SEASONAL ADJUSTMENT OF THE HICP [1]

ENERGY AND UNPROCESSED FOOD

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1. Introduction

Since the year 2000 the ECB has been compiling seasonally adjusted results for the Harmonised Indices of Consumer Prices (HICP) of the euro area and EU countries. For the euro area, seasonal adjusted series are calculated for the total HICP, for its main aggregates, i.e. the price indices on unprocessed food, processed food, non-energy industrial goods, energy and services, and for some additional special aggregates (e.g. seasonal food). This note reviews the current practices. Feedback from NCBs is invited in order to identify the way forward in this research project.

The paper starts by outlining the motivation and scope of this work (Section 2). Section 3 describes how the ECB/DG-S currently compiles seasonally adjusted results for the euro area HICP. First results of ongoing ECB/DG-S research are presented in Section 4 (analysis of seasonal patterns and differences and similarities of directly and indirectly seasonally adjusted results). Seasonal adjustment is performed with X-12-ARIMA and TRAMO/SEATS. Section 5 summarises the conclusions.

For illustration and comparison, the annex also contains charts on the seasonally adjusted country HICPs, however, the results are not further discussed in this paper.

2. Background

The ECB closely follows short-term developments of the HICP. When analysing month-on-month rates of change, it is useful to separate between more fundamental movements in prices and those which appear each year in the same month. The latter effects can be extracted via seasonal adjustment methods. Seasonally adjusted HICPs for the euro area and EU countries are calculated by the ECB/DG-S using X-12-ARIMA and follow the recommendations agreed by the Statistics Committee in 2000.[2] Since then, seasonally adjusted HICP data have been released together with the non-adjusted data in the ECB databases and disseminated to all NCBs. The most important euro area results are published in the Monthly Bulletin (table 5.1). DG-S also compiles seasonally adjusted national HICPs for all EU countries. The work presented in this note follows up from ECB user requests for additional seasonally adjusted HICP data (in particular for the COICOP-components[3] of the unprocessed food and energy indices).

3. Current method of adjusting HICPs for their seasonal component

The ECB/DG-S calculates the seasonally adjusted HICP for the euro area by applying an indirect approach. In a first step, the seasonal patterns from the HICP main components, i.e. indices on unprocessed food, processed food, industrial goods excluding energy and services, are estimated using X-12-ARIMA. These results are weighted together using the HICP weights and adding the sub-index for energy in unadjusted format, since its seasonal pattern is affected by significant short-term volatility, implying that seasonal factors can not be reliably estimated.

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2 "Seasonal Adjustment of Monetary Aggregates and HICP for the Euro Area", European Central Bank, August 2000.
3 COICOP = **C**lassification **o**f **I**ndividual **C**onsumption by **P**urpose.

The most important reason for indirectly adjusting the euro area HICP is that the seasonal pattern varies substantially between these components. In such cases, an indirect approach usually yields better results than the direct adjustment of the aggregated series.

4. Analysing seasonal cycles in the price indices for energy and unprocessed food

Detailed insights in the seasonal cycles of the energy and unprocessed food indices can be gained by analysing the sub-indices of each of these main components on the 4-digit COICOP-level. The unprocessed food index consists of the indices meat, fish, fruit and vegetables.[4] The index for energy prices is broken down into price indices for electricity, gas, liquid fuels, solid fuels, heat energy and fuels and lubricants for personal transport equipment (f.l.p.t.e.).[5] Additionally, alternative seasonal adjustments are compared in order to provide the users a more comprehensive view according to their demands as well as to check the validity and reliability of current practices.

4.1 Energy price index

Chart A.1 in the annex shows the graphics of the non-adjusted components covered by the energy price index. At present, the aggregate index for energy is not adjusted, a practice that has occasionally been questioned. Graphical (correlogram, periodogram and seasonal sub-series) and statistical analysis (regression of the original series on seasonal dummies) were conducted for the 4-digit components of the energy series. In addition, the test statistics implemented in X-12-ARIMA for the presence of seasonality in the seasonal-irregular component were conducted. The results are shown in Table 1.

The following are the main results for the six energy HICP components:

- *Electricity (weight in euro area HICP: 2%):* The tests implemented in X-12-ARIMA were not conclusive, indicating that seasonality is *probably* not present. The graphical analysis and a regression on seasonal dummies did not reveal the presence of a seasonal pattern aside from increases in prices occurring in January. Such increases are to a large extent related to changes in taxes and administered energy prices which are often introduced in January. The statistical analysis of this series reveals several sources of non-normality due to outliers, which are partially related to taxation and price administration.
- *Gas (1.5%):* The graphical analysis and a regression on seasonal dummies suggested the relevance of some of the seasonal cycles, highlighting several price increases in January. However, X-12-ARIMA did not find identifiable seasonality. As in the previous case, a part of the variability in seasonal cycles is likely to be related to changes in taxes and/or administered prices in January.
- *Liquid fuels (0.9%):* The graphical analysis and a regression on seasonal dummies did not suggest a significant seasonal pattern. The same is concluded by X-12-ARIMA.

[4] The respective COICOP codes are 011200, 011300, 011600 and 011700.
[5] The respective COICOP codes are 045100, 045200, 045300, 045400, 045500 and 072200.

- *Solid fuels (0.1%):* The graphical analysis and a regression on seasonal dummies suggested the presence of a prominent seasonal pattern. X-12-ARIMA confirmed this and also found evidence of changing seasonality.
- *Heat energy (0.5%):* Neither the graphical analysis and a regression on seasonal dummies nor X-12-ARIMA found seasonality.
- *Fuel and lubricants for personal transport equipment (4.2%):* The analysis suggested a weak seasonal pattern. However, X-12-ARIMA did not identify seasonality.

Table 1: Tests for the presence of seasonality

	F-test		Kruskal Wallis		Moving Seasonality		Combined test
electricity	Yes	18.15 (0.1%)	Yes	96.41 (1%)	Yes	8.00 (1%)	Identifiable seasonality probably not present
gas	No	2.42 (0.1%)	Yes	29.50 (1%)	No	1.87 (5%)	Identifiable seasonality not present
liquid fuels	No	2.92 (0.1%)	Yes	30.26 (1%)	Yes	2.12 (5%)	Identifiable seasonality not present
solid fuels	Yes	134.67 (0.1%)	Yes	121.32 (1%)	Yes	18.78 (1%)	Identifiable seasonality present
heat energy	No	1.50 (0.1%)	No	20.88 (1%)	No	1.06 (5%)	Identifiable seasonality not present
f.l.p.t.e.	Yes	7.78 (0.1%)	Yes	63.76 (1%)	Yes	5.56 (1%)	Identifiable seasonality not present

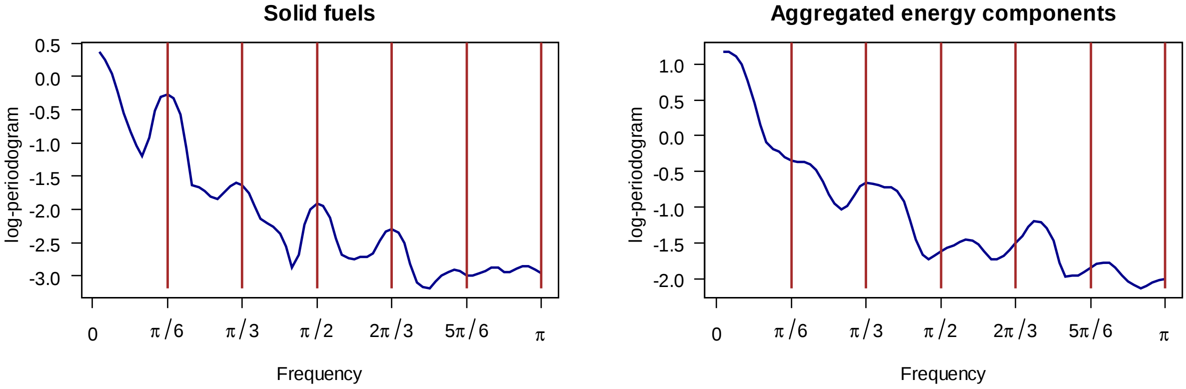
Based on results from `X12-ARIMA`.
Yes/No: Seasonality present/not present according to the corresponding statistic at the level reported in brackets.

The time series dynamics can be characterised as follows: The short-run dynamics of these series are mainly explained by transitory cycles, so that the effect of shocks vanishes rapidly throughout time, and irregular fluctuations. Only for solid fuel, a relevant part of the variability is explained by seasonal cycles. Furthermore, some of the seasonal fluctuations can be explained by the effect of tax and/or administered prices. Nevertheless, one may argue that taxes are a particular feature of the data and that it should be treated as part of the seasonal component to be adjusted.

For energy as a whole, and despite the seasonal pattern of solid fuels, a comparison of the non-adjusted and partially seasonally adjusted energy series shows only very small differences. Furthermore, full concordance of the sign of the month-on-month growth rates was obtained. The reason for this is the small share of the solid fuels index in the aggregate energy index.

This result is also confirmed by a comparison of the log-periodograms. The unadjusted solid fuels series shows that the seasonal cycles - highlighted with vertical dotted lines - explain a relatively large amount of the variability of the series, since peaks are reached at some of the seasonal frequencies. In the non-adjusted energy index, seasonal cycles are not significant. Peaks in the log-periodogram are reached for frequencies in the neighbourhood of the seasonal frequencies that are related to transitory cycles or irregularities instead of seasonal fluctuations.

Chart 1: Log-periodogram of the solid fuels and the aggregated energy index (n.s.a.)



Source: ECB calculations based on Eurostat data.

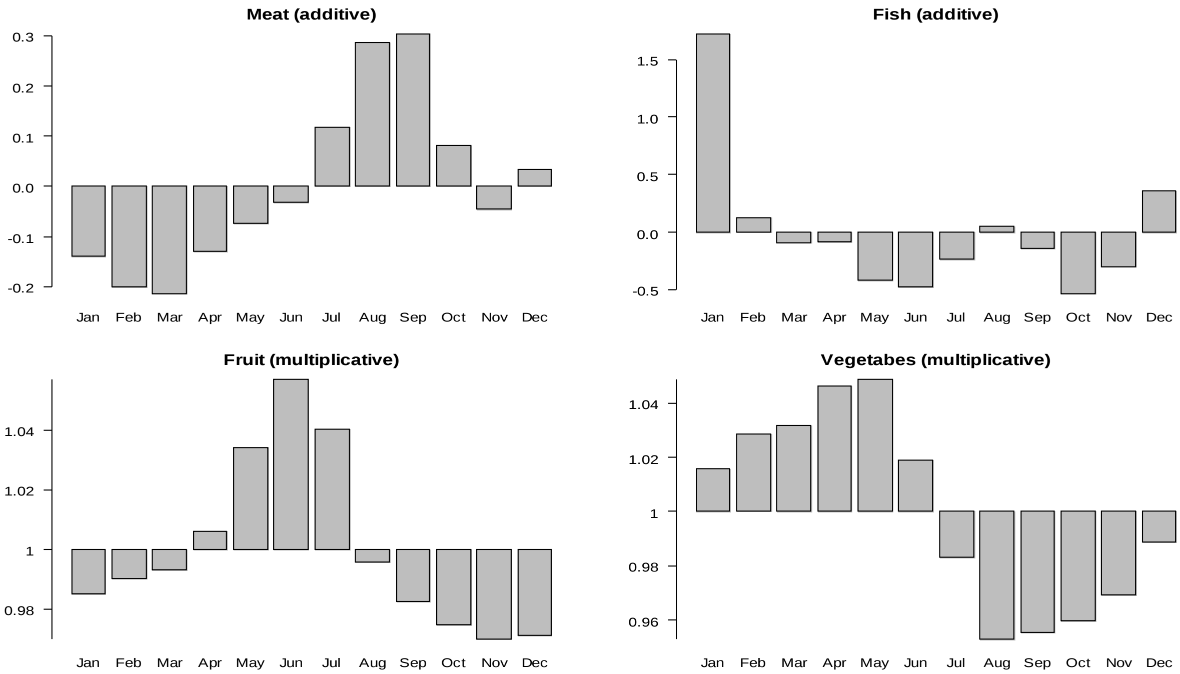
4.2 Unprocessed food

The unprocessed food HICP shows a pronounced seasonality which might significantly change from year to year due to differing weather conditions. Statistical tests for the presence of seasonality are usually significant. Section 4.2.1 gives a more detailed description of the seasonal patterns in these series. Section 4.2.2 compares the results of the direct and indirect approaches, using X-12-ARIMA and TRAMO/SEATS, respectively.

4.2.1 Seasonal patterns in unprocessed food components: overview

Chart A.2 in the annex displays the components of the unprocessed food index. Chart 2 displays the seasonal factors obtained with X-12-ARIMA. The weights of each component in 2006 are: 3.7% (meat), 1.2% (fish), 1.1% (fruit) and 1.5% (vegetables).

Chart 2: Seasonal factors in unprocessed food components



Source: ECB calculations based on Eurostat data.

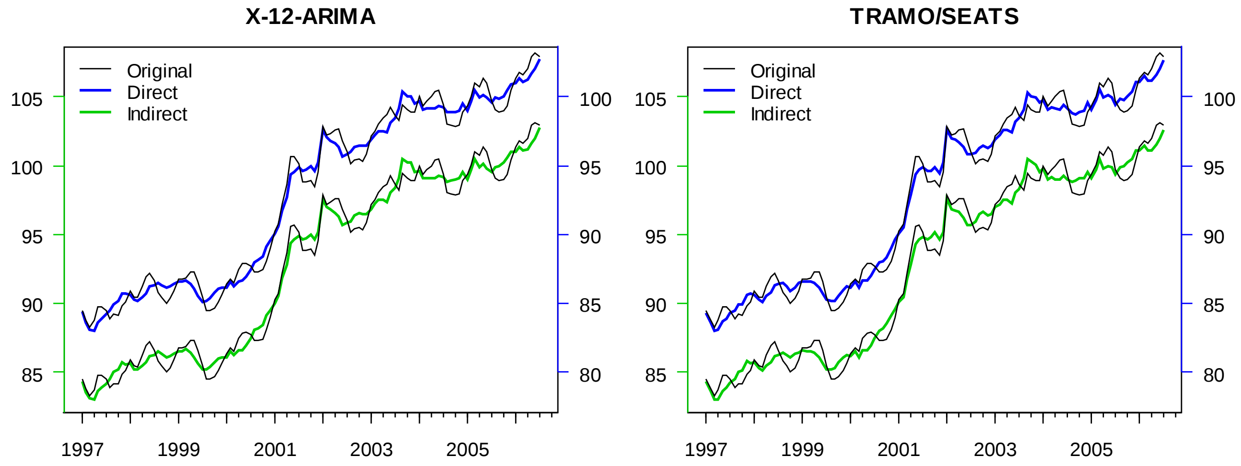
. The following effects of seasonality can be observed:

- *Meat (weight in euro area HICP: 3.7%):* Seasonal effects are negative during the first half of the year. In summer, prices tend to be higher. From the components compared, the seasonal pattern is least pronounced.
- *Fish (1.2%):* In spring and autumn prices are lower. In December and January higher out of season prices cause positive and large seasonal factors.
- *Fruit (1.1%):* The estimated seasonal factors show a progressive increase in price during the first half of the year, reaching their maximum values in June. After that month, seasonal effects make prices drop, reaching minimum impacts in November and December. In June, prices are about 9% higher than prices at the end of the year due to seasonal influences.
- *Vegetables (1.5%):* There is a progressive increase of seasonal factors from August to May. A sharp decline is observed from that month to August. During the first half of the year seasonal factors are positive and negative in the second half of the year. In May, prices are about more than 8% higher than in August and September due to seasonality.

4.2.2 Alternative seasonally adjusted series for unprocessed food

Seasonal adjustment of unprocessed food component was performed following the direct and indirect approaches with X-12-ARIMA and TRAMO/SEATS, respectively. Thus, there are four alternative adjustments. Chart 3 displays the results for these four alternatives and show no major differences.

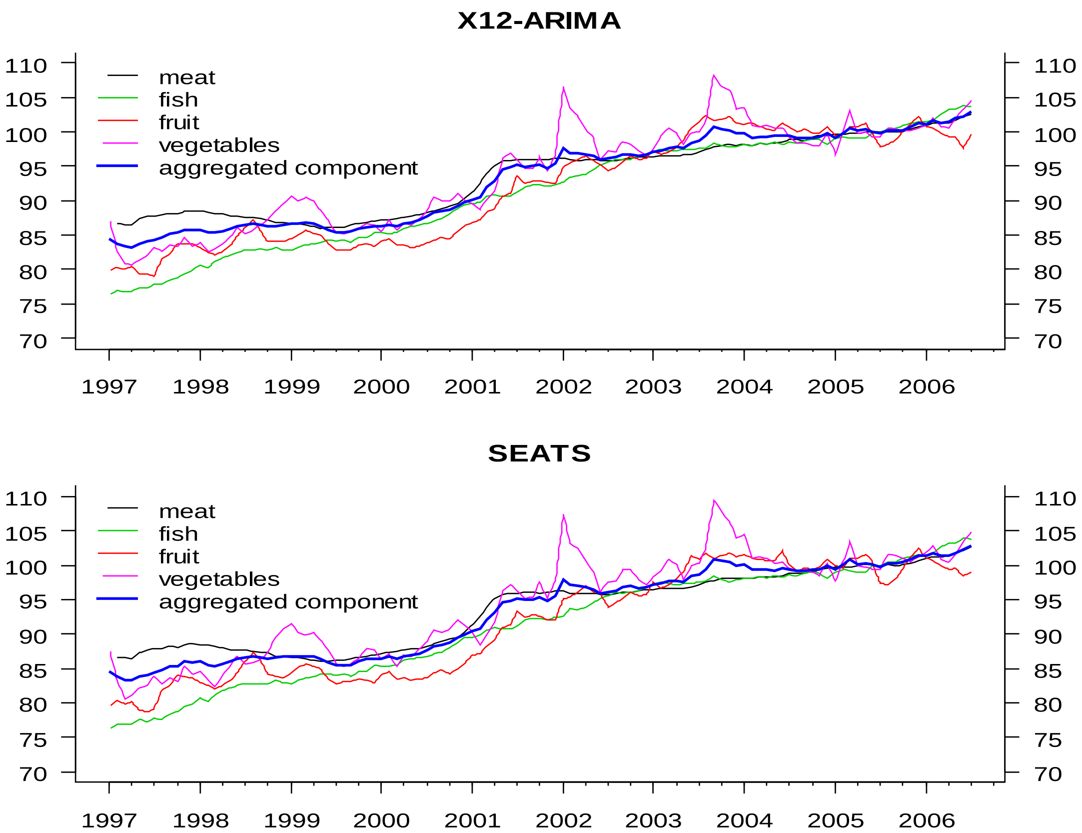
Chart 3: Alternative seasonally adjusted series for unprocessed food



Source: ECB calculations based on Eurostat data.

The seasonally adjusted series used in the indirect approach and the resultant aggregated indices are shown in Chart 4 for both methods. The series obtained with both methods display similar paths, even for vegetables which shows the highest variability throughout the sample period.

Chart 4: Indirect seasonal adjustment with X-12-ARIMA and TRAMO/SEATS for unprocessed food



Source: ECB calculations based on Eurostat data.

Furthermore, both X-12-ARIMA and TRAMO/SEATS detect the same type of outliers at the same dates for the vegetables component, as reported in Table 2. The temporary changes detected in vegetables in January 2002 and September 2003 are related to special weather conditions occurred at that time.

Table 2: ARIMA model with regression variables. Unprocessed food price index

	X-12-ARIMA	TRAMO/SEATS
Meat	LS 1997:05	AO 1997:04
Fish	None	None
Fruit	None	LS 1997:08; LS 2002.01; TC 2002:07
Vegetables	AO 1997:01; TC 2002:01; TC 2003:09	AO 1997:01; TC 2002:01; TC 2003:09

AO: Additive outlier, LS: Level shift, TC: Temporary change.

In any case, no indication of lack of normality in the residuals of the respective models was found[6]. It is neither the case in the results for the fruit price index obtained with X-12-ARIMA, where no outliers are detected in spite of the fact that TRAMO did it.

4.2.3 Assessing differences and similarities of alternative seasonally adjusted series

Table 3 reports different measures to compare the direct and indirect approaches when X-12-ARIMA and TRAMO/SEATS are applied for the adjustment of unprocessed food HICPs.

Table 3 Comparison of indirectly and directly adjusted series

		X-12-ARIMA	TRAMO/SEATS
Absolute percentage deviations	average	0.052	0.096
	maximum	0.177	0.246
Percentage of concordance in growth rates		92.982	93.860
Percentage of differences in growth rates	mean	0.000	0.001
	minimum	-0.146	-0.230
	maximum	0.136	0.231
	variance	0.004	0.008

On average, the absolute percentage differences are small, below 0.1 percentage points (p.p.). The maximum average percentage differences between the direct and indirect approaches are around 0.18 and 0.25 p.p. for X-12-ARIMA and TRAMO/SEATS respectively.

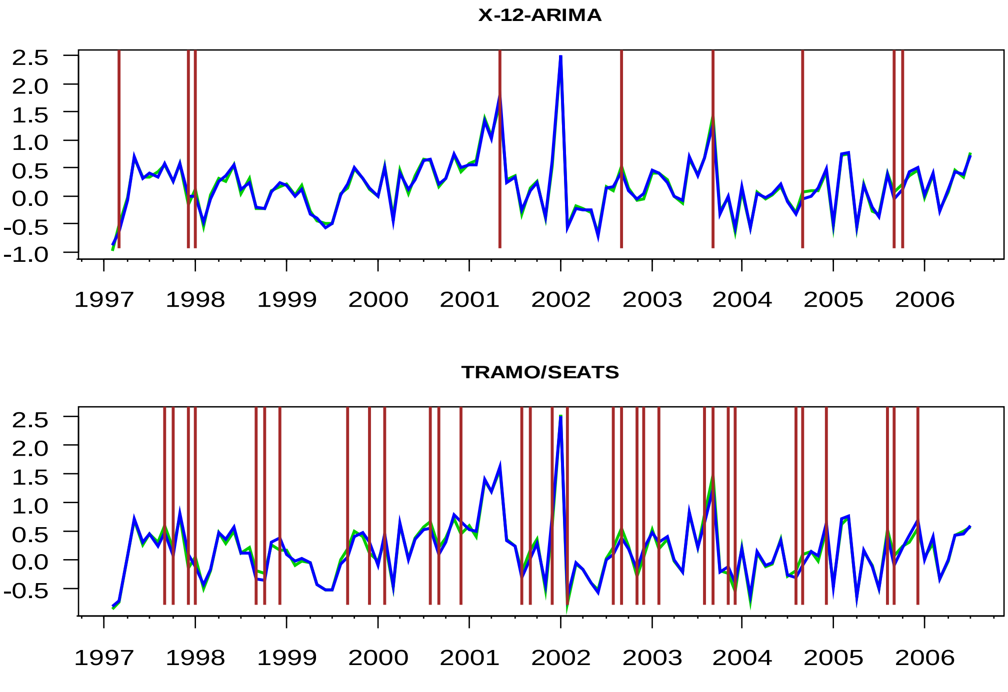
6 Normality is checked on the basis of the skewness and the kurtosis of the distribution of residuals. The lack of normality could indicate that outliers or exceptional events occurred in the sample period were not detected in a satisfactory way.

The second part of Table 3 indicates the degree of consistency in month-on-month growth rates, that is, the percentage of observations in which both series under comparison entail the same sign in the corresponding growth rate. The degree of concordance between the direct and indirect approaches is around 93.5%.

Looking to the values (not only the sign) of the growth rates, the third part of Table 3 shows that the average of the growth rates is almost identical. However, for individual observations there are differences in growth rates which are significantly distinct from zero. As a reference, in the direct versus indirect approaches, it can be seen that the range between the most extreme cases (minimum and maximum differences) is around 0.28 p.p. with X-12-ARIMA and around 0.46 with TRAMO/SEATS. This shows that the differences between direct and indirect adjustment can be substantial for unprocessed food.

Chart 5 shows the growth rates implied by the direct and indirect approaches. Those dates where the differences between both approaches are higher than 0.10 p.p. are indicated with vertical dotted lines. Their number is relatively low with X-12-ARIMA. The variance of the differences in growth rates is slightly higher in TRAMO/SEATS, as also indicated in Table 3.

Chart 5 Growth rates of the direct (blue lines) and indirect (green lines) approaches



Source: ECB calculations based on Eurostat data.

4.2.4 Measures of smoothness of the seasonal adjusted series and the seasonal factors

For comparing the direct and indirect approaches, the smoothness of the respective seasonally adjusted is often used as a reference criterion, though it has to be underlined that there is no reason as to expect a smooth behaviour of the seasonal adjusted series (since the irregular component is part of the seasonally adjusted series). The first part of Table 4 reports a measure of smoothness based on the sum of squares of month-to-month differences of the seasonally adjusted series. The results are provided for the direct and indirect approaches and also for each individual component. The measures of smoothness are very close for X-12-ARIMA and TRAMO/SEATS, nonetheless it can be noted that the direct approach with X-12-ARIMA is the smoothest case. The adjusted series for vegetables price index is the roughest.

Table 4 also reports a measure of smoothness in the seasonal factors. The seasonal patterns are usually defined to change only gradually over time, showing a higher degree of stability. This measure of smoothness is based on the sum of squares of the annually aggregated values. The results are shown for the direct approach and for the disaggregated index. The seasonal factors obtained with TRAMO/SEATS are slightly less smooth than those from X-12-ARIMA.

Table 4: Measures of smoothness

	Un-Food		Components			
	Direct	Indirect	Meat	Fruit	Fish	Vegetables
X-12-ARIMA SSA[a]	0.248e-02	0.435e-02	0.270e-02	0.186e-02	0.988e-02	5.784e-02
TRAMO/SEATS SSA	0.445e-02	0.456e-02	0.261e-02	0.203e-02	1.232e-02	6.144e-02
X-12-ARIMA SSF[b]	0.182	-	0.170	0.009	0.106	0.191
TRAMO/SEATS SSF	0.215	-	0.153	0.004	0.106	0.195

[a]Measure of smoothness of the seasonally adjusted series.
[b]Measure of smoothness of the seasonal factors.
The lower the measure statistics the smoother is the series.

4.2.5 Measures of stability of the seasonal adjusted series and the seasonal factors

Table 5 reports the results from an exercise for which X-12-ARIMA and TRAMO/SEATS are applied over different rolling spans. It is done for the aggregated unprocessed food index and for the direct approach. Data from 1990 to 2006 are used.

Each span period or sub-sample covers eight years which are rolled one year forward for each new span. Thus, the first sub-sample covers the period from January 1990 to December 1997, the second from January 1991 to December 1998 and so forth. Two measures of stability of the seasonal factors and the seasonally adjusted series are computed for the period July 1999 to June 2000, where the number of spans that cover these dates is relatively large.

Those cases in which the seasonally adjusted series or the seasonal factors are less stable do not always match the same month in both methods. For instance the statistic for the seasonally adjusted series in March with X-12-ARIMA is relatively low (0.238) whereas with TRAMO/SEATS it is one of the largest values (0.490). The statistic for December related to the differences in seasonal factors is another case where the value for X-12-ARIMA is well below the average whereas the value for TRAMO/SEATS is above the corresponding average.

Table 5: Measures of stability of the seasonal adjustment procedure

	Maximum percent difference in seasonal factors						
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
X-12-ARIMA	0.295	0.342	0.102	0.109	0.359	0.092	0.103
SEATS	0.219	0.169	0.217	0.137	0.351	0.313	0.174
	Feb	**Mar**	**Apr**	**May**	**Jun**	**Avge**	
X-12-ARIMA	0.450	0.515	0.173	0.231	0.114	0.240	
SEATS	0.318	0.604	0.322	0.465	0.150	0.287	
	Maximum difference in monthly changes in SA series						
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
X-12-ARIMA	0.362	0.150	0.122	0.133	0.276	0.336	0.375
SEATS	0.319	0.247	0.362	0.333	0.532	0.219	0.359
	Feb	**Mar**	**Apr**	**May**	**Jun**	**Avge**	
X-12-ARIMA	0.283	0.238	0.200	0.169	0.170	0.248	
SEATS	0.451	0.490	0.269	0.283	0.234	0.341	

The average values of the differences in the seasonal factors and the seasonally adjusted series are slightly higher in TRAMO/SEATS. Hence, in this particular case, the results from TRAMO/SEATS appear to be slightly less stable.

5 Conclusions

The following preliminary conclusions can be drawn from the research outlined in this note:

- *No evidence suggesting the need for seasonally adjust the energy price index is found.*

It is concluded that the inclusion of the unadjusted energy price index in the calculations of the seasonally adjusted overall HICP is a sensible practice. Seasonality was reliably identified only in the solid fuels series, the energy component with the lowest weight in the HICP. Differences in the growth rates between the unadjusted component and the indirectly adjusted component were found to be negligible.

- *Implicit treatment of taxes and administered energy prices.*

Energy price series are affected by changes in taxes and administered prices and, as they are usually modified periodically, are likely to cause a seasonal (or quasi-seasonal) pattern. The current approach of not adjusting the energy series for seasonality implies that tax effects and administered price changes are not removed from the seasonally adjusted euro area HICPs. For other HICP components which are subject to tax of administered price changes (e.g. tobacco) the practice depends on whether such effects have a larger impact at the euro area level so that they are identified as outliers. If so, their impact is not allocated to the seasonal component; if not, changes in taxes and administered prices may influence the seasonal component (and are thus – at least partially – not included in the adjusted series). A clear-cut separation between these and other (seasonal) effects would require to estimate the impact of tax and administered price changes at a very detailed HICP level, preferably at the country level.

- *The direct approach for the unprocessed food index.*

Regarding the stage at which aggregation is performed, the indirect adjustment would provide a better understanding of all the components of the overall HICP. However, bearing in mind the longer computation time that is required and the potential higher uncertainty in estimating seasonal factors on a more detailed level, the results shown in the paper for unprocessed food cast doubt on the efficiency of such approach. Absolute differences between the direct are indirect approach are small. The agreement in the sign of growth rates between both approaches is around 93.5% for unprocessed food. It is not found evidence suggesting a significant improvement by using the indirect approach instead of the direct approach in the unprocessed food price index.

- *Additional sub-indices for unprocessed food to be seasonally adjusted.*

Seasonally adjustment should and can be done for the components of unprocessed food (meat, fish and in particular fruit and vegetables). The results suggest a sufficiently stable seasonal pattern, however, significant outliers will remain part of the seasonally adjusted series in particular for fruit and vegetables.

- *Comparing X-12-ARIMA*

The performance of the current procedure employed in seasonal adjustment is validated by comparing the results with the model-based-approach methodology implemented in TRAMO/SEATS. Despite conceptual differences between X-12-ARIMA and TRAMO/SEATS, results are on average very similar. No systematic discrepancies between both methods were found. By comparing the results for the unprocessed food index, X-12-ARIMA showed good results in terms of smoothness and stability of the seasonally adjusted results and seasonal component.

Annex

Chart A.1: Euro area energy price index components (n.s.a. and s.a., 2005=100)

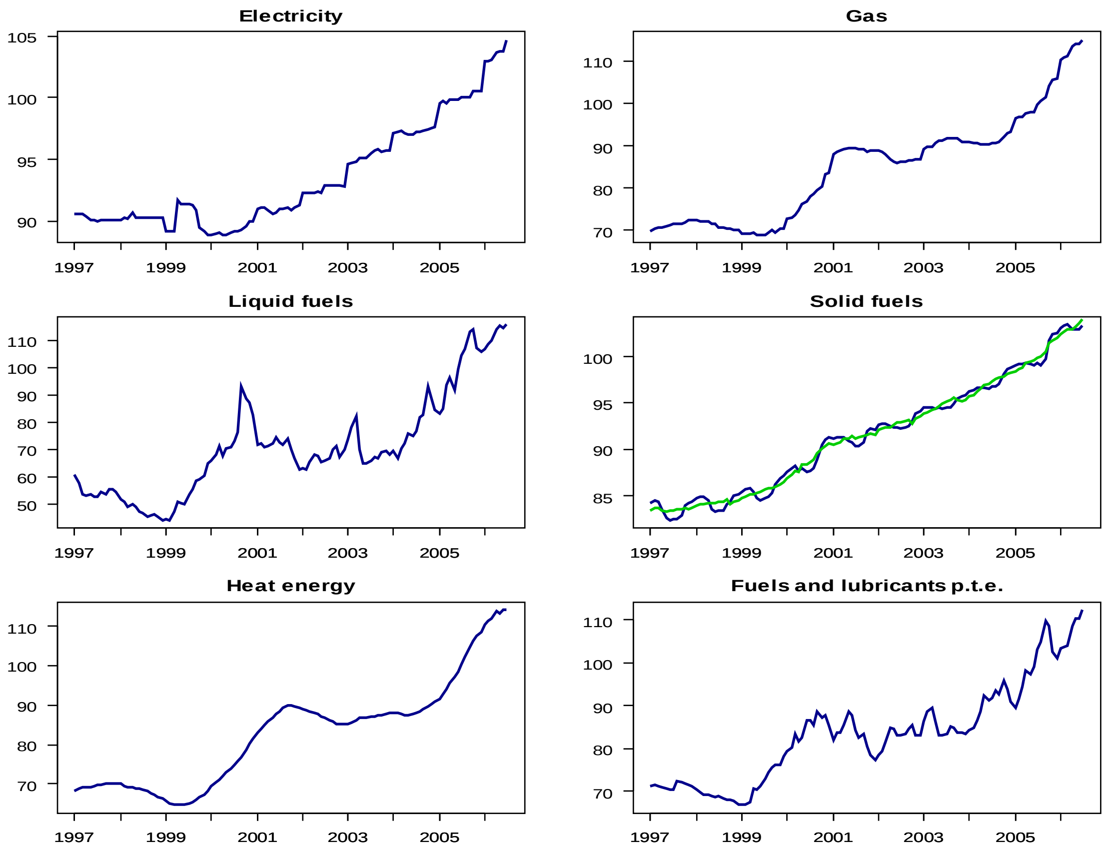


Chart A.2: Euro area unprocessed food price index components (n.s.a. and s.a, 2005=100)

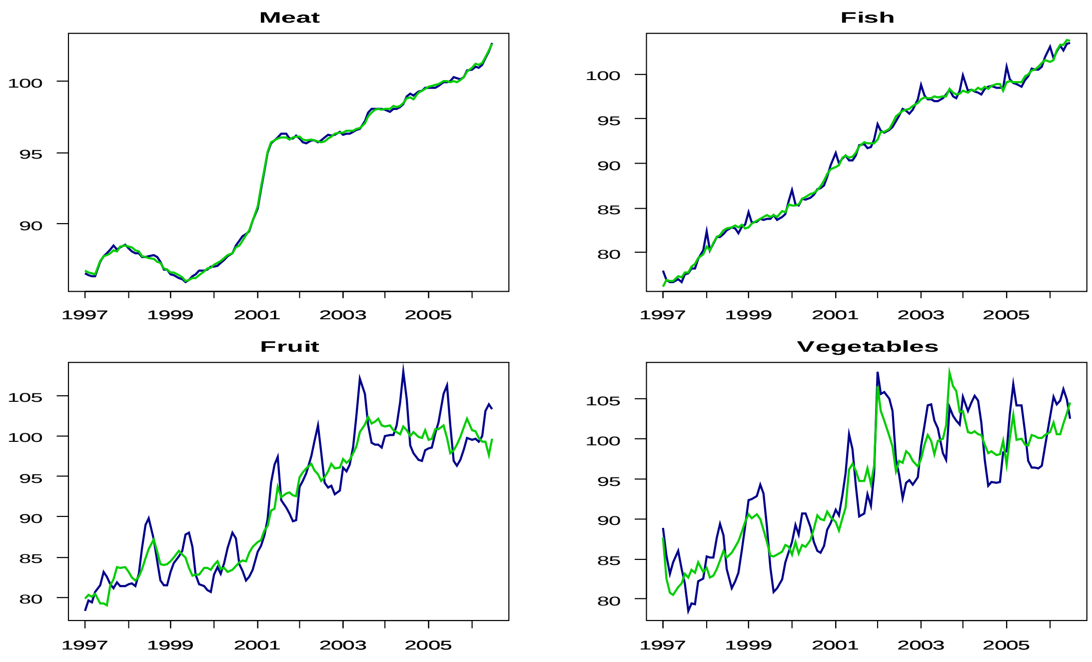


Chart A.3: National HICPs. Original and seasonally adjusted. 1/4 (n.s.a. and s.a, 2005=100)

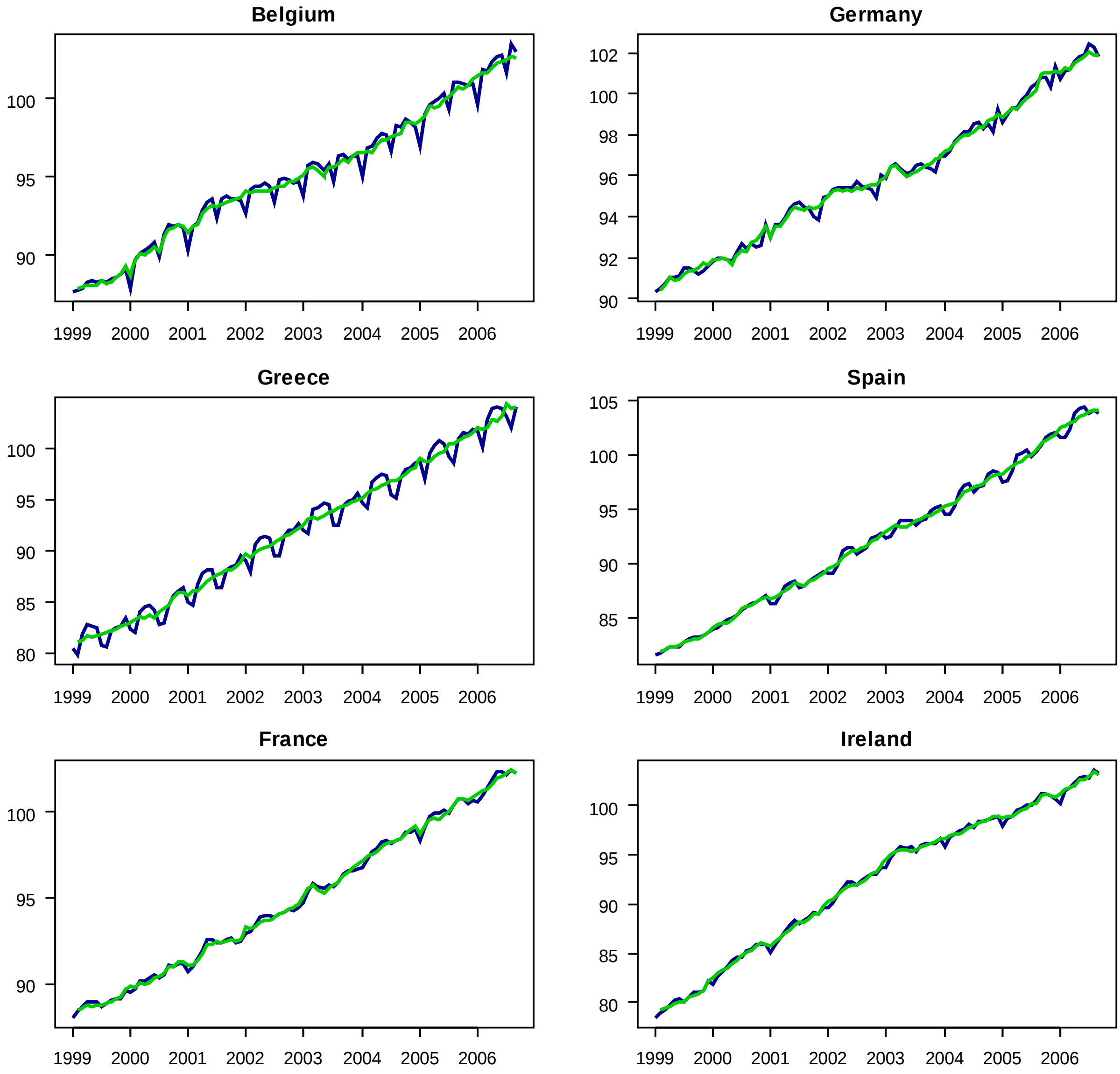


Chart A.4: National HICPs. Original and seasonally adjusted. 2/4 (n.s.a. and s.a, 2005=100)

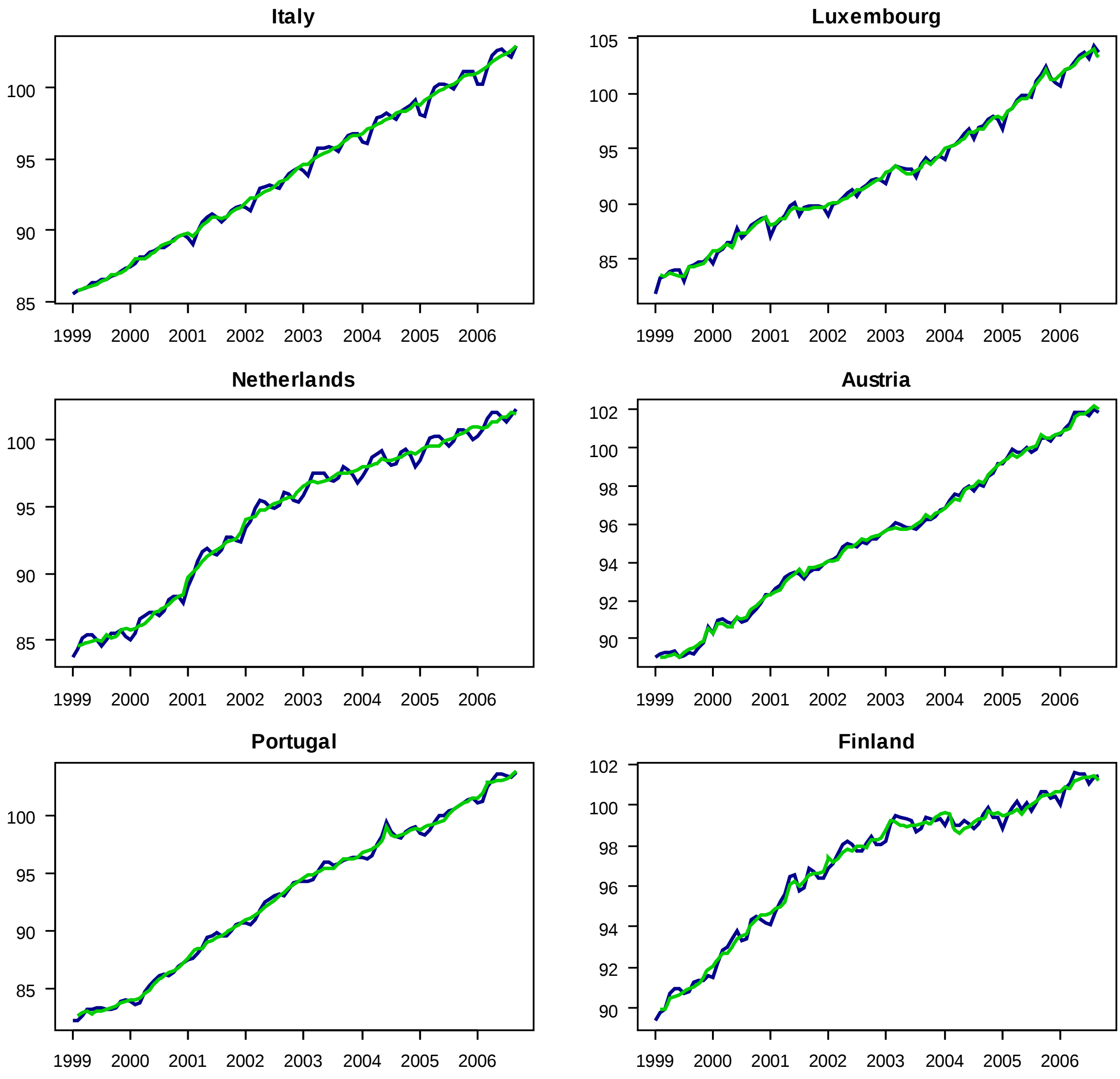


Chart A.5: National HICPs. Original and seasonally adjusted. 3/4 (n.s.a. and s.a, 2005=100)

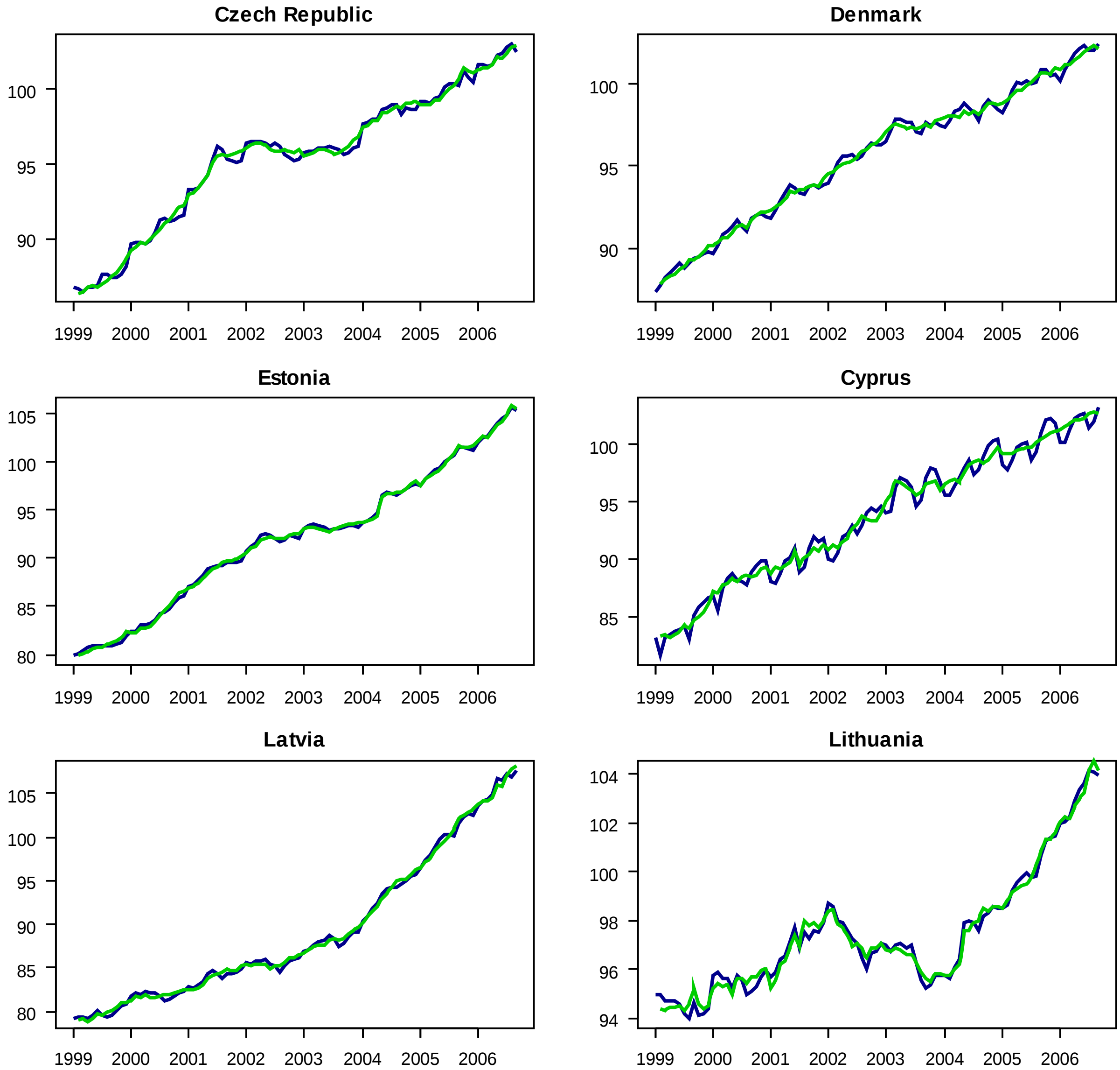


Chart A.6: National HICPs. Original and seasonally adjusted. 4/4 (n.s.a. and s.a, 2005=100)