Increasing importance of seasonality in inflation volatility

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Abstract

Given the increasing popularity of inflation targeting in the OECD countries the business cycle volatility of inflation substantially decreased in the past four decades. But due to the absence of corresponding decline in the seasonal cycle volatility the share of seasonality in the total volatility has increased.

Keywords: seasonality, inflation, structural breaks; JEL code C22,E31,E52.

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1 Introduction

It is common for empirical studies of inflation to either work with seasonally adjusted data or assume there is no seasonality. For example, Cecchetti and Debelle (2006) and Altansukh, Becker, Bratsiotis and Osborn (2017) use X-12 seasonal adjustment procedure before analysing CPI inflation in 13 OECD countries, while Ngai and Tenreyro (2014) assume there is no seasonality in US CPI. Eisenstat and Strachan (2016) use official seasonally adjusted US data but such data are available only for US and Germany (Cecchetti and Debelle, 2006). The OECD Statistics note that "*the majority of OECD countries do not produce seasonally adjusted CPIs because seasonal effects are not generally significant enough to warrant it*". On the other hand, Bryan and Cecchetti (1995) find the seasonal price movements in the US have become more prominent in the relatively stable inflation environment that has prevailed since 1982. In this paper we extend Bryan and Cecchetti's (1995) thesis to 13 OECD countries using the recent developments in the structural break tests of unknown number and timing.

Barsky and Miron (1989) document little seasonality in US inflation while Osborn (1990) find UK prices having slightly higher seasonal fluctuations than in the US. Beaulieu and Miron (1992) point to an evidence that shows seasonals in prices are small in 21 countries they study. But these studies assume not only constant volatility in the non-seasonal component but also constant seasonal patterns. Ignoring structural changes can reduce seasonal share in the total volatility in the former case and will reduce the volatility of the seasonal components in the latter, since the standard deviation of fitted seasonal dummies are used to used to measure the seasonal volatility in these studies. Changing monetary policy and economic structures, shifts in preferences, technological improvements, changes in business environment due to the globalization, and increase in competition from both domestic and foreign players can be behind such changes[1].

Bataa *et al.* (2014) propose an iterative decomposition that tests and accounts for multiple structural breaks in the mean, seasonality, dynamics and conditional volatility, while also accounting for outliers. They apply the methodology to G7 and Euro area CPI monthly inflation and document mean and seasonality breaks for all countries and, accounting for these the persistence also changes. Most interestingly they show that volatility reductions are widespread in the early to mid 1980s, with some countries exhibiting increases from 1999 onwards. In their study of the globalization of inflation Altansukh *et al.* (2017) reject the null hypothesis of constant volatility in the non-seasonal component of inflation for 13 OECD countries[2].

2 Methodology

We adopt Bataa *et al.* (2014) methodology by explicitly using its volatility decomposition implications. To be specific, consider decomposing an observed seasonal series Y_t into components capturing the level (L_t), deterministic seasonality (S_t),

[1]See Beaulieu and Miron (1996) and Cecchetti, Kashyap and Wilcox (1997), and Wen (2002), among others, for formal models that explicitly considers seasonality in macroeconomy.

[2]See Eisenstat and Strachan (2016) and references therein for Bayesian approach to modelling US inflation volatility.

outliers (extreme observations) (O_t) and dynamics (y_t):

$$\begin{aligned}
Y_t &= O_t + S_t + L_t + y_t && (1)\\
S_t &= \sum_{l=1}^{s} \delta_{k_1,l} D_{lt}, \qquad t = T_{k_1-1}+1,\ldots,T_{k_1}; \quad k_1 = 1,\ldots,m_1+1 && (2)\\
L_t &= \mu_{k_2}, \qquad t = T_{k_2-1}+1,\ldots,T_{k_2}; \quad k_2 = 1,\ldots,m_2+1 && (3)\\
y_t &= \sum_{i=1}^{p} \phi_{k_3,i} y_{t-i} + u_t, \quad t = T_{k_3-1}+1,\ldots,T_{k_3}; \quad k_3 = 1,\ldots,m_3+1 && (4)\\
\sigma^2_{u,t} &= var(u_t), \qquad t = T_{k_4-1}+1,\ldots,T_{k_4}; \quad k_4 = 1,\ldots,m_4+1 && (5)\\
\sigma^2_{S,t} &= \sum_{l=1}^{s} \delta^2_{k_1,l}\sigma^2_{D_{lt}} + 2\sum_{l=1}^{s}\sum_{i=l+1}^{s} \delta_{k_1,l}\delta_{k_1,i}\sigma_{D_{lt},D_{it}} \\
&\quad t = T_{k_1-1}+1,\ldots,T_{k_1}; \quad k_1 = 1,\ldots,m_1+1 && (6)\\
Ss_t &= \frac{\sigma^2_{S_t}}{\sigma^2_{u_t}+\sigma^2_{S_t}}, \quad t = T_{k_5-1}+1,\ldots,T_{k_5}; \quad k_5 = 1,\ldots,m_1+m_4+1 && (7)
\end{aligned}$$

where m_j denotes the number of breaks of type j that occur at observations T_{k_j} ($k_j = 1,\ldots,m_j$), with $T_0 = 0$ and $T_{m_j+1} = T$ (where T denotes the total sample size), and for s seasons per year ($s = 12$ for monthly data), D_{lt} ($l = 1,\ldots,s$) are seasonal dummies equal to unity if the observation at time t falls in season l and zero otherwise. Note that the coefficient $\delta_{k_1 l}$ represents the deviation of the unconditional mean of Y_t in the l^{th} season (month) from the overall mean level μ_{k_2} and, for identification purposes, we impose the restriction $\sum_{j=1}^{s} \delta_{k_l l} = 0$ for all seasonality regimes $k_1 = 1,\ldots,m_1+1$. Under the restriction that $O_t = p = m_1 = m_2 = m_3 = m_4 = 0$; equations (1)-(5) collapse to the model used in Barsky and Miron (1989), Osborn (1990), Beaulieu and Miron (1992) and Bryan and Cecchetti (1995).

Testing and decomposition method and their trimming parameter specifications are the same as in Bataa *et al.* (2014) hence the details are omitted to conserve space. Only difference is that we use conventional *F test* (at 5% significance level) for seasonality before estimating (2) as it is not clear whether all inflation components are indeed seasonal.

The assumption of deterministic seasonality is justified by the lack of seasonal unit roots in CPI inflation (see Canova and Hansen, 1995 for the US, Osborn and Sensier, 2009 for the UK and Narayan and Popp, 2011 for the G7). However if there is stationary stochastic seasonality, this will be evidenced as quantitatively important s^{th} order autocorrelation in y_t (Barsky and Miron, 1989 and Bataa *et al.*, 2014).

3 Data

We use monthly CPI aggregate, core, energy, and food inflation series from the OECD Main Economic Indicators database but concentrate on the aggregate one in this paper and provide the other results in the online Appendix. Our sample period extends from January 1970 to December 2017 and includes Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Italy (ITA), Japan (JPN), Netherlands (NLD), Sweden (SWE) Swtitzerland (CHE), UK (GBR) and USA. Hence our data are the same as that of Altansukh *et al.* (2017) but our sample is 4 years longer and we also consider area-wide inflation for G7, OECD Europe and OECD Total.

4 Results

Our principal empirical results concerning the presence of structural breaks in different characteristics of inflation and their implications for seasonal share in total volatility are discussed in this section. Results for the mean, seasonality and outliers are discussed first, followed by dynamics, volatility and increasing seasonality role in inflation volatility.

4.1 Mean, seasonality and outlier components

Table 1 provides numerical results relating to the outer loop of Bataa *et al.* (2014) procedure, specifically relating to mean, seasonality and outlier components. Several interesting conclusions emerge. Firstly, mean breaks are detected for all thirteen countries consistent with their result. Indeed, all experience at least one mean break in the first half of the 1980s, with inflation falling by more than half by the end of 1985 compared to its value at the beginning of the sample (compare the regime means). The high inflation levels of the 1970s, of course, reflect the global price shocks of large oil price increases, while Goodfriend (2007) points to the actions of the US Federal Reserve Chairman Paul Volker from 1979 onwards as crucial for not only reducing US inflation, but also in showing other countries that a central bank could successfully tackle inflation. It is beyond the scope of the present article to investigate whether the substantial reductions in mean inflation evident in Table 1 across all countries in the first half of the 1980s can be attributed to the adoption of similar policies, nevertheless the effective concurrence of these inflation declines is remarkable.

In a similar vein, it is notable that Austria, Canada, Denmark, Finland, France, Italy, Sweden, Switzerland, and the UK all experience further declines in the early 1990s, with all countries except Italy, then having inflation rates between 0.05% and 0.22% a month. In the case of Italy, however, the decline in mean inflation is somewhat delayed with its mean inflation converging to the others starting from 2008. Interestingly, in Switzerland the mean inflation from mid 2010 is negative, which could be due to the fall in energy, rent and transport costs as a result of lower oil prices.

The mean breaks dated for a number of countries in the early 1990s further evidence the role of monetary policy for inflation. Specifically, the February 1991 break for Canada coincides with its date of adoption of inflation targeting, while the June 1992 date for the UK is just prior to the event (inflation target announced in October 1992). Altissimo et al. (2006) point out that 1990s breaks for countries that adopted the euro may correspond to implementation of the nominal convergence required by the Maastricht Treaty, which was signed in February 1992. Although Germany does not experience any 1990s mean break, those for other Euro area countries may be viewed as bringing their inflation levels into line with those already experienced by Germany.

Overall, and in line with Altissimo et al. (2006), Cecchetti and Debelle (2006) and others, Table 1 provides evidence that level shifts are an important feature of the inflation process for these countries since 1970. These are relatively large in magnitude and often associated with policy changes.

Table 1 also indicates that all countries experience at least one break in their seasonal patterns, with these patterns altering in both the first half of 1980s and late 1990s/early 2000s in Denmark, Canada, Japan, and Sweden, and with changes in the 1990s and around 2000 for France and Germany. Austria, the Netherlands, Sweden and the UK have three seasonal breaks. Indeed, the close co-incidence of the first two dates of the latter three countries is notable. Finland, Switzerland and the US have only one seasonal breaks, the latter two countries' breaks are dated in early 2000s. The second change in seasonality for the UK dated in June 1992 in Table 1 is close to that found by Osborn and Sensier (2009) for the UK retail price index and may be due to the timing of budgets being disrupted after that year.

For some countries the seasonal standard deviation changes significantly across regimes defined by the break dates and substantially different when ignoring the breaks. For example, the seasonal variation was not so high in the US inflation but it has almost tripled since 2000. When the break is ignored the standard deviation of the seasonals is estimated to be 0.14. While for others the seasonal standard deviation does not change much, suggesting a change in the seasonal patterns; see November 1992 break for the UK.

Panel B of Table 1 also shows the seasonal R^2. One striking feature is that once the breaks are taken into account the seasonal R^2s are very high but if they are ignored these are estimated to be very low. This suggests that estimating seasonal dummy model ignoring the breaks produces a model that essentially averages seasonal dummy coefficients of different seasonal regimes and is inconsistent with data, hence the low R^2s.

The number of detected outliers varies between 1 for Austria, Canada, France, Japan, the Netherlands, Switzerland and the US to six for Italy, see Table 1. The dates of these aberrant observations are not shown in Table 1 to save space. Most outliers are related to specific exogenous events such as tax changes, in particular the introduction of the Canadian Goods and Services Tax in January 1991 or the introduction of the UK Council Tax in April 1991.

The AR lag lengths shown in Table 1 relate to the final iteration. In all iterations, the AR order is selected using the HQ criterion[3], with a lag of one adopted for inference purposes when HQ selects zero lags. The residual correlograms[4] suggest that stationary stochastic seasonality might be present in Austria, the Netherlands and Switzerland. However these would only suggest that the seasonal share in the total volatility we discuss in the next section is a lower bound. Finally, Table 1 also shows the number of iterations required for convergence of the main loop of our procedure. The procedure does not converge for Italy and Japan, so that the final model is selected using the HQ criterion. For both countries the iterative procedure cycles between two sets of break dates. These are very close in each case, with no substantive difference between their implications.

4.2 Dynamics, volatility and seasonal share in total volatility

Turning to Table 2, it is notable that we find inflation dynamics to remain unchanged from 1970 only for Canada, Germany, Japan, Sweden and the US. Indeed, Canada and Sweden effectively has zero inflation persistence (estimated as 0.06 and 0.04 respectively), which is compatible with Table 1 indicating that no AR component is required for the former. Although Germany and the US exhibit some inflation persistence, they are relatively modest at 0.42 and 0.46 respectively. Japan's persistence is highest among these five ecountries. The one AR coefficient break uncovered for Austria, the Netherlands, Switzerland, and the UK inflation

[3]The maximum number of lags considered is $P_max = integer[12 * (T/100)1/4]$.

[4]Not provided, but available upon request.

has an effect of decreasing persistence (measured as the sum of the AR coefficients), while for Finland and France where two breaks are detected the persistence has a U-shape. always very low after this break. It is note worthy that, in common with other studies (including Levin and Piger, 2004; Cecchetti and Debelle, 2006), our results imply that inflation persistence is only moderate when mean breaks are taken into account.

The estimated dates of persistence declines range between 1985 and 1999, and apparently show less cross-country communality than seen in the estimated dates of mean breaks in Table 1. Nevertheless, to the extent that good monetary policy was successful in reducing the level of inflation during the 1980s and 1990s, such policy may also have (largely) eliminated inflation persistence.

Having taken into account the effects of multiple structural breaks in level, seasonal and dynamic components as well as outliers through the model of equations (1)-(4), Table 2 also provides evidence on changes in (conditional) inflation volatility. The volatility break dates are broadly consistent across countries, with most countries experiencing such a break in the first half of the 1980s, corresponding to the beginning of the Great Moderation. In all cases except Germany, there is a close correspondence between the estimated date of the early 1980s decline in mean inflation (Table 1) and a volatility decline. Improved monetary policy may explain both characteristics, as monetary policy tightening can reduce inflation expectations (Goodfriend, 2007), thereby reducing volatility alongside the level of inflation.

However, there is also evidence that (at least for inflation) the Great Moderation may have came to an end around the close of the century, with volatility increases dated after 1999 for Canada, Italy, Japan and the US. Particularly note-worthy is the US, for which we find that (conditional) inflation volatility increasing by 50%. Denmark shows a different pattern, with an early volatility decline (in 1981), followed by a further decline in 1990.

The convergence in the iteration between the autoregressive and volatility component is relatively quick as can be seen from Panel C of Table 2.

Panel D reports the evolution of the seasonal share in inflation volatility. The regimes are defined by the break dates in Panel Bs of Tables 1 and 2. The seasonal share ignoring the breaks are reported in bracket. A striking feature here is that the seasonal share has been increasing monotonically for all countries. This increase is driven by either increases in seasonal standard deviations (Panel B of Table 1), or decreases in residual standard deviations (Panel B of Table 2), or both changes. For some countries such "seasonalization" is rather rapid. For example, the seasonal share in the US inflation volatility is mere 0.07 prior to 1982, while it has reached 0.66 after 2004.

This pattern of increased seasonal share is specifically strong for core inflation and rather muted for energy and food price inflation (provided in the Appendix).

5 Conclusion

We revisit Bryan and Cecchetti's (1995) thesis that suggests the seasonal price movements in the US have become more prominent in the relatively stable inflation environment that has prevailed since 1982 to 13 OECD countries using the recent developments in the structural break tests of unknown number and timing.

Our results show that the seasonal share in the total volatility has been increasing monotonically for all countries with either increases in seasonal standard deviations, or decreases in residual standard deviations, or both changes contributing toward such a trend.

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Table 1. Mean, seasonality and outlier components of CPI inflation decomposition

	AUT	CAN	DNK	FIN	FRA	DEU	ITA	JPN	NLD	SWE	CHE	GBR	USA
A. Mean	1984.09	1983.07	1983.06	1983.07	1978.02	1982.11	1987.11	1986.03	1982.04	1985.06	1982.10	1982.06	1982.07
breaks	1993.02	1991.02	1990.10	1991.02	1985.04		1996.06			1993.02	1993.09	1992.06	
					1992.06		2008.08				2010.05		
Regime	0.46	0.65	0.75	0.84	0.68	0.42	0.92	0.50	0.57	0.72	0.42	0.97	0.63
means	0.27	0.36	0.34	0.44	0.84	0.15	0.49	0.05	0.16	0.43	0.25	0.41	0.22
	0.16	0.15	0.16	0.13	0.25		0.25			0.10	0.08	0.17	
					0.12		0.11				-0.02		
	(0.27)	(0.32)	(0.35)	(0.38)	(0.34)	(0.22)	(0.51)	(0.20)	(0.27)	(0.35)	(0.19)	(0.43)	(0.33)
B. Seasonal	1987.08	1983.12	1983.12	1993.02	1993.02	1997.04	1986.08	1985.03	1981.02	1980.01	2001.11	1982.10	2000.02
breaks	1997.05	1999.03	2000.08		2006.08	2007.09	2004.09	1999.12	1992.02	1993.02		1992.11	
	2007.12								2008.02	2005.01		2002.07	
Regime	0.21	0.16	0.22	0.22	0.11	0.18	0.24	0.55	0.34	0.22	0.14	0.43	0.09
seasonal	0.45	0.13	0.24	0.19	0.14	0.23	0.09	0.35	0.23	0.40	0.28	0.35	0.24
std.	0.09	0.21	0.30		0.29	0.28	0.12	0.20	0.38	0.29		0.35	
	0.35								0.40	0.31		0.28	
	(0.13)	(0.14)	(0.22)	(0.17)	(0.10)	(0.13)	(0.10)	(0.31)	(0.30)	(0.17)	(0.13)	(0.27)	(0.14)
Regime	0.84	0.48	0.28	0.45	0.22	0.56	0.23	0.82	0.55	0.38	0.15	0.97	0.17
seasonal	0.22	0.29	0.21	0.37	0.37	0.42	0.32	0.51	0.45	0.49	0.65	0.67	0.54
R^2	0.72	0.41	0.41		0.72	0.72	0.39	0.82	0.75	0.57	0.50	0.64	0.37
		0.19	0.67					0.46	0.70			0.59	
								0.24					
	(0.04)	(0.11)	(0.11)	(0.17)	(0.11)	(0.16)	(0.05)	(0.22)	(0.43)	(0.10)	(0.12)	(0.30)	(0.17)
C. Outliers	1	1	5	2	1	1	6	1	1	3	1	3	1
D. AR order	14	0	15	15	13	11	17	14	12	15	13	16	15
E. Iterations	8	3	5	4	11	4	*	*	4	4	3	8	5

Notes: Decomposition of the components of equation (1) using the iterative method described in section III, with 15% trimming and a maximum of five breaks (20% and 3, respectively, for seasonality breaks). Regimes for the mean and seasonality are defined by the corresponding estimated break dates (written as yyyy.mm), with mean or standard deviation values (as appropriate) with no breaks in parentheses. The autoregressive order of the dynamic component is selected by the HQ criterion and is used at entry to the dynamic/volatility sub-loop in the final iteration. Iterations is the number of iterations of the main loop required to achieve convergence, with * indicating that the iteration converged to a two cycle oscillation and the choice between these is made using the HQ criterion.

Table 2. Dynamic and volatility components of CPI inflation decomposition and seasonal share in volatility

	AUT	CAN	DNK	FIN	FRA	DEU	ITA	JPN	NLD	SWE	CHE	GBR	USA
A. Dynamic	2000.03		2010.04	1986.08	1985.04		1978.06		1987.07		1993.10	1980.05	
breaks				2007.11	2007.07								
Regime	0.68	0.06	0.27	0.66	0.76	0.42	0.87	0.73	0.83	0.04	0.75	0.80	0.46
persistence	0.26		0.85	0.20	-0.23		0.90		0.49		-0.22	0.22	
				0.53	0.43								
	(0.61)	(0.06)	(0.34)	(0.58)	(0.56)	(0.42)	(0.86)	(0.73)	(0.71)	(0.04)	(0.67)	(0.61)	(0.46)
Regime AR order	12, 10	12	15, 7	7, 15, 2	6, 2, 0	11	5, 13	14	14, 12	15	12, 13	3, 14	15
B. Volatility	1987.08	1983.07	1981.06	1983.06	1983.01	2010.01	1986.08	1984.07	1978.08	1993.02	1982.06	1982.03	1983.05
breaks		1999.12	1990.10				2007.10	1999.03			2009.04		2004.10
								2008.04					
Regime	0.30	0.41	0.44	0.48	0.22	0.22	0.31	0.57	0.30	0.49	0.40	0.39	0.31
residual	0.18	0.20	0.32	0.23	0.17	0.18	0.12	0.31	0.21	0.27	0.23	0.23	0.18
std.		0.34	0.19				0.17	0.19			0.18		0.29
								0.29					
	(0.23)	(0.33)	(0.29)	(0.32)	(0.19)	(0.22)	(0.21)	(0.39)	(0.23)	(0.39)	(0.28)	(0.28)	(0.26)
C. Iterations	3	4	3	3	2	2	3	3	4	2	3	3	2
D. Regime	0.21	0.13	0.20	0.17	0.21	0.38	0.36	0.32	0.55	0.16	0.11	0.55	0.07
seasonal	0.33	0.28	0.33	0.40	0.32	0.51	0.36	0.48	0.56	0.40	0.25	0.60	0.19
share	0.79	0.31	0.36	0.47	0.41	0.60	0.39	0.51	0.72	0.54	0.58	0.70	0.41
	0.86	0.40	0.61		0.75	0.70	0.50	0.55	0.77	0.58	0.71	0.70	0.66
		0.53	0.71					0.75	0.79			0.78	
								0.76					
	(0.19)	(0.15)	(0.31)	(0.19)	(0.15)	(0.17)	(0.13)	(0.35)	(0.59)	(0.12)	(0.17)	(0.36)	(0.21)

Notes: Decomposition of the breaks in AR process of equation (4) into dynamic and volatility components using the iterative method described in section III of the text, with 15% trimming and a maximum of five breaks for both components. NA indicates not applicable, as no break is found in dynamics. Regimes for dynamics and volatility are defined by the corresponding estimated break dates (written as yyyy.mm), with persistence or standard deviation values (as appropriate) with no breaks in parentheses. Persistence is defined as the sum of estimated autoregressive coefficients. The AR orders are chosen by HQ for each dynamic regime. Iterations is the number of iterations of the dynamic/volatility sub-loop loop required to achieve convergence.

Table A1. Univariate iterative decomposition of core inflation

	AUT	CAN	DNK	FIN	FRA	DEU	ITA	JPN	NLD	SWE	CHE	GBR	USA
A. Mean	1977.07	1982.11	1983.02	1983.12	1977.04	1983.10	1978.03	1981.06	1983.02	1985.06	1977.04	1982.01	1983.02
breaks	1996.12	1991.09	1991.02	1994.11	1985.01	1997.09	1986.05	1997.11		1994.10	1995.04	1993.09	1992.04
					1993.04		1995.12			2007.01	2009.12		2001.12
							2008.12						
Regime	0.56	0.63	0.70	0.80	0.60	0.39	0.83	0.56	0.55	0.67	0.43	0.93	0.57
means	0.30	0.37	0.39	0.37	0.81	0.21	1.22	0.16	0.16	0.43	0.29	0.45	0.37
	0.15	0.13	0.15	0.12	0.28	0.10	0.48	-0.01		0.05	0.06	0.15	0.22
					0.11		0.20			0.09	-0.02		0.16
							0.09						
	(0.27)	(0.31)	(0.34)	(0.37)	(0.33)	(0.21)	(0.52)	(0.18)	(0.27)	(0.33)	(0.19)	(0.42)	(0.32)
B. Seasonal	1987.06	1979.09	1990.04	1995.09	1995.02	1980.01	1985.11	1985.07	1980.07	1983.02	1984.04	1982.10	1983.05
breaks	1997.01	2006.06	2001.06		2007.10	1997.03	1995.08	2000.04	1991.08	1996.10	1993.11	1993.01	1992.12
	2007.12					2008.01	2008.06		2008.06	2008.01	2003.06	2002.09	2008.05
Regime	0.12	0.16	0.29	0.22	0.12	0.20	0.30	0.51	0.43	0.25	0.16	0.53	0.13
seasonal	0.57	0.12	0.32	0.26	0.20	0.12	0.13	0.34	0.27	0.32	0.27	0.44	0.14
std.	0.13	0.22	0.34		0.39	0.30	0.08	0.18	0.44	0.46	0.13	0.45	0.18
	0.43					0.38	0.23		0.44	0.49	0.28	0.34	0.13
	(0.13)	(0.13)	(0.28)	(0.15)	(0.13)	(0.13)	(0.11)	(0.30)	(0.37)	(0.22)	(0.16)	(0.34)	(0.11)
C. Outliers	3.00	1.00	4.00	4.00	1.00	2.00	4.00	11.00	1.00	3.00	1.00	3.00	1.00
D. Dynamic	1988.08	1983.08	1982.04	1994.07	1985.01	1998.01	1986.05	2001.04	1982.12		1994.11	1993.04	1983.01
breaks	1996.09				1995.11			2008.04	1990.06				
Regime	0.52	0.63	0.43	0.61	0.86	0.60	0.85	0.68	0.78	0.18	0.82	0.67	0.86
persistence	1.07	0.02	0.41	0.54	-0.04	-0.56	0.32	0.41	0.55		-0.40	0.23	0.13
	0.15				0.65			0.58	0.60				
	(0.51)	(0.49)	(0.43)	(0.59)	(0.76)	(0.47)	(0.81)	(0.67)	(0.69)	(0.18)	(0.73)	(0.61)	(0.77)
AR lags	12, 11, 6	11, 13	6, 13	12, 13	6, 12, 13	8, 2	6, 0	13, 2, 11	5, 11, 12	6	14, 12	5, 12	2, 6
	(12)	(14)	(15)	(13)	(12)	(13)	(13)	(17)	(12)	(12)	(14)	(13)	(5)
E. Volaitility	1988.08	1981.07	1988.08	1983.07	1983.09	2010.04	1984.02	1984.11	1979.05	1977.09	1981.12	1991.10	1983.01
breaks				1994.07	1995.07			1995.11	2006.01	1994.02			2010.06
										2007.01			
Regime	0.24	0.30	0.35	0.49	0.21	0.19	0.36	0.35	0.34	0.51	0.30	0.36	0.21
seasonal	0.16	0.20	0.16	0.31	0.10	0.12	0.14	0.17	0.17	0.38	0.16	0.19	0.09
std.				0.18	0.12			0.11	0.24	0.22			0.07
										0.39			
	(0.20)	(0.23)	(0.25)	(0.32)	(0.15)	(0.18)	(0.23)	(0.23)	(0.23)	(0.37)	(0.20)	(0.28)	(0.14)
F.Regime	0.20	0.08	0.18	0.09	0.17	0.44	0.20	0.56	0.57	0.10	0.13	0.57	0.14
seasonal	0.53	0.31	0.30	0.31	0.22	0.25	0.60	0.58	0.77	0.47	0.19	0.62	0.43
R^2	0.76	0.20	0.67	0.66	0.97	0.68	0.24	0.72	0.66	0.40	0.64	0.79	0.62
	0.33	0.40	0.77	0.63	0.69	0.82	0.20	0.81	0.75	0.62	0.17	0.79	0.81
	0.86				0.91	0.86	0.68	0.64	0.69	0.80	0.71	0.76	0.72
									0.66	0.75			0.77
										0.59			
	(0.09)	(0.10)	(0.19)	(0.12)	(0.19)	(0.16)	(0.05)	(0.36)	(0.49)	(0.17)	(0.15)	(0.38)	(0.24)
G. Regime	0.21	0.13	0.40	0.17	0.26	0.27	0.22	0.68	0.61	0.19	0.23	0.60	0.27
seasonal	0.37	0.22	0.76	0.35	0.63	0.53	0.41	0.71	0.70	0.30	0.40	0.68	0.65
share	0.85	0.25	0.80	0.60	0.72	0.72	0.47	0.79	0.76	0.42	0.52	0.76	0.65
	0.87	0.54	0.81	0.67	0.81	0.80	0.73	0.90	0.77	0.58	0.74	0.84	0.70
	0.92				0.91	0.91	0.82	0.90	0.86	0.61	0.77	0.85	0.78
									0.86	0.67			0.78
										0.81			
	(0.21)	(0.21)	(0.47)	(0.16)	(0.33)	(0.18)	(0.14)	(0.57)	(0.67)	(0.18)	(0.32)	(0.45)	(0.33)
H. Convergence	19 (2)	10 (3)	19 (3)	5 (2)	9 (2)	19 (4)	13 (2)	10 (3)	5 (3)	4 (2)	6 (3)	8 (3)	5 (2)

Notes: See Notes to Tables 1 and 2.

Table A2. Univariate iterative decomposition of food inflation

	AUT	CAN	DNK	FIN	FRA	DEU	ITA	JPN	NLD	SWE	CHE	GBR	USA
A. Mean		1986.10	1984.04	1984.11	1983.04	1982.07	1985.07		1977.08	1987.10	1992.07	1980.08	1980.12
breaks					1990.06		1996.06					1990.06	1995.07
													2008.08
Regime	0.21	0.67	0.78	0.83	0.80	0.36	1.00	0.15	0.57	0.77	0.32	1.15	0.61
means		0.17	0.17	0.15	0.38	0.12	0.43		0.12	0.16	0.03	0.43	0.26
					0.12		0.15					0.19	0.23
													0.08
	(0.21)	(0.35)	(0.35)	(0.36)	(0.35)	(0.18)	(0.49)	(0.15)	(0.19)	(0.38)	(0.17)	(0.45)	(0.30)
B. Seasonal	1986.05	1981.06	1990.07	1984.01	1990.03	2000.12	1990.07	1991.02	2008.04	1993.02	1983.03	2002.03	1992.06
breaks	1997.08	1992.01	2000.07	1995.03	2008.02		2007.08				1993.07		
				2008.06							2008.05		
Regime	0.60	0.64	0.25	0.66	0.13	0.44	0.19	1.31	0.14	0.53	0.53	0.52	0.37
seasonal	0.58	0.76	0.24	0.37	0.38	0.37	0.14	0.57	0.45	0.27	0.70	0.44	0.22
std.	0.40	0.53	0.20	0.54	0.31		0.26				0.36		
				0.46							0.33		
	(0.32)	(0.51)	(0.12)	(0.29)	(0.22)	(0.41)	(0.17)	(0.86)	(0.14)	(0.36)	(0.34)	(0.30)	(0.23)
C. Outliers	1.00	1.00	2.00	3.00	1.00	1.00	5.00	1.00	1.00	2.00	1.00	1.00	1.00
D. Dynamic	1978.05	1990.06		1997.06	1988.11		2010.07	1983.07			1978.05		1990.01
breaks	2010.06							1995.07					2008.05
Regime	0.65	0.21	0.07	0.17	0.67	0.14	0.76	0.75	0.19	0.01	0.61	0.47	0.34
persistence	0.32	-0.09		-0.18	0.08		0.00	0.07			0.30		-0.01
	0.22							0.25					0.53
	0.37	0.12	0.07	0.05	0.37	0.14	0.72	0.58	0.19	0.01	0.43	0.47	0.26
AR lags	11, 14,0	1, 0	2	4, 2	6, 16	1	13, 4	11, 8	2	12	11, 14	13	1, 5, 2
	12	13	2	13	18	1	13	12	2	12	14	18	13
E. Volaitility	1985.07	1986.03	1984.04	1984.01	1983.02	1977.05	1981.10	1982.09	1991.06	1987.08	1992.07	1979.09	1978.08
breaks	2010.06		2005.03	1994.10	1990.03	2001.01	1990.07	2000.01	2005.11	2008.04		1990.08	1995.07
					2002.02		2008.03					2010.12	
Regime	0.77	1.08	0.73	1.04	0.29	0.44	0.42	1.35	0.43	0.87	0.70	0.83	0.79
residual	0.54	0.58	0.43	0.44	0.19	0.29	0.26	0.97	0.63	0.61	0.46	0.38	0.51
std.	0.37		0.56	0.68	0.51	0.50	0.17	0.72	0.38	0.43		0.61	0.31
					0.38		0.30					0.41	
	(0.61)	(0.79)	(0.57)	(0.77)	(0.38)	(0.40)	(0.29)	(1.01)	(0.49)	(0.69)	(0.59)	(0.59)	(0.50)
F. Regime	0.41	0.41	0.09	0.39	0.08	0.68	0.29	0.51	0.16	0.39	0.35	0.52	0.26
seasonal	0.47	0.47	0.17	0.86	0.28	0.35	0.32	0.30	0.13	0.11	0.48	0.18	0.31
R^2	0.32	0.48	0.25	0.32	0.44		0.45	0.31	0.61	0.18	0.24	0.20	0.23
	0.28		0.09	0.24	0.22		0.38				0.29	0.29	
	(0.11)	(0.25)	(0.02)	(0.10)	(0.10)	(0.49)	(0.16)	(0.31)	(0.06)	(0.19)	(0.05)	(0.14)	(0.16)
G. Regime	0.36	0.26	0.10	0.23	0.16	0.36	0.16	0.26	0.05	0.17	0.34	0.28	0.16
seasonal	0.38	0.33	0.11	0.29	0.32	0.51	0.34	0.39	0.10	0.27	0.36	0.35	0.18
share	0.53	0.46	0.18	0.31	0.36	0.62	0.41	0.48	0.13	0.29	0.38	0.42	0.33
	0.54	0.63	0.25	0.38	0.40	0.70	0.44	0.65	0.59	0.44	0.50	0.54	0.35
	0.56		0.25	0.42	0.50		0.71				0.70	0.65	
	(0.19)	(0.26)	(0.04)	(0.10)	(0.21)	(0.50)	(0.23)	(0.37)	(0.06)	(0.20)	(0.20)	(0.19)	(0.17)
H. Convergence	13 (19)	19 (4)	4 (2)	4 (3)	6 (3)	3 (2)	7 (3)	7 (3)	2 (3)	4 (2)	9 (3)	19 (3)	6 (3)

Notes: See Notes to Table A1.

Table A3. Univariate iterative decomposition of energy inflation

	AUT	CAN	DNK	FIN	FRA	DEU	ITA	JPN	NLD	SWE	CHE	GBR	USA
A. Mean	1982.02	2000.02	1982.11	1982.02	1991.04				1985.06	1985.04		1983.01	
breaks				1999.04	1999.04								
Regime	0.78	0.55	1.13	0.84	0.60	0.31	0.40	0.06	0.54	0.90	0.19	1.06	0.29
means	0.14	0.30	0.15	0.15	0.09				0.16	0.28		0.31	
				0.33	0.26								
	(0.30)	(0.45)	(0.41)	(0.39)	(0.38)	(0.31)	(0.40)	(0.06)	(0.28)	(0.48)	(0.19)	(0.51)	(0.29)
B. Seasonal		2001.04	1991.04	1999.04				2005.04	1988.01	1986.04	1991.04	1979.09	1986.01
breaks												1990.04	1999.04
Regime	0	0.40	0.33	0.37	0	0	0	0.15	0.59	0.57	0.70	0.55	0.50
seasonal		1.27	0.46	0.84				0.38	0.50	0.67	0.57	0.46	1.21
std.												0.43	1.89
	(0)	(0.56)	(0.33)	(0.41)	(0)	(0)	(0)	0.14)	(0.49)	(0.54)	(0.46)	(0.33)	(1.04)
C. Outliers	1.00	1.00	4.00	5.00	2.00	1.00	14.00	21.00	14.00	6.00	1.00	2.00	1.00
D. Dynamic breaks				2010.08		1990.08		1980.06					1981.03
Regime	0.26	-0.04	0.18	0.04	0.36	0.33	0.32	0.74	0.11	0.04	0.24	0.34	0.90
persistence				0.43		0.08		0.41					0.17
	(0.26)	(-0.04)	(0.18)	(0.09)	(0.36)	(0.18)	(0.32)	(0.49)	(0.11)	(0.04)	(0.24)	(0.34)	(0.36)
AR lags	1	3	1	13, 2	1	11, 1	5	2, 9	6	0	1	18	3, 12
	(1)	(3)	(1)	(1)	(1)	(11)	(5)	(9)	(6)	(0)	(1)	(18)	(12)
E. Volaitility	1980.01	1979.09	1979.02	1981.05	1984.02	1977.05	1979.09	1980.12	1980.08	1991.03	2010.07	2000.03	1986.02
breaks	1992.02	1986.11	1991.04	1999.04	1991.04	1984.10	1990.12	1988.02	1988.01	1999.12			1999.04
	1999.08	1999.04	1999.07	2009.01	1999.12	1992.02	2005.04	1996.01	2009.02				
	2010.05		2010.02		2010.05	1999.04		2004.06					
						2009.10							
Regime	1.17	1.20	1.43	1.46	1.18	1.70	0.78	0.58	0.87	1.85	2.38	1.07	0.86
residual	1.43	2.29	1.73	1.12	1.31	1.31	1.34	0.72	0.72	0.90	1.37	1.31	1.47
std.	0.78	1.33	0.90	2.26	0.55	1.65	0.87	0.32	1.38	1.72			2.59
	1.60	2.66	1.53	1.43	1.81	0.81	1.29	0.47	1.07				
	1.13		1.07		1.21	1.88		0.97					
						1.28							
	(1.31)	(2.10)	(1.43)	(1.56)	(1.31)	(1.53)	(1.12)	(0.70)	(1.15)	(1.68)	(2.27)	(1.18)	(1.90)
F. Regime	0	0.11	0.03	0.14	0	0	0	0.10	0.28	0.40	0.07	0.10	0.28
seasonal		0.05	0.17	0.19				0.04	0.15	0.21	0.03	0.22	0.29
R^2		0.02	0.12	0.09				0.02	0.04	0.10		0.04	
		0.16	0.09					0.49					
								0.03					
	(0)	(0.06)	(0.05)	(0.05)	(0)	(0)	(0)	(0.02)	(0.14)	(0.09)	(0.03)	(0.06)	(0.17)
G. Regime	0	0.02	0.04	0.06	0	0	0	0.02	0.12	0.09	0.05	0.10	0.25
seasonal		0.03	0.05	0.10				0.04	0.18	0.12	0.08	0.14	0.35
share		0.08	0.08	0.12				0.06	0.31	0.13	0.15	0.16	0.41
		0.10	0.16	0.26				0.09	0.40	0.36		0.20	0.67
		0.19	0.21					0.13					
								0.18					
	(0)	(0.06)	(0.05)	(0.06)	(0)	(0)	(0)	(0.04)	(0.15)	(0.09)	(0.04)	(0.07)	(0.21)
H. Convergence	3 (2)	3 (2)	3 (2)	3 (3)	2 (2)	2 (3)	19 (2)	8 (4)	4 (2)	3 (2)	3 (2)	5 (2)	5 (4)

Notes: See Notes to Table A1.