). These results suggest, in general, a relatively high degree of inflation persistence for consumer prices that have a relatively large weight in the EA HICP. This finding may also be observed for the large majority of the EU15 countries as well as for the EU15 and the euro area aggregate. For the mean reversion coefficient γ, we find little evidence for a weighting effect in Luxembourg. For the other EU15 member countries, the evidence is mixed, but in general it is less strong than in the case of the ΣAR coefficients. Overall, aggregation across sub-indices may lead to a higher degree of measured inflation persistence. However, the size and the direction of the aggregation effect do not seem to be as clear-cut as those reported in Clark (2003).

Table 5: Weighted persistence (ΣAR) estimates at the lowest level of disaggregation

	EU	EA	be	dk	de	gr	es	fr	ie	it	lu	nl	at	pt	sf	sv	uk
# Indices	93	93	78	84	90	81	77	88	87	84	77	82	83	86	87	83	80
Minimum	-0.77	-1.33	-1.06	-2.88	-1.85	-1.68	-2.44	-1.61	-1.30	-2.12	-0.90	-1.62	-3.96	-1.16	-2.12	-0.72	-2.51
Maximum	0.88	0.97	0.80	0.88	1.01	0.81	0.88	5.14	0.89	0.85	0.81	1.14	0.58	0.76	0.77	0.72	0.82
25 Percentile	0.02	0.12	-0.09	-0.08	0.14	-0.06	0.01	0.08	0.12	0.05	-0.12	0.00	-0.08	0.02	-0.11	-0.11	-0.14
Median	0.30	0.40	0.26	0.16	0.34	0.17	0.27	0.28	0.25	0.34	0.09	0.27	0.18	0.32	0.08	0.10	0.11
75 Percentile	0.54	0.59	0.44	0.29	0.53	0.44	0.49	0.54	0.42	0.54	0.27	0.44	0.33	0.45	0.23	0.29	0.31
Average	0.27	0.30	0.15	0.01	0.29	0.11	0.18	0.29	0.23	0.22	0.03	0.18	0.04	0.22	-0.05	0.09	0.02
Std.dev	0.34	0.42	0.41	0.58	0.39	0.46	0.51	0.69	0.31	0.49	0.41	0.42	0.58	0.36	0.54	0.32	0.49
Weighted 25 %ile	0.16	0.10	0.03	-0.08	0.18	0.00	-0.02	0.09	0.13	0.06	-0.07	-0.07	-0.09	0.00	-0.04	-0.08	-0.02
Weighted Median	0.40	0.46	0.26	0.16	0.34	0.20	0.33	0.35	0.22	0.39	0.19	0.24	0.21	0.28	0.15	0.22	0.18
Weighted 75 %ile	0.57	0.64	0.54	0.29	0.60	0.49	0.58	0.55	0.42	0.60	0.47	0.44	0.36	0.49	0.29	0.44	0.41
Weighted Average	0.35	0.31	0.15	0.08	0.28	0.16	0.16	0.29	0.25	0.16	0.13	0.20	0.12	0.22	-0.07	0.17	0.14
Cum. Weight	992.2	992.2	927.8	950.4	987.3	933.4	898.1	977.3	947.8	965.3	914.6	861.0	963.6	961.8	971.5	922.3	927.7
Evidence of weighted statistics > unweighted statistics																	
Average	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes
Median	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes
75 %ile	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aggr. persistence	0.40	-0.14	-0.33	0.21	-0.16	0.51	-0.50	0.49	0.38	0.23	-0.17	0.28	0.43	0.31	0.07	0.06	0.32
% persis.<agg. persis.	57.0%	12.9%	14.1%	61.9%	10.0%	81.5%	9.1%	72.7%	67.8%	40.5%	22.1%	53.7%	86.7%	48.8%	48.3%	45.8%	75.0%
Correl(persist., weight	0.19	0.02	0.01	0.11	-0.02	0.09	-0.03	0.00	0.06	-0.11	0.21	0.03	0.13	-0.01	-0.04	0.22	0.22

Note: All results use HICP weights for euro area in 2002. Sum of weights vary across countries and aggregation levels, as estimates were not possible for all indices.

Table 6: Weighted persistence (γ) estimates at the lowest level of disaggregation

	EU	EA	be	dk	de	gr	es	fr	ie	it	lu	nl	at	pt	sf	sv	uk
# Indices	94	94	88	92	93	88	83	92	92	88	92	89	91	88	92	88	83
Minimum	0.00	0.00	0.14	0.00	0.24	0.00	0.29	0.00	0.00	0.18	0.21	0.00	0.00	0.18	0.00	0.00	0.00
Maximum	0.82	0.88	0.88	0.91	0.91	0.94	0.85	0.83	0.88	0.91	1.00	0.83	0.97	0.82	0.81	0.83	0.77
25 Percentile	0.50	0.50	0.50	0.43	0.56	0.50	0.50	0.50	0.50	0.53	0.41	0.50	0.50	0.50	0.44	0.47	0.43
Median	0.56	0.56	0.56	0.50	0.62	0.56	0.56	0.57	0.59	0.64	0.59	0.57	0.59	0.56	0.53	0.56	0.50
75 Percentile	0.65	0.68	0.68	0.64	0.71	0.72	0.68	0.65	0.65	0.74	0.68	0.65	0.64	0.65	0.59	0.65	0.57
Average	0.52	0.56	0.57	0.51	0.63	0.53	0.58	0.55	0.55	0.62	0.55	0.56	0.56	0.57	0.51	0.55	0.46
Std.dev	0.20	0.19	0.14	0.17	0.12	0.25	0.12	0.18	0.18	0.15	0.18	0.15	0.15	0.12	0.15	0.15	0.18
Weighted 25 %ile	0.50	0.50	0.50	0.41	0.56	0.52	0.50	0.50	0.50	0.53	0.44	0.47	0.50	0.50	0.44	0.50	0.43
Weighted Median	0.57	0.56	0.57	0.50	0.65	0.58	0.56	0.57	0.56	0.63	0.59	0.56	0.62	0.56	0.53	0.59	0.50
Weighted 75 %ile	0.68	0.68	0.71	0.62	0.76	0.70	0.65	0.70	0.65	0.76	0.68	0.71	0.65	0.68	0.59	0.62	0.53
Weighted Average	0.53	0.56	0.59	0.48	0.64	0.53	0.56	0.55	0.54	0.62	0.55	0.54	0.55	0.56	0.50	0.53	0.45
Cum. Weight	998.9	998.9	984.1	996.3	998.9	979.7	943.0	996.3	974.7	982.8	992.9	963.0	996.8	970.5	996.3	960.9	947.1
Evidence of weighted statistics > unweighted statistics																	
Average	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	No	No	No	No	No	No	No	No
Median	Yes	No	Yes	No	Yes	Yes	No	Yes	No	No	No	No	Yes	No	No	Yes	No
75 %ile	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	No	No	No
Aggr. persistence	0.41	0.47	0.44	0.38	0.38	0.06	0.35	0.41	0.62	0.47	0.62	0.32	0.56	0.56	0.47	0.18	0.12
% persis.<agg. persis.	17.0%	17.0%	11.4%	14.1%	3.2%	8.0%	3.6%	12.0%	60.9%	10.2%	54.3%	6.7%	40.7%	40.9%	30.4%	2.3%	8.4%
Correl(persis., weight)	0.04	0.01	0.13	-0.15	0.11	0.01	-0.12	0.02	-0.04	-0.02	-0.02	-0.11	-0.04	-0.06	-0.06	-0.08	-0.06

Note: All results use HICP weights for euro area in 2002. Sum of weights vary across countries and aggregation levels, as for some indices no estimates were obtained

IV. STRUCTURAL BREAKS

As discussed by Perron (1990) and implemented by Levin & Piger (2004) and Batini (2002) and others, the restriction of not allowing structural breaks may result in misleadingly high inflation parameter estimates. While the above reported summary statistics indicate only a moderate degree of inflation persistence in Luxembourg, we nevertheless allow for structural breaks in the series in the later sections. This is motivated by the different degree to which EU15 countries may have been affected by the two major innovations that occurred during the time period under investigation in Luxembourg; the adoption of sales prices in the HICP price collection and the dawn of EMU Stage III at the beginning of 1999.

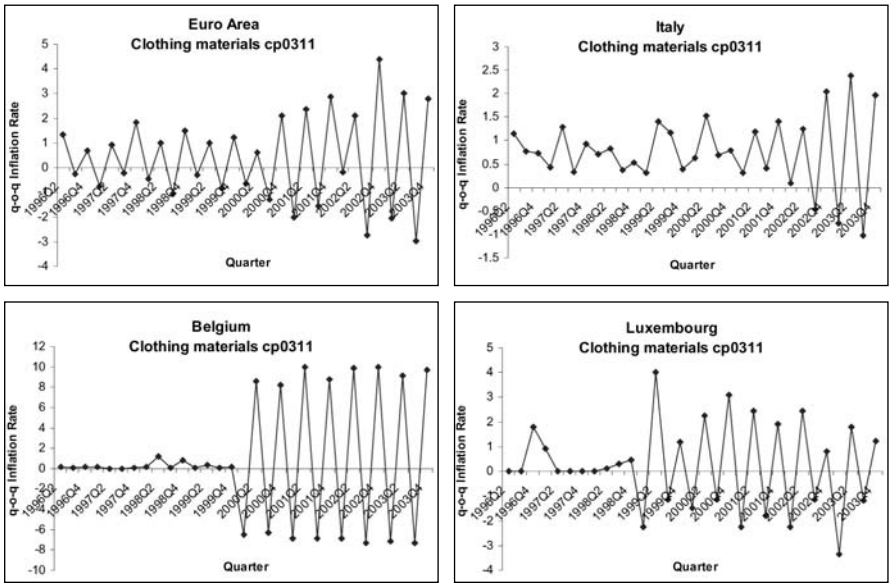
a. A different treatment of sales: A methodological change resulting in structural breaks?

The implementation of further harmonisation rules for the HICP indices within the EU15 has led to methodological changes in some countries in recent years. One important modification results from the implementation of a European Commission Regulation on the treatment of price reductions in the national indices, in particular due to seasonal sales. Prices of selected goods (such as clothing and footwear, furnishings, household equipment and durables) are typically affected by end-of season sales in January/February and July/August. The Luxembourg national statistical institute includes seasonal sales price reductions since 2000. Most EU15 countries' national statistical institutes (i.e. Austria, Denmark, Finland, France, Greece, Netherlands, Portugal, Sweden and The United Kingdom) had already taken account of sales prices in 1995. Other national statistical institutes followed suit over the years 1999 (Germany, Portugal), 2000 (Ireland) and 2001 (Belgium). The introduction of this practice in the HICP for Italy and Spain in January 2002 represented the last step of this harmonisation process within the EU15[12].

For the purpose of illustration, Figure 6 reports the quarterly inflation rates of the HICP sub-index "*cp0311 Clothing materials*" for Luxembourg as well as for Belgium, the euro area and Italy. In the case of Luxembourg, the modified treatment of sales prices is not only clearly visible, but the time series properties change fundamentally too. In fact, the q-o-q inflation rate oscillates around the mean without necessarily approaching it, thereby boosting the volatility of the series. Importantly, in the context of the present study, the impact of sales prices can vary across member states depending not only on the nature, the date and the duration of price reductions, but also on the exact timing of the HICP data collection within a single month. As shown by figure 6, these methodological changes may also affect the properties of the inflation process at the aggregate euro area level.

[12] When member states introduce price reductions in the index, they are also required to revise HICP data for the previous 12 months in order to avoid a distortion of the annual rate of change (e.g. ECB, 2002).

Figure 6: The effect of the HICP methodological revision



Not taking account of the harmonisation of the treatment of price reductions may distort the estimation of the ΣAR coefficients. Due to oscillating behaviour, the lagged inflation coefficients may cancel out. Hence, inferring the degree of inflation persistence from the estimated ΣAR coefficients and comparing them across countries as well as across sub-indices may be misleading. The poor signalling properties of the ΣAR coefficients in these cases have also been acknowledged by Andrews & Chen (1994). In the Appendix, we compute a different measure based on Cumulated Impulse Response Functions (CIRF) and illustrate how oscillating inflation impacts on the measured degree of persistence.

Among the 94 most disaggregated HICP sub-indices for Luxembourg, we would a priori expect 25 indices to be affected by end-of season sales. These potentially affected HICP sub-indices mainly refer to the aggregates of "*cp03 Clothing and footwear*", "*cp05 Furnishings, household equipment and routine maintenance of the house*", "*cp09 Recreation and culture*" and "*cp123 Personal effects n.e.c.*" with the exception of services, such as "*cp0314 Cleaning, repair and hire of clothing*" or "*cp0923 Maintenance and repair of other major durables for recreation and culture*". In 2002, the total weight of the indices considered affected by seasonal sales as a fraction of the Luxembourg HICP had been approximately 20.7 percent, which is slightly lower than the corresponding figures for the euro area and the EU15 aggregates (22 percent approximately). The indices considered and their weights in the Luxembourg HICP (next to the weights for the euro area and the EU15) are presented in Table 7.

Table 7: Description of indices considered being affected by the modified treatment of sales

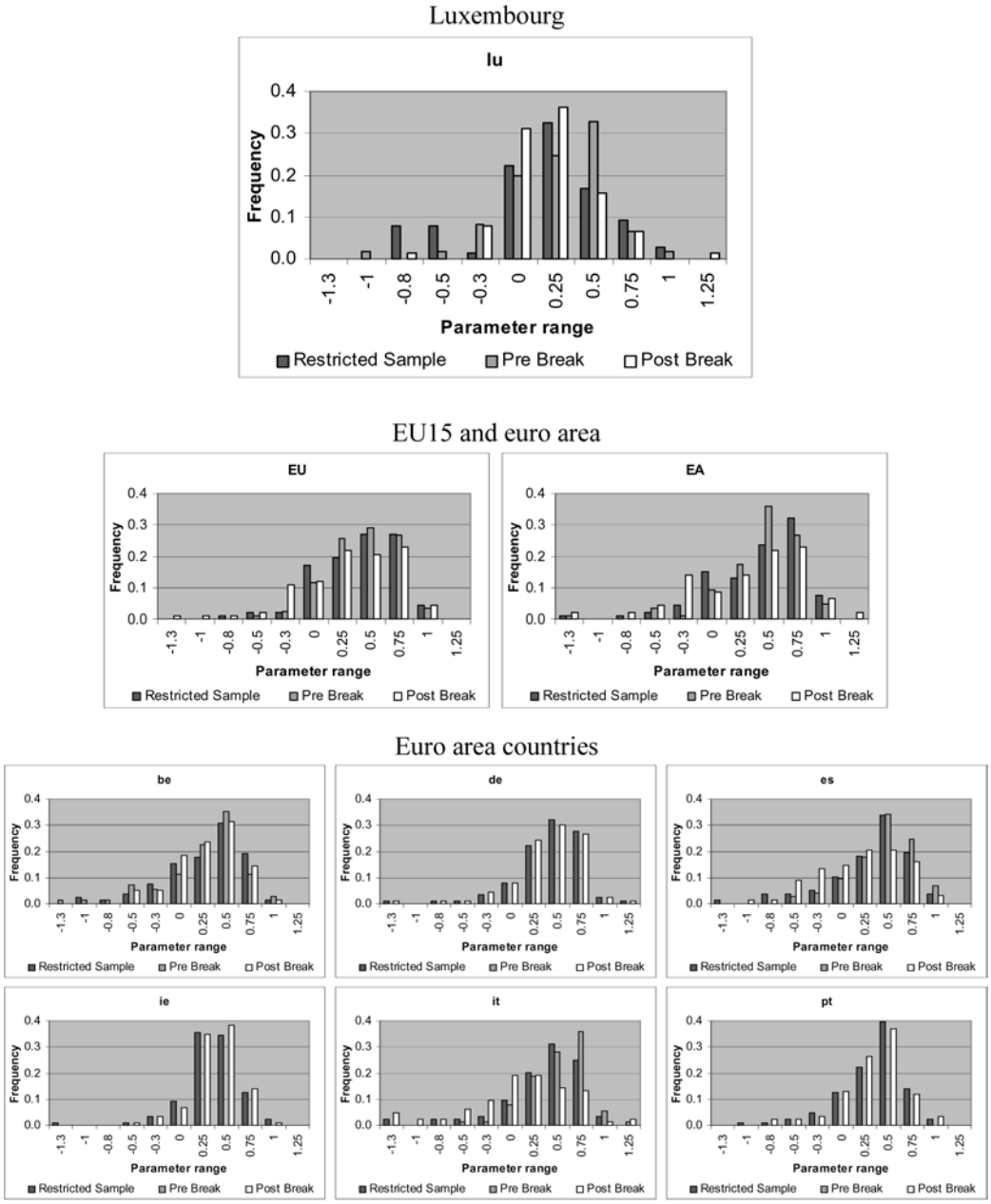
	HICP Description	Luxembourg	EU15	Euro area
cp0311	Clothing materials	0.1	0.29	0.33
cp0312	Garments	45.5	55.06	56.4
cp0313	Other articles of clothing & clothing accessories	1.8	2.42	2.29
cp032	Footwear including repair	12.2	14.7	16.21
cp0511	Furniture & furnishings	28.1	27.01	28.36
cp0512	Carpets & other floor coverings	4	3.51	2.83
cp052	Household textiles	8.3	6.72	6.45
cp0531_532	Major househ. appl. whether elec. or not & small elec. househ. appl.	9.2	10.17	10.73
cp054	Glassware, tableware & household utensils	8.4	6.42	6.14
cp055	Tools & equipment for house & garden	6.5	4.71	4.57
cp0561	Non-durable household goods	13.6	9.26	10.19
cp0911	Equipment for the reception, recording & reproduction of sound & pictures	3.7	6.44	6.17
cp0912	Photographic & cinematographic equipment & optical instruments	1.4	2.27	1.75
cp0913	Information processing equipment	4.5	4.53	4.18
cp0914	Recording media	3.7	5.43	4.28
cp0921_922	Major durables for in- & outdoor recreation incl. musical instruments	2.7	3.57	2.62
cp0931	Games, toys and hobbies	3.4	6.6	4.31
cp0932	Equipment for sport, camping and open-air recreation	1.3	3.2	2.8
cp0933	Gardens, plants and flowers	10.3	6.28	6.24
cp0934_935	Pets and related products; veterinary and other services for pets	4.5	5.21	4.8
cp0951	Books	4.8	6.4	6.71
cp0953_954	Miscellaneous printed matter; stationery and drawing materials	3.4	3.98	3.22
cp096	Package holidays	14.7	18.03	15.52
cp1231	Jewellery, clocks and watches	5.7	5.71	5.5
cp1232	Other personal effects	5.2	5.36	6.12
Total		**207.00**	**223.28**	**218.72**

Note: Weights refer to 2002.

As we do not know whether we correctly identified the indices affected by end-of-season sales, we split the sample of each sub-index at the respective date and we estimate the sub-samples separately. The obtained persistence estimates will be referred to as "unrestricted" or "unconstrained" estimates. Since the date of the potential break is known (namely January 1999), we use a Chow test in order to assess the presence of an overall structural break in the inflation process.[13] We expect to obtain confirmation of a structural break for the sub-indices being substantially affected by end-of-season sales.

[13] For those countries that adopted sales prices at an earlier or later stage, the break point test is applied according to the date from which onwards sales prices were included, respectively. For the EU15 and the euro area, we chose to use the break date of 2001Q1, as by then all countries had adopted the HICP methodology revision. The countries having adopted the sales prices from the outset are not considered.

Figure 7: Distribution of inflation parameter ρ prior and after the HICP methodology revision



Note: The graphs show the distribution of the restricted model, the unrestricted model (sub-period prior and after the structural break) **regardless of whether the Chow break point test is significant or not**. The countries not shown, i.e. Greece, France, The Netherlands, Austria, Finland, Denmark, Sweden, and The United Kingdom adopted sales prices from the outset, and thus are not included in the figure.

Figure 7 shows a clear leftward shift in the frequency distribution of the ΣAR coefficients in Luxembourg after 1999.[14] Whereas the share of the inflation persistence parameter ρ within the

[14] In Luxembourg (as well as in Ireland), the date of the implementation of the modified treatment of sales coincided with the inception of the single monetary policy. Therefore, the possible impacts of the introduction of sales prices into the HICP and of the inception of EMU stage III may superimpose and may not be assessed separately. For the purpose of cross-country comparability, we apply break tests for both the date of the sales price adoption and the date of the inception of the single monetary policy. Obviously, structural breaks may also emanate for reasons other than those considered here.

interval (0, 0.5] increases substantially, the opposite is the case for the interval (0.5, 0.75]. A similar effect may be observed for most of the other EU15 countries concerned by the implementation of the regulation on the treatment of price reductions. This shift is to a lesser extent also visible for the EU15 and the euro area. Comparing Table 8 with Table 1, we observe that the median ΣAR coefficients falls from 0.09 for the entire sample to 0.05 in Luxembourg. For all countries, which adopted sales prices in their HICP collection during the sample period (except for Germany and Ireland), the median of the post sales sample is below the median of the restricted estimations.

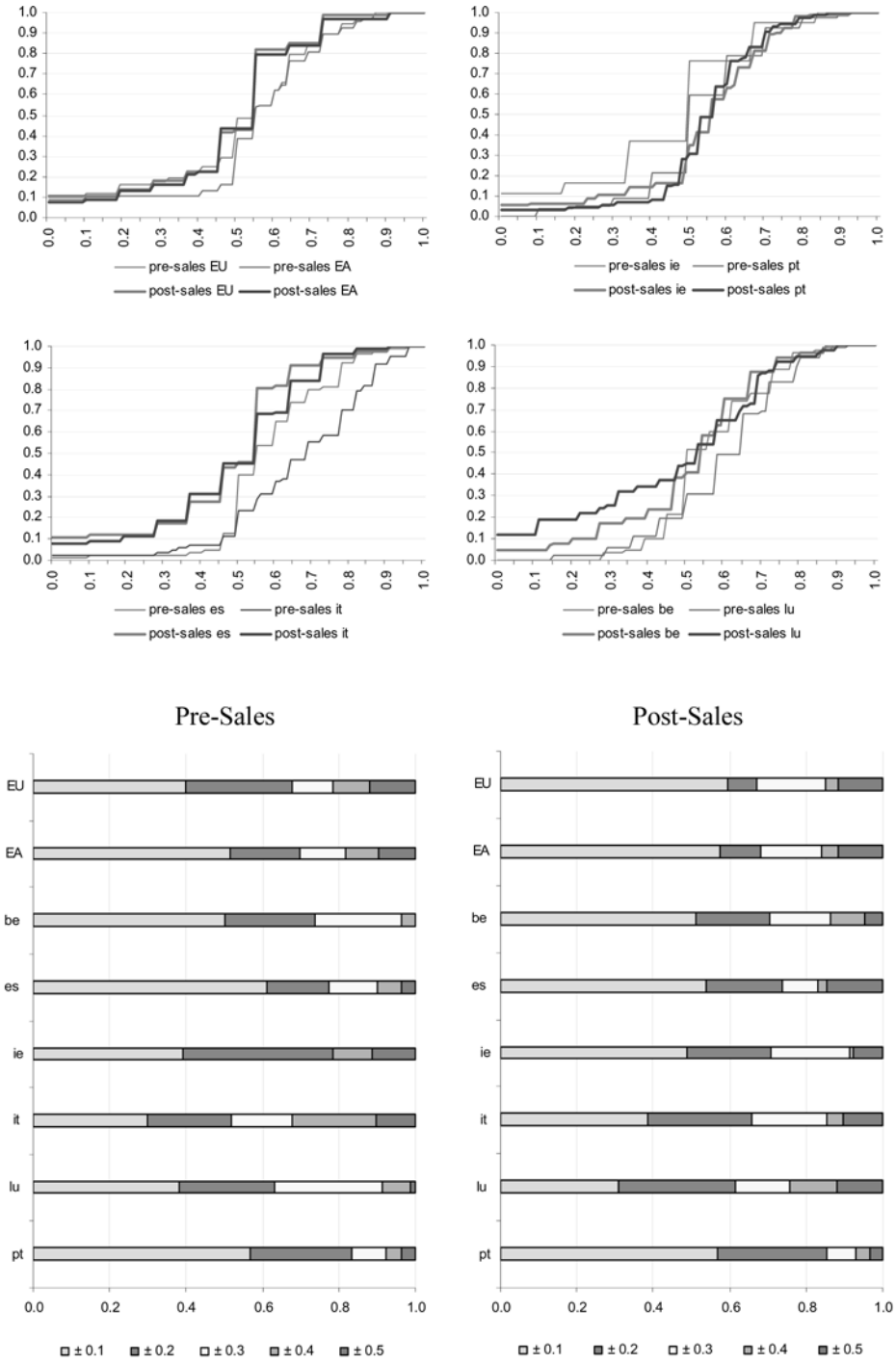
Table 8: Descriptive statistics of inflation persistence parameter ρ per country, for post HICP revision period

Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	92	0.21	0.50	-0.54	-0.02	0.25	0.55	0.79
EA	Euro Area	92	0.19	0.58	-0.68	-0.10	0.29	0.55	0.93
be	Belgium	76	0.18	0.33	-0.47	-0.02	0.23	0.41	0.62
dk	Denmark								
de	Germany	90	0.28	0.40	-0.38	0.11	0.34	0.55	0.71
gr	Greece								
es	Spain	68	0.07	0.45	-0.64	-0.26	0.15	0.43	0.64
fr	France								
ie	Ireland	86	0.26	0.27	-0.22	0.14	0.27	0.40	0.70
it	Italy	83	0.05	0.81	-1.24	-0.26	0.05	0.38	1.09
lu	Luxembourg	77	0.08	0.29	-0.32	-0.10	0.05	0.24	0.54
nl	Netherlands								
at	Austria								
pt	Portugal	84	0.21	0.35	-0.41	0.05	0.29	0.44	0.65
sf	Finland								
sv	Sweden								
uk	United Kingdom								
	All								

Note: The estimated parameters are taken at face value and are not treated as zeros in case of statistical insignificance.

How does the different treatment of sales prices impact on the mean reversion indicator γ? As shown by Figure 8, overall, the fraction of sub-indices close to 0.5 diminishes after inclusion of seasonal sales prices. On the contrary, a larger number of sub-indices of the Luxembourg HICP reveal a relatively large deviation from the expected value under the assumption of no serial correlation. Figure 8 illustrates a strong increase in the number of frequently mean-crossing indices (i.e. γ close to 0). For example, whereas prior to the inclusion of sales prices a mean crossing was observed in at least 1 out of 2 months for 30 percent of all the sub-indices of the Luxembourg HICP, their share increased to roughly 45 percent after the adoption of sales prices. Again, a similar effect can be observed for the other countries concerned. It seems that the impact of the sales price adoption has been relatively strong in Luxembourg. On average, the share of indices with a mean reversion coefficient $\gamma < 0.1$ rises from 3.3 percent prior to the revision to 7.8 percent after the revision. In Luxembourg, this share rises from 0 to 12 percent. On the contrary, in Luxembourg, the fraction of indices with infrequent mean crossings diminishes after the modified treatment of sales prices. As illustrated by the lower panels in Figure 9, the number of indices with sizeable deviations from 0.5 increases, thus, implying (ceteris paribus) a higher rejection frequency of the null of zero persistence for Luxembourg price indices. With the exception of Italy and Portugal, a similar effect is observed for other countries.

Figure 8: Distribution of mean reversion indicator γ prior and after the HICP revision



The above-presented unconstrained results did not take into account as to whether an overall structural break is present in the data. In the following, the presence of a structural break is assessed by means of the Chow test. Additionally, in order to explore the source of a structural break, a Wald-test is applied to the ΣAR coefficients and the intercept. Lastly, we also provide a one-sided F-test on the standard deviations of the sub-samples prior and after the HICP revision date for the respective country. In each case, we distinguish between indices that we, a priori, consider to be affected by the HICP revision ("sales indices" hereafter) from those that

are considered unaffected by end-of-season sales ("non-sales indices" hereafter). The results are summarised in Table 9. As a critical rejection value we use the 5 percent level of confidence.

Table 9: Frequency of structural breaks, per country, in percent

	EU	EA	BE	DK	DE	GR	ES	FR	IE	IT	LU	NL	AT	PT	SF	SV	UK	All
Break Date	**2001**	**2001**	**2000**		**1998**		**2001**		**1999**	**2001**	**1999**			**1998**				
Chow Break point test																		
All Indices	65.1	64.0	45.6				70.8			57.3	49.2							
Sales Indices	72.0	60.0	65.2				95.2			68.0	78.3							
Non-sales indices	62.3	65.6	35.6				59.1			52.0	31.6							
Wald-test on Change in ΣAR coefficients																		
All Indices	9.3	10.5	11.4				20.0			21.3	4.9							
Sales Indices	16.0	4.0	4.0				33.3			28.0	8.7							
Non-sales indices	6.6	13.1	15.6				13.6			18.0	2.6							
Wald-test on Change in intercept																		
All Indices	16.3	11.6	10.6				15.6			20.0	30.5							
Sales Indices	40.0	24.0	23.8				35.0			32.0	52.4							
Non-sales indices	6.6	6.6	4.4				6.8			14.0	18.4							
One-sided non-param. F-test: Std. dev S_2 (post-break) > Std. dev. S_1 (pre break): $F(n_1/(n_1-1))\ S_1^2 / ((n_2/(n_2-1))\ S_2^2)\ ,\ n_1-1,\ n_2-1)$																		
All Indices	19.8	33.7	38.7		39.1		36.2		38.0	17.1	58.0			21.5				
Sales Indices	32.0	48.0	40.0		60.0		66.7		32.0	32.0	68.0			30.4				
Non-sales indices	14.8	27.9	38.0		30.6		22.9		40.7	10.5	53.6			17.9				

Note: A break is identified with a p-value ≤ 0.05.

The hypothesis of no overall structural break is rejected for approximately 1 out of 2 sub-indices of the Luxembourg HICP. The frequency of rejection seems to be relatively low compared to the other countries concerned by the sales price adoption (except for Belgium) and relative to the aggregates EU15 and euro area (both 65 percent approximately). The corresponding shares for Italy and Spain are 71 and 57 percent. Our results indeed suggest a higher rejection frequency in the case of sales indices. Whereas the hypothesis of no structural break is rejected for the large majority of the sub-indices of the Luxembourg HICP considered affected by end-of-season sales (78.3 percent), it is only rejected for about 3 out of 10 non-sales indices. With a rejection frequency more than two ½ times as high for sales indices than for non-sales indices, the Chow tests provide strong support for the notion that the HICP methodology revision affected the overall time series properties of some inflation series of the Luxembourg HICP. A similar picture emanates in the case of Belgium, Spain and Italy. The difference in the rejection frequencies between sales indices and non-sales indices is, however, not as strong as in Luxembourg. For the EU15 and the euro area, no clear-cut differences are observed between sales indices and non-sales indices. This may be related to the "artificial" choice of the break test date.

In a second step, we analyse the source of the structural breaks identified in step 1. We apply the Wald-test to the ΣAR coefficients and to the intercept. In addition, we test whether the structural breaks are due to differences in the variance of the two sub-samples. The following results emanate: First, the rejection frequency is much lower for the two Wald-tests than for the Chow test. Second, for a large number of sub-indices of the Luxembourg HICP, we reject the hypothesis of an identical variance of the inflation process. Again, the rejection frequency is larger for the sales indices than for the non-sales indices. A similar pattern applies to most of the other countries (except for Ireland). Third, the Wald-tests suggest that structural breaks primarily relate to the intercept (approximately 1 out of 3 sub-indices of the Luxembourg HICP),

while we find little evidence for structural breaks in the ΣAR coefficients (roughly 1 out of 20 sub-indices). The frequency of rejecting the hypothesis of no structural break in the intercept is approximately three times larger for sales indices (52.4 percent) than for non-sales indices (18.4 percent). In the case of the EU15, the rejection frequency is even approximately 6 times larger for sales indices than for non-sales indices. Whereas the general pattern described above holds for most of the other countries, the EU15 and the euro area, it seems that the rejection frequencies are particularly large and that the distinction between sales indices and non-sales indices is particularly relevant in Luxembourg. All in all, these results suggest that the introduction of sales prices may have been a driving factor for structural breaks in the respective inflation series. Whether the breaks emanating from this factor are stronger than those emanating from the shift in the monetary regime cannot be answered conclusively. However, given the stronger evidence of a structural break for sales price indices we may argue that the introduction of seasonal sales has substantially altered the inflation processes.

Table 10 synthesises the implications of the HICP methodology revision with respect to the estimated inflation persistence. For each index, if the Null of no structural break is not rejected, then we use the inflation persistence estimate ρ of the regression referring to the full sample. If the Null is rejected at the 5 percent level or better, the different ρ estimates relate to the respective sub-samples. The median and mean level of ρ decreases after the introduction of sales prices in the Luxembourg HICP. In addition, the volatility of ρ across the sub-indices of the Luxembourg HICP decreases. Whereas the idea of a lower degree of persistence extends to both the euro area and the EU15, we find that the volatility of ρ became more pronounced after the breaks in the case of both the EU15 and the euro area.

Table 10: Statistics of inflation persistence parameter ρ per country, unrestricted model

Pre-sales sample

Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	93	0.31	0.30	-0.18	0.13	0.33	0.54	0.73
EA	Euro Area	93	0.32	0.37	-0.28	0.16	0.37	0.57	0.77
be	Belgium	78	0.11	0.42	-0.74	-0.05	0.20	0.39	0.65
dk	Denmark	84	0.01	0.58	-1.02	-0.08	0.16	0.29	0.55
de	Germany	90	0.29	0.39	-0.33	0.14	0.34	0.53	0.73
gr	Greece	81	0.11	0.46	-0.76	-0.06	0.17	0.44	0.72
es	Spain	77	0.30	0.34	-0.46	0.14	0.36	0.56	0.75
fr	France	88	0.29	0.69	-0.54	0.08	0.28	0.54	0.83
ie	Ireland	87	0.23	0.31	-0.33	0.12	0.25	0.42	0.65
it	Italy	84	0.36	0.32	-0.19	0.17	0.43	0.61	0.75
lu	Luxembourg	77	0.15	0.36	-0.43	-0.03	0.16	0.34	0.64
nl	Netherlands	82	0.18	0.42	-0.60	0.00	0.27	0.44	0.68
at	Austrria	83	0.04	0.58	-0.73	-0.08	0.18	0.33	0.51
pt	Portugal	86	0.22	0.36	-0.40	0.02	0.32	0.45	0.68
sf	Finland	87	-0.05	0.54	-1.20	-0.11	0.08	0.23	0.50
sv	Sweden	83	0.09	0.32	-0.47	-0.11	0.10	0.29	0.61
uk	United Kingdom	80	0.02	0.49	-0.85	-0.14	0.11	0.31	0.53
	All	1433	0.18	0.46	-0.58	-0.01	0.24	0.44	0.70

Post-sales sample

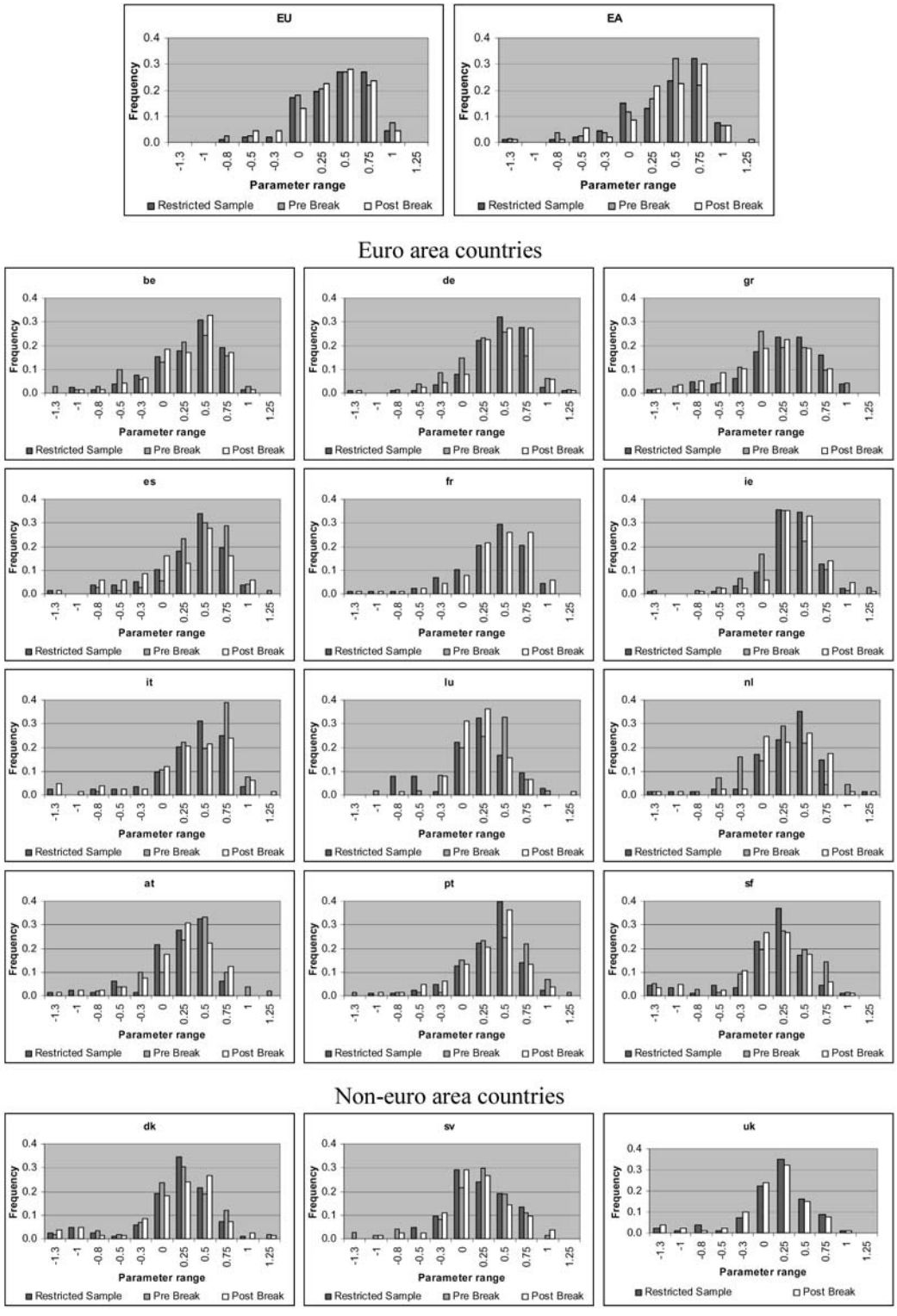
Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	93	0.22	0.45	-0.54	-0.01	0.23	0.51	0.75
EA	Euro Area	93	0.21	0.52	-0.67	-0.09	0.29	0.55	0.92
be	Belgium	78	0.20	0.38	-0.56	-0.02	0.27	0.44	0.68
dk	Denmark	84	0.01	0.58	-1.02	-0.08	0.16	0.29	0.55
de	Germany	90	0.29	0.39	-0.33	0.14	0.34	0.53	0.73
gr	Greece	81	0.11	0.46	-0.76	-0.06	0.17	0.44	0.72
es	Spain	77	0.12	0.45	-0.62	-0.23	0.21	0.46	0.74
fr	France	88	0.29	0.69	-0.54	0.08	0.28	0.54	0.83
ie	Ireland	87	0.23	0.31	-0.33	0.12	0.25	0.42	0.65
it	Italy	84	0.14	0.69	-1.16	-0.18	0.23	0.50	0.75
lu	Luxembourg	77	0.08	0.30	-0.35	-0.08	0.07	0.27	0.58
nl	Netherlands	82	0.18	0.42	-0.60	0.00	0.27	0.44	0.68
at	Austria	83	0.04	0.58	-0.73	-0.08	0.18	0.33	0.51
pt	Portugal	86	0.22	0.36	-0.40	0.02	0.32	0.45	0.68
sf	Finland	87	-0.05	0.54	-1.20	-0.11	0.08	0.23	0.50
sv	Sweden	83	0.09	0.32	-0.47	-0.11	0.10	0.29	0.61
uk	United Kingdom	80	0.02	0.49	-0.85	-0.14	0.11	0.31	0.53
	All	1433	0.14	0.49	-0.65	-0.05	0.21	0.43	0.70

Note: Only the most disaggregated sub-indices are considered. The estimated parameters are taken at face value and are not treated as zeros in case of statistical insignificance. **The summary statistics are based on the unrestricted model. In cases where no overall structural break was found, the parameter estimates of the restricted model are assumed to hold. The values for France and the UK are identical as due to data limitations no structural break tests could be performed.**

b. Structural breaks due to EMU?

In contrast to the introduction of sales into the HICP by national statistical institutes, the inception of Stage III constitutes a general shift to a new monetary regime potentially affecting the full set of price indices in all euro area countries. Similar to the modified treatment of sales prices, we allow for both a break in the intercept and in the ΣAR coefficients. The sample split date is 1999Q1. Figure 9 below presents three different distributions for the inflation persistence parameter ρ based on the most disaggregated sub-indices. The first distribution reflects the results of the ΣAR coefficients in the restricted regression, assuming the absence of a structural break in the inflation series. These were already presented in a more aggregate form in Figure 1. The second and third distributions present the inflation parameters estimated for the respective sub-samples.

Figure 9: Distribution of inflation parameter ρ before and after EMU



Note: The graphs show the distribution of the restricted model, the unrestricted model (sub-period prior and after the structural EMU break) **regardless of whether the Chow break point test is significant or not**. For France and The United Kingdom, the separate estimation of the pre EMU period was not possible due to the lack of a sufficient number of observations.

Given that in Luxembourg the modified treatment of sales prices and the inception of the single monetary policy coincided in January 1999, the panel of Figure 9 in case of Luxembourg is equivalent to the one presented in Figure 7. Figure 9 indicates that the change in the monetary regime does not impact on the distribution of ρ in a uniform direction across countries. Contrary to our results for Luxembourg (but also Austria, Finland, Greece, Italy, Portugal and Spain), where we find both a lower mean and median of ρ after 1999, we observe find an increase of both the mean and the median ρ for Belgium, Germany, Ireland and The Netherlands. Conflicting signals are observed for the non-euro area countries Denmark and Sweden (see Table 11).[15]

Table 11: Summary statistics of inflation persistence parameter ρ per country

Pre-EMU sample

Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	78	0.26	0.37	-0.28	0.02	0.30	0.57	0.78
EA	Euro Area	78	0.24	0.47	-0.75	0.07	0.36	0.56	0.77
be	Belgium	70	0.08	0.52	-0.78	-0.17	0.16	0.44	0.72
dk	Denmark	59	0.10	0.45	-0.56	-0.12	0.10	0.33	0.69
de	Germany	82	0.21	0.39	-0.49	-0.03	0.24	0.49	0.80
gr	Greece	73	0.06	0.59	-0.70	-0.11	0.05	0.35	0.76
es	Spain	73	0.32	0.36	-0.41	0.14	0.32	0.58	0.75
fr	France								
ie	Ireland	77	0.13	0.41	-0.45	-0.03	0.13	0.36	0.71
it	Italy	67	0.37	0.34	-0.12	0.10	0.46	0.63	0.76
lu	Luxembourg	61	0.18	0.40	-0.33	-0.06	0.21	0.40	0.60
nl	Netherlands	69	0.03	0.41	-0.56	-0.26	0.07	0.30	0.62
at	Austria	51	0.21	0.41	-0.50	0.01	0.27	0.42	0.84
pt	Portugal	73	0.44	1.45	-0.18	0.01	0.31	0.53	0.83
sf	Finland	77	0.03	0.51	-0.93	-0.15	0.09	0.36	0.63
sv	Sweden	74	0.06	0.47	-0.78	-0.10	0.08	0.30	0.67
uk	United Kingdom								
	All	1062	0.18	0.58	-0.60	-0.04	0.20	0.46	0.76

Post-EMU sample

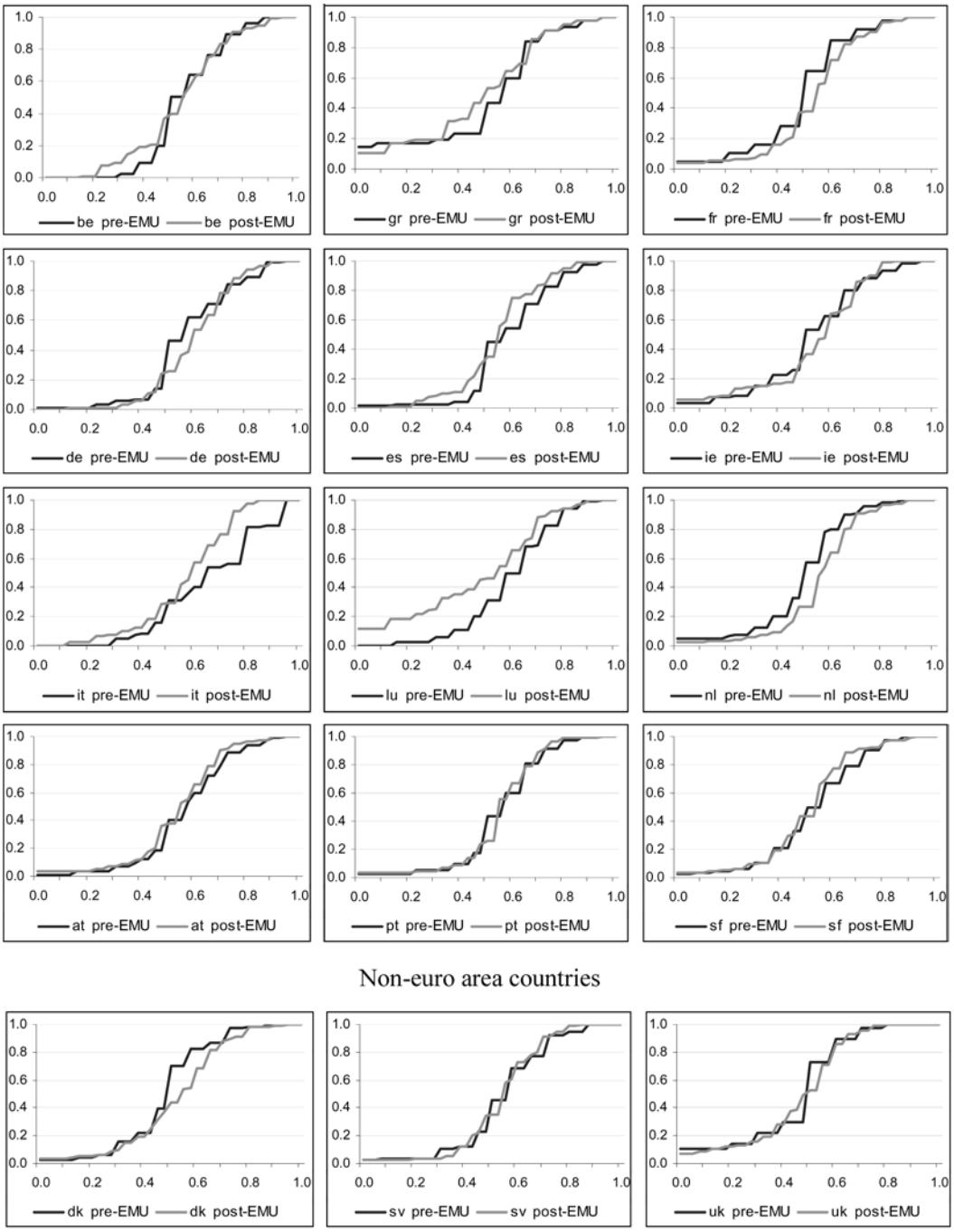
Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	93	0.26	0.36	-0.47	0.03	0.32	0.52	0.74
EA	Euro Area	93	0.29	0.43	-0.57	0.10	0.37	0.57	0.77
be	Belgium	76	0.16	0.37	-0.56	-0.03	0.27	0.46	0.60
dk	Denmark	83	0.09	0.94	-1.12	-0.11	0.18	0.35	0.64
de	Germany	88	0.30	0.40	-0.42	0.11	0.39	0.59	0.76
gr	Greece	58	-0.08	0.52	-0.86	-0.40	0.02	0.30	0.55
es	Spain	69	0.10	0.55	-0.85	-0.12	0.23	0.48	0.77
fr	France	88	0.33	0.70	-0.51	0.07	0.32	0.56	0.83
ie	Ireland	85	0.27	0.33	-0.36	0.10	0.29	0.41	0.80
it	Italy	83	0.16	0.63	-1.03	-0.02	0.29	0.57	0.81
lu	Luxembourg	77	0.08	0.29	-0.32	-0.10	0.05	0.24	0.54
nl	Netherlands	81	0.16	0.44	-0.42	-0.06	0.24	0.45	0.63
at	Austria	81	0.02	0.59	-0.80	-0.10	0.13	0.31	0.60
pt	Portugal	83	0.19	0.39	-0.67	-0.03	0.27	0.45	0.63
sf	Finland	86	-0.04	0.56	-1.18	-0.23	0.03	0.25	0.53
sv	Sweden	83	0.06	0.39	-0.55	-0.17	0.04	0.30	0.68
uk	United Kingdom	80	-0.02	0.51	-1.06	-0.13	0.07	0.23	0.58
	All	1387	0.15	0.53	-0.71	-0.06	0.21	0.45	0.71

Note: The estimated parameters are taken at face value and are not treated as zeros in case of statistical insignificance.

[15] Note that, due to an insufficient number of observations, no pre-EMU estimates are obtained for France and for the UK.

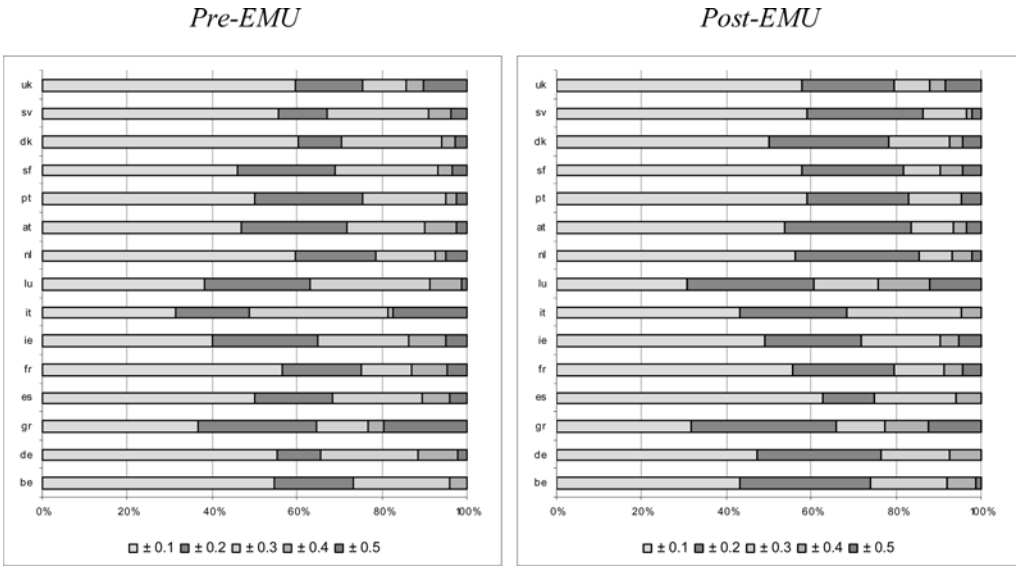
Similar to the autoregressive coefficients, the shift in the monetary regime seems to have affected the frequency of mean crossing in different ways. In Figure 10, we compare the cumulative distribution of the frequency of mean crossings across countries. First, comparing the results with Figure 8, we observe similarities for those countries which we analysed with respect to the inclusion of sales prices into the HICP (e.g., Belgium, Italy and Spain). This is due to the relatively small lag between the two sample split dates. The remaining countries do not show any clear-cut changes in the cumulative distribution.

Figure 10: Distribution of mean reversion coefficient γ before and after EMU



In order to analyse the implications of the beginning of Stage III on the Null of zero persistence, Figure 11 illustrates the distribution of deviations of the mean reversion coefficient γ from 0.5. In contrast to Luxembourg, we observe an increased share of smaller deviations from 0.5 in the case of Austria, Finland, Italy, Portugal and Spain. To a smaller extent, a similar tendency may be observed for Sweden. These results are indicative of a lower degree of inflation persistence in these countries after 1999.

Figure 11: Distribution of deviations of γ from 0.5 before and after EMU



We have contrasted the results between the pre-EMU and the post-EMU period, but have not yet addressed the significance of structural breaks. As done for sales, we compute different structural break tests. Table 12 presents the results of the Chow tests. It seems that there is no unique pattern distinguishing high inflation countries prior to EMU Stage III from low inflation countries. However, we need to bear in mind that the effect of the HICP revision is not considered here explicitly. Rather, as previously mentioned, these two effects are likely to superimpose each other.

Table 12: Frequency of structural break, per country and significance level, in percent

Level of Significance	EU	EA	BE	DK	DE	GR	ES	FR	IE	IT	LU	NL	AT	PT	SF	SV	UK	All
P-value<0.1	52.6	48.7	55.7	49.2	42.7	68.6	57.6		59.2	67.2	57.4	69.6	60.8	51.4	52.6	55.4		56.0
P-value<0.05	39.7	38.5	35.7	37.3	31.7	49.0	40.9		38.2	47.8	49.2	49.3	37.3	42.9	36.8	44.6		41.0
P-value<0.01	16.7	12.8	15.7	15.3	18.3	27.5	16.7		17.1	23.9	36.1	31.9	11.8	22.9	18.4	17.6		20.0

Note: The estimated parameters are taken at face value and are not treated as zeros in case of statistical insignificance.

In order to investigate the source of the overall structural break, we apply Wald-tests to the intercept and to the ΣAR coefficients. As reported within the section on sales, in Luxembourg, instability of the intercept is far more frequently observed than a break in the ΣAR coefficients (30.5 percent and 4.9 percent rejection frequency respectively at the 5 percent significance level, see Table 13). For the euro area, on the contrary, we find a structural break in the intercept in 1 sub-index out of 20, whereas the hypothesis of no break in ρ is rejected in 9.0 percent of the cases (at 5 percent significance level). Overall, there is no clear pattern with regard to the driving force of these structural breaks across countries.

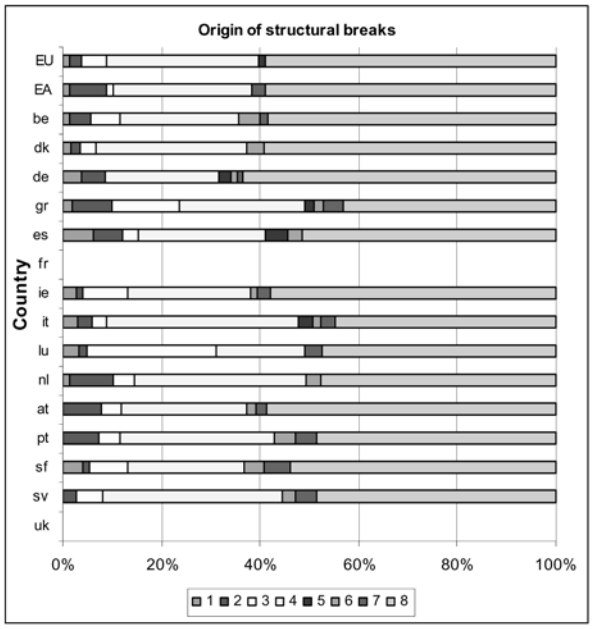
Table 13: Frequency of structural breaks in the ΣAR coefficients and the intercept, per country and significance level, in percent.

Level of Significance	EU	EA	BE	DK	DE	GR	ES	FR	IE	IT	LU	NL	AT	PT	SF	SV	UK	All
Σ AR coefficients																		
P-value<0.1	11.5	9.0	17.1	10.2	15.9	23.5	30.3		10.5	13.4	9.8	21.7	15.7	18.8	15.8	9.5		15.3
P-value<0.05	5.1	9.0	10.0	6.8	12.2	13.7	19.7		5.3	10.4	4.9	13.0	9.8	10.1	9.2	5.4		9.5
P-value<0.01	2.6	3.8	2.9	5.1	4.9	5.9	13.6		1.3	6.0	1.6	4.3	5.9	4.3	5.3	1.4		4.5
Intercept																		
P-value<0.1	10.3	7.7	17.1	15.3	11.0	31.4	21.2		19.7	17.9	37.3	10.1	9.8	12.9	25.0	20.3		17.3
P-value<0.05	7.7	5.1	8.6	5.1	7.3	21.6	13.6		14.5	11.9	30.5	5.8	5.9	8.6	17.1	9.5		11.2
P-value<0.01	2.6	1.3	2.9	1.7	2.4	5.9	6.1		3.9	3.0	22.0	2.9	0.0	1.4	10.5	2.7		4.5

Note: These structural breaks in the ΣAR coefficients and the intercept reported are irrespective of whether the overall F-statistic of the structural break test is significant.

Figure 12 summarises the origin of structural breaks. Eight possible cases are distinguished. For example, it may be the case that the overall structural break test suggests the presence of a structural break, while the separate Wald-tests return significant differences in both the ΣAR coefficients and the intercept, or only one of the two, or neither. Similarly, it may be the case that one of the Wald-tests is significant, while the overall structural break test does not indicate the presence of a structural break. Firstly, we note that the three cases where either one or both Wald-tests indicate differences in the ΣAR coefficients or the intercept, while the absence of an overall structural break is not rejected remain very rare. This is true for Luxembourg as well as all other EU15 countries and for both country aggregates.

Figure 12: The origin of structural breaks



Legend: p-values conditions to be met

Legend	Break test	Wald-test	
	Overall	ΣAR coeff.	Intercept
1	<0.05	<0.05	<0.05
2	<0.05	<0.05	>0.05
3	<0.05	>0.05	<0.05
4	<0.05	>0.05	>0.05
5	>0.05	<0.05	<0.05
6	>0.05	<0.05	>0.05
7	>0.05	>0.05	<0.05
8	>0.05	>0.05	>0.05

Secondly, both the overall structural break combined with either significant Wald-tests for differences in the ΣAR coefficients and/or the intercept at the 5 percent level or better emerges in more than one out of three sub-indices from the Luxembourg HICP. Thirdly, Figure 12 displays that the frequency of no overall break is roughly 50 percent for the sub-indices of the Luxembourg HICP. This is relatively low compared to other countries. Lower frequencies were only found for Greece and Italy. Fourthly, we see that a considerable share of the indices show a structural break, while neither the ΣAR coefficients nor the intercept is significantly different from each other.

Table 14: Statistics of inflation persistence parameter ρ per country, unrestricted model

Pre-EMU sample

Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	93	0.24	0.39	-0.57	-0.01	0.30	0.54	0.74
EA	Euro Area	93	0.25	0.47	-0.72	-0.01	0.38	0.57	0.75
be	Belgium	78	0.13	0.44	-0.72	-0.09	0.20	0.43	0.73
dk	Denmark	84	-0.03	0.62	-1.12	-0.12	0.16	0.29	0.52
de	Germany	90	0.28	0.37	-0.40	0.08	0.32	0.54	0.75
gr	Greece	81	0.07	0.57	-0.76	-0.09	0.09	0.34	0.72
es	Spain	77	0.25	0.43	-0.56	0.07	0.31	0.57	0.76
fr	France	88	0.29	0.69	-0.54	0.08	0.28	0.54	0.83
ie	Ireland	87	0.21	0.35	-0.38	0.08	0.24	0.40	0.66
it	Italy	84	0.28	0.36	-0.23	0.06	0.33	0.55	0.69
lu	Luxembourg	77	0.15	0.36	-0.43	-0.03	0.16	0.34	0.64
nl	Netherlands	82	0.08	0.47	-0.65	-0.13	0.14	0.43	0.61
at	Austria	83	0.06	0.57	-0.69	-0.05	0.16	0.34	0.53
pt	Portugal	86	0.36	1.35	-0.40	0.05	0.31	0.45	0.72
sf	Finland	87	-0.02	0.53	-1.20	-0.11	0.07	0.24	0.60
sv	Sweden	83	0.04	0.39	-0.71	-0.13	0.10	0.27	0.64
uk	United Kingdom	80	0.02	0.49	-0.85	-0.14	0.11	0.31	0.53
	All	1433	0.16	0.58	-0.70	-0.04	0.21	0.44	0.71

Post-EMU sample

Country code	Country	# Indices	Average	Std.dev.	5%ile	25%ile	50%ile	75%ile	95%ile
EU15	European Union 15	93	0.28	0.34	-0.29	0.02	0.31	0.54	0.73
EA	Euro Area	93	0.30	0.42	-0.49	0.12	0.39	0.59	0.75
be	Belgium	78	0.18	0.40	-0.56	-0.03	0.27	0.47	0.70
dk	Denmark	84	0.09	0.92	-1.02	-0.09	0.17	0.31	0.63
de	Germany	90	0.30	0.38	-0.33	0.13	0.37	0.54	0.73
gr	Greece	81	0.01	0.49	-0.76	-0.22	0.05	0.34	0.61
es	Spain	77	0.14	0.53	-0.83	-0.06	0.25	0.48	0.75
fr	France	88	0.29	0.69	-0.54	0.08	0.28	0.54	0.83
ie	Ireland	87	0.26	0.32	-0.35	0.10	0.27	0.43	0.66
it	Italy	84	0.20	0.56	-0.92	0.06	0.34	0.51	0.72
lu	Luxembourg	77	0.08	0.30	-0.35	-0.08	0.07	0.27	0.58
nl	Netherlands	82	0.16	0.41	-0.60	-0.02	0.21	0.44	0.63
at	Austria	83	0.02	0.58	-0.79	-0.11	0.14	0.33	0.53
pt	Portugal	86	0.22	0.34	-0.40	0.04	0.29	0.45	0.61
sf	Finland	87	-0.03	0.57	-1.20	-0.13	0.08	0.25	0.52
sv	Sweden	83	0.10	0.33	-0.42	-0.13	0.11	0.30	0.64
uk	United Kingdom	80	0.02	0.49	-0.85	-0.14	0.11	0.31	0.53
	All	1433	0.16	0.51	-0.65	-0.04	0.22	0.44	0.69

Note: Only the most disaggregated sub-indices are considered. The estimated parameters are taken at face value and are not treated as zeros in case of statistical insignificance. **The summary statistics are based on the unrestricted model. In cases where no overall structural break was found, the parameter estimates of the restricted model are assumed to hold.**

Table 14 above reports summary statistics relative to the inflation parameter ρ taking into account the presence of structural breaks (as provided by the Chow test at the 5 percent level of significance). In the case of Luxembourg, the mean and the median ρ are lower for the period 1999 – 2003 than for the pre-EMU period (0.15 vs. 0.08 and 0.16 vs. 0.07 respectively). In addition, it seems that the decline in the degree of inflation persistence is particularly pronounced for rather persistent indices. This is illustrated by the considerable reduction of the 95 percentile maximum ρ. This is also the case for Greece and Portugal. Moreover, and contrary to the EU15 and the euro area, we observe a smaller volatility of ρ in the post-EMU period in Luxembourg.

c. Panel data regressions

In order to get a clearer picture about the significance of differences in inflation persistence across countries, we use a fixed effects panel regression with robust standard errors to explore the degree of inflation persistence in Luxembourg relative to EU15 countries taking account of differences in the composition of the HICP across countries. Table 15 reports the results of these regressions. In order to avoid the results to be driven by outliers, we decided to remove all indices outside $|\rho|>1$. All coefficients are relative to the EU15 aggregate.

Table 15: Panel data results for different persistence estimates

Country	ρ (fs)	ρ (pre emu)	ρ (post emu)	ρ (pre sales)	ρ (post sales)	ρ (fs new)	γ (fs)	γ (pre emu)	γ (post emu)	γ (pre sales)	γ (post sales)	γ (fs new)
EU15	0.27 ***	0.27 ***	0.27 ***	0.33 ***	0.21 ***	0.21 ***	0.52 ***	0.52 ***	0.50 ***	0.51 ***	0.47 ***	0.47 ***
EA	0.04	0.01	0.04	0.01	0.01	0.00	0.04 **	0.03	0.03	0.04 *	0.01	0.01
be	-0.10 **	-0.14 **	-0.09 **	-0.17 ***	-0.03	-0.03	0.05 **	0.05 **	0.05 **	0.05 **	0.04 *	0.04 *
dk	-0.14 ***	-0.15 **	-0.12 **			-0.08	-0.02	-0.04	0.02			0.04 *
de	0.04	-0.06	0.06		0.09 **	0.09 **	0.10 ***	0.06 ***	0.11 ***	0.06 **	0.14 ***	0.14 ***
gr	-0.14 ***	-0.18 ***	-0.27 ***			-0.07	0.01	-0.02	-0.02			0.06 **
es	-0.05	0.04	-0.15 ***	-0.01	-0.14 **	-0.13 **	0.06 ***	0.08 ***	0.06 ***	0.08 ***	0.00	0.00
fr	-0.01		0.03			0.05	0.02	-0.02	0.03 *			0.07 ***
ie	-0.02	-0.14 ***	-0.01		0.06	0.06	0.03	0.01	0.04 *	-0.08 ***	0.07 ***	0.07 ***
it	0.00	0.11 **	0.00	0.07 **	-0.15 ***	-0.15 ***	0.10 ***	0.15 ***	0.08 ***	0.16 ***	0.01	0.01
lu	-0.24 ***	-0.13 **	-0.20 ***	-0.18 ***	-0.14 ***	-0.14 ***	0.03	0.08 ***	-0.03	0.08 ***	-0.01	0.00
nl	-0.06	-0.22 ***	-0.08 *			0.00	0.04 **	-0.02	0.06 ***			0.10 ***
at	-0.16 ***	-0.10 *	-0.17 ***			-0.09 **	0.04 **	0.05 **	0.04 *			0.09 ***
pt	-0.03	0.02	-0.05		0.00	0.01	0.05 ***	0.04 *	0.06 ***	0.02	0.08 ***	0.08 ***
sf	-0.20 ***	-0.17 ***	-0.21 ***			-0.13 ***	-0.01	0.01	0.00			0.04 **
sv	-0.17 ***	-0.15 ***	-0.18 ***			-0.11 **	0.03	0.03	0.04 *			0.08 ***
uk	-0.18 ***		-0.19 ***			-0.11 **	-0.06 ***	-0.06 **	-0.05 **			0.00

Note: (fs) stands for full sample and refers to the estimated coefficients from the restricted regressions (i.e. without allowing for structural breaks). (fs new) uses the inflation persistence estimates of ρ and the mean reversion coefficient of γ for the period after the HICP methodology revision for those countries which adopted sales prices during the observation period (EU15, EA, be, de, es, ie, it, lu, pt) and the full number of observations for the remaining countries. All coefficients relative to the EU15 aggregate. Estimates are within estimates (sub-indices absorbed) with robust standard errors. ***,**,* denote significance at the 1%, 5%, 10% level, respectively.

In summary, the following results appear with regard to the inflation persistence coefficient ρ: First, the degree of inflation persistence in Luxembourg at the disaggregate level of consumer prices seems to be relatively small. It seems to be significantly lower than for the EU15 aggregate. For the full sample period, we obtain the largest (negative) country fixed effect for Luxembourg, followed by (in decreasing order) Finland, The United Kingdom, Sweden and Austria. For the full sample period, we obtain negative country fixed effects for all countries except Germany. This is suggestive of a positive aggregation effect. Second, for both the pre-EMU and the post-EMU sample period, we obtain a significant negative country fixed effect for Luxembourg. Although the order becomes slightly different, the degree of inflation persistence remains low compared to most other EU15 countries. Third, the HICP methodology revision to include sales prices reduces the inflation persistence estimate for the EU15 from 0.33 prior to the revision to 0.21 after the revision. Again, we obtain a negative significant country fixed effect for Luxembourg for both sub-sample periods. Fourth, for the euro area as a whole, no major differences in terms of overall inflation persistence are discernable between the pre-EMU and the post-EMU sample periods.

With regard to the mean reversion coefficient γ the following results appear: First, the estimated coefficient for the EU15 is very close to 0.5, i.e. the theoretically expected value for a zero-mean white noise process. Second, and in contrast to the results with regard to the inflation persistence indicator ρ, in general, no significantly different average inflation persistence is obtained for Luxembourg. Third, prior to EMU and the sales inclusion, the degree of inflation persistence in Luxembourg seems to have been significantly larger than in the EU15. Fourth, our results suggest that the previously higher degree of inflation persistence has vanished, as no significant differences are obtained relative to the EU15 for the post-EMU and post-sales period.

In general, both measures of inflation persistence suggest a lower degree of persistence in Luxembourg relative to the EU15 in the post-EMU and the post-sales sub-samples. Nonetheless, in general, the obtained levels of inflation persistence at the disaggregate level are relatively low across all countries.

V. COMPARING RESULTS ACROSS HICP SUB-INDICES

Finally, we investigate differences in the degree of inflation persistence across the sub-indices of the Luxembourg HICP. To answer the question of typical differences across indices, Figure 13 and Figure 14 summarise for all HICP sub-indices the coefficients obtained for Luxembourg after the introduction of sales prices (grey shaded bars). For the purpose of comparison, they also report selected percentiles of the distribution across EU15 countries. They illustrate that the cross-index differences are not robust to the choice of the persistence indicator.[16]

With regard to the ΣAR coefficients, the following results seem to emerge. At the lower end of the spectrum are indices such as "*cp0611 Pharmaceutical products*", "*cp0311 Clothing materials*", "*cp0431 Materials for the maintenance and repair of the dwelling*" and "*cp0953_954 Miscellaneous printed matter; stationery and drawing materials*". Apart from clothing materials, these categories are not characterised by a particularly small ΣAR coefficients in the majority of the other countries. Relatively strong positive autocorrelation is observed for the sub-indices "*cp0116 Fruit*" and "*cp0117 Vegetables*" and "*cp0453 Liquid fuels*" of the Luxembourg HICP. Again, this is contrary to the results obtained for most other EU15 countries, as vegetables, fruit and liquid fuels, in general, figure among the least persistent indices. In general, only for a small number of sub-indices (e.g., "*cp096 Package holidays*", "*cp112 Accommodation services*", "*cp0312 Garments*" and "*cp032 Footwear including repair*") we observe a low degree of persistence in both Luxembourg and other EU15 countries. Given the quarterly observation frequency, these indices can be affected by seasonality.

[16] The lower (upper) end of the black lines indicates the 25th (75th) percentile. The asterisk indicates the median level of the indicator in question.

Figure 13: ΣAR coefficients, post sales, per index

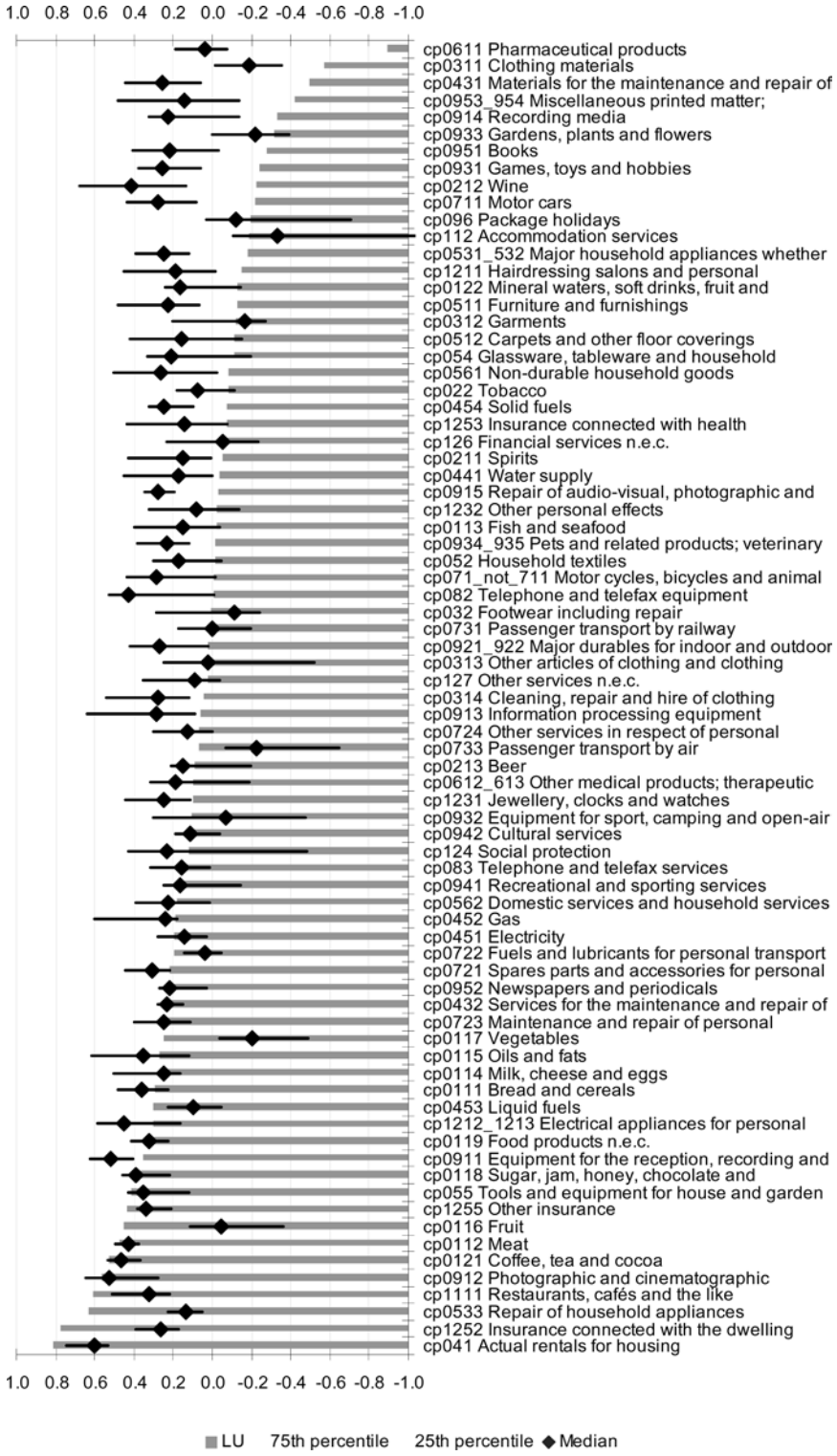
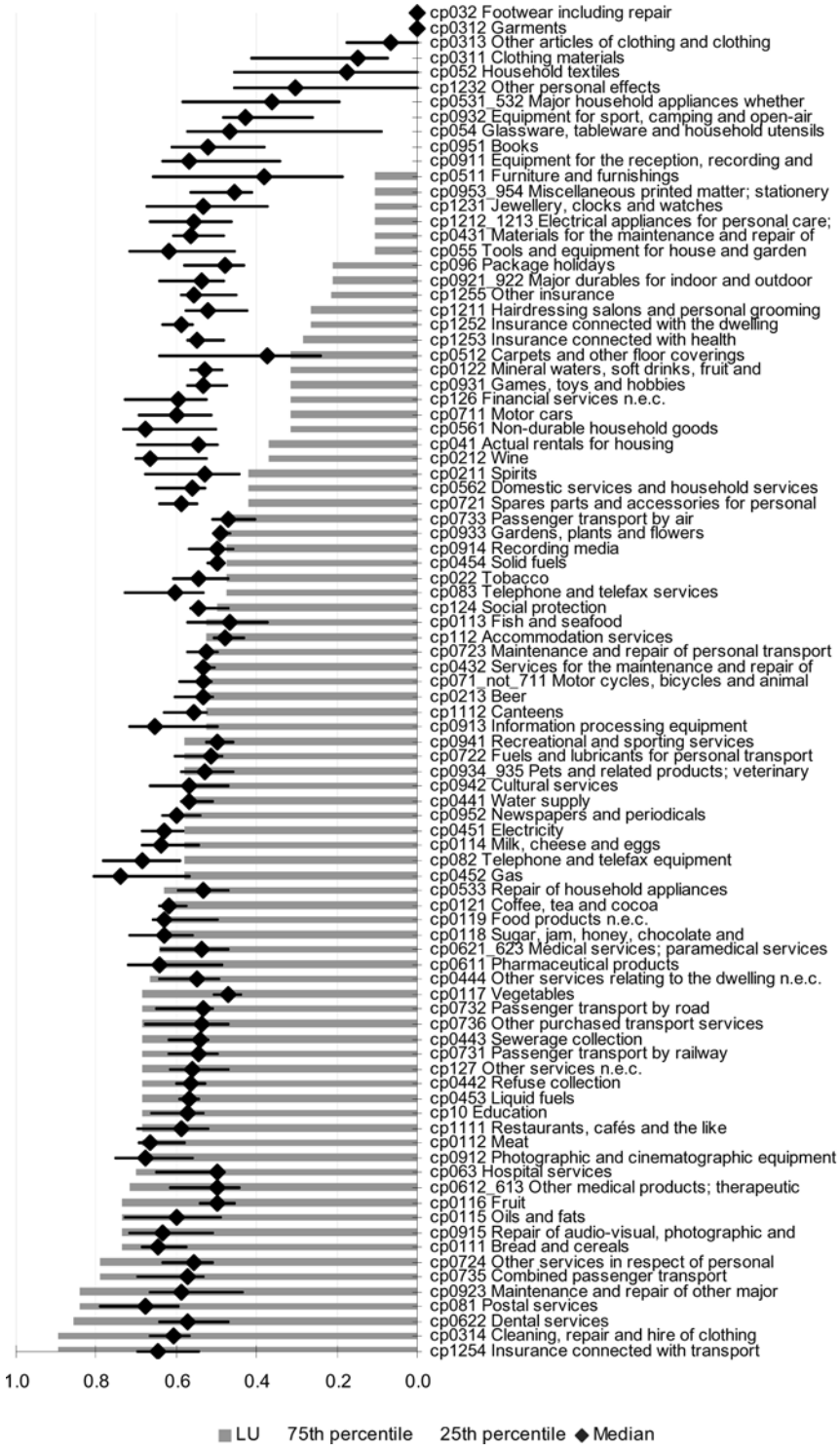


Figure 14: Mean reversion coefficient γ, post sales, per index



Among the most persistent sub-indices of the Luxembourg HICP are "*cp041 Actual rentals for housing*", "*cp1252 Insurance connected with the dwelling*", "*cp0533 Repair of household appliances cafés and the like*", "*cp1111 Restaurants, cafés and the like*" and "*cp0912 Photographic and cinematographic equipment and optical instruments*". Most of these sub-indices (in particular actual rentals for housing as well as photographic and cinematographic equipment) tend to reveal a similarly high degree of inflation persistence in other EU15 countries as well. Among the more persistent sub-indices are also "*cp0121 Coffee, tea and cocoa*", "*cp0112 Meat*" and "*cp0118 Sugar, jam, honey, chocolate and confectionery*". Again, a similar degree of inflation persistence is observed for most other EU15 countries.

With regard to the frequency of mean crossings, a very large fraction of outcomes for γ is between 0.5 and 0.7. This implies a certain skewness in favour of positive autocorrelation in the inflation processes. Indices for which we obtain very small values of γ are by and large indices subject to sales (e.g., "*cp0311 Clothing materials*", "*cp0312 Garments*", "*cp0313 Other articles and clothing accessories*", "*cp032 Footwear including repair*", "*cp052 Household textiles*" as well as "*cp1232 Other personal effects*"). The same applies to the median γ across the EU15 countries. The large impact the inclusion of sales prices had on the degree of inflation persistence is also reflected by the relatively large number of sub-indices of the Luxembourg HICP characterised by a high frequency of mean crossing (e.g., $\gamma < 0.4$ in Figure 14). Relatively low frequencies of mean crossing are reported for the sub-indices "*cp1254 Insurance connected with transport*", "*cp0314 Cleaning, repair and hire of clothing*", "*cp0622 Dental services*", "*cp081 Postal services*", "*cp0923 Maintenance and repair of other major durables for recreation and culture*" and "*0735 Combined passenger transport*".

Rather than analysing sub-indices of the HICP, policy conclusions, in general, relate to product categories. One of the essential questions is about the degree of inflation persistence of services relative to goods. Clark (2003) reports no material differences of different product categories. In the case of Luxembourg, on average, the smallest degree of inflation persistence is obtained for the product category durable goods followed by non-durable goods, while energy and services are not significantly more or less persistent than food products. If we include sales indices as an additional product category, durable goods become insignificant. This is due to the high overlap of indices within these two categories. On average, it seems though, as if the degree of persistence is small for all product categories in Luxembourg (see Table 16). In addition, for none of the product categories we observe, on average, a high degree of inflation persistence relative to the other countries. We do however find, relative to the other EU15 countries, a low degree of average inflation persistence in Luxembourg for non-durable goods and durables.

VI. SUMMING UP

This paper analyses the degree of inflation persistence in Luxembourg based on disaggregate data from HICP sub-indices. The degree of inflation persistence is then compared to persistence estimates for the EU15 countries as well as the EU15 and the euro area aggregates. In general, the results indicate a relatively low degree of inflation persistence in Luxembourg at the disaggregate level. From 1995 to 2003, the average and the median ΣAR coefficients is 0.03 and 0.09, respectively. The unit root hypothesis is rejected in 83 percent of the sub-indices considered at the 5 percent significance level. The non-parametric measure based on the frequency of mean reversion, in general, confirms a low degree of inflation persistence with 2 out of 3 γ coefficients in $0.3 < \gamma \leq 0.7$. The results also suggest that simple time series aggregation, both across indices and individual euro area countries, may lead to higher degrees of inflation persistence. Nevertheless, we find a substantial degree of heterogeneity across the sub-indices of the Luxembourg HICP with a few sub-indices revealing a rather high degree of inflation persistence.

We show that structural breaks are present, which are associated with the inception of the single monetary policy and/or the modified treatment of sales in the HICP. The modified treatment of sales prices in the HICP changes the time series properties of a large share of indices concerned, and may result in negative serial correlations for numerous indices. The evidence for structural breaks seems particularly strong in the case of Luxembourg. Structural breaks seem to relate primarily to instability of the intercept and to stronger volatility in the inflation process. Both, the ΣAR coefficients and the mean reversion coefficient γ are affected by the inception of the single monetary policy and/or the adoption of seasonal sales in the HICP. In general, we find a lower degree of persistence for the period 1999 – 2003 compared to the period 1995 – 1998. A comparison between indices that are typically affected by sales prices and those that are typically not suggests that the inclusion of seasonal sales is the dominant source of a structural break in the inflation process of the sub-indices of the Luxembourg HICP.

A relatively high degree of inflation persistence is observed for the sub-indices "*cp1111 Restaurants*", "*cp0112 Meat*" and "*cp0116 Fruit*". Similar to most EU15 countries, we find a relatively high degree of persistence for the sub-indices "*cp0121 Coffee, tea and cocoa*" and "*cp0118 Sugar, jam, honey, chocolate and confectionery*". A small degree of inflation persistence is observed for the sub-indices "*cp0913 Information processing equipment*" and "*cp022 Tobacco*". Fixed effects panel estimations confirm that the degree of inflation persistence in Luxembourg is relatively low compared to other EU15 countries. This holds in particular for the post-sales and the post-EMU periods. Compared to other EU15 countries but also in absolute terms, it seems that the degree of inflation persistence is, on average, low for non-durable goods and for durables. A relatively high degree of persistence is found, on average, for food and energy products. Services do not seem to be more persistent than, on average, other product categories.

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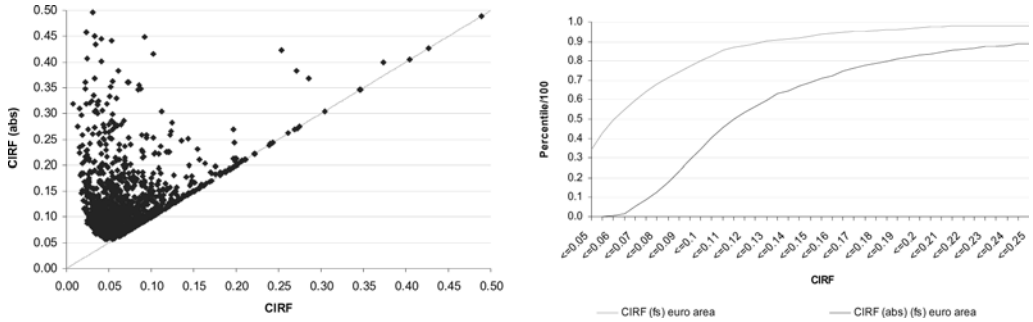
VIII. APPENDIX

While the CIRF may generally be a good indicator synthesizing the information content of the impulse response function, it may not be sufficient in capturing the exact properties of inflation persistence in a quantitative manner (e.g. Andrews & Chen, 1994). This criticism extends to the inflation persistence parameter ρ, as it is related to the CIRF (in the limit it can be established that CIRF=1/(1-ρ), where ρ refers to the ΣAR regression coefficients), as both the CIRF and the ΣAR coefficients may understate the degree of persistence if the impulses oscillate. In order to illustrate the impact of oscillating impulses we calculate a complementary measure of persistence, namely the cumulative response function in absolute terms (CIRFabs).[17]

Figure A1 illustrates the impact of oscillating impulses. In absence of oscillations around zero, we expect all scatter points to lie on the 45° diagonal in the left hand side panel. The vertical deviation from the 45° diagonal indicates the relevance of oscillating impulse responses. Moreover, figure A1 indicates that oscillating impulse responses coincide to a large extent with small CIRF values. Combining these measures with the common CIRF may give us additional information about the properties of the autocorrelation process.

Figure A1: The impact of oscillations



The cumulative density functions of the CIRF and the CIRFabs (right hand side panel of figure A1) illustrate that the common CIRF yields a lower degree of inflation persistence than when taking account of oscillating impulses.

[17] In computing these measures we use a fixed lag length of four quarters and an impulse response horizon of 20 quarters. For purposes of illustration, the CIRFabs is standardised such that the minimum value is 0.05 (i.e. immediate absorption of the initial shock) and the maximum value is 1 (perfect inertia). As figure A1 is for illustrative purposes, data from all individual country-index combinations within the euro area are used.