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The Persistence of Inflation in Switzerland: Evidence from Disaggregate Data*

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Abstract

This paper investigates persistence of Swiss consumer price inflation using aggregate and disaggregate inflation data covering 1983–2008. We document that persistence of sectoral inflation rates is below persistence of aggregate inflation. Our main finding is that inflation persistence significantly declines in the early 1990s. An estimated factor model reveals that inflation persistence stems from a persistent component that is common to inflation rates across sectors. Both the relevance and the persistence of the common component decline over time. Depending on the sample period and aggregation level, 70 to 90 percent of the variance in sectoral inflation rates is accounted for by short-lived sectoral factors.

JEL classification: E31, E52, C22

Keywords: inflation persistence, inflation dynamics, aggregation and persistence

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1 Introduction

Inflation persistence is subject to a substantial debate in macroeconomics. Centering on the question whether inflation persistence is intrinsic in the sense of Lucas (1976), a large empirical literature has not reached a consensus yet.[1] Supporting intrinsic inertia, Pivetta and Reis (2007) and O'Reilly and Whelan (2005) show that inflation persistence is high and has not significantly changed over the past 30 years in the U.S. and euro area, respectively. Contrary to these studies, Cogley and Sargent (2005) find that U.S. inflation persistence has declined since the 1970s. Benati (2008) provides evidence that inflation persistence varies across monetary regimes and diminishes in inflation targeting regimes. Regarding Switzerland, Benati (2008) shows that the persistence of inflation is high during 1947–1999 but close to zero during 2000–2006. Although the reported confidence intervals still include the non-stationary case, the results of Benati (2008) suggest that inflation persistence has declined under the new monetary policy concept. Broadly in line with Benati (2008), Levin and Piger (2004) report that Swiss inflation is highly persistent in the sample 1984–2003.[2]

The goal of our paper is to provide a detailed assessment of the level and change in persistence of Swiss consumer price inflation from 1983 to 2008. We investigate both headline inflation and disaggregate price data that constitutes the consumer price index (CPI). Working with disaggregate data allows to consistently estimate average persistence

[1] In the standard New Keynesian model, inflation is purely forward looking. Consequently, inflation persistence is determined by the persistence of the expected nominal marginal costs. To reconcile the model with the empirical regularity of inflation persistence, the literature has brought forward hybrid versions of the New Keynesian Phillips curve. Galí and Gertler (1999) motivate an intrinsic relevance of lagged inflation by suggesting that a fraction of firms use backward looking rule of thumb behavior to set prices. Other micro-level foundations are proposed by Christiano, Eichenbaum, and Evans (2005) and Fuhrer and Moore (1995). See Rudd and Whelan (2007) and Woodford (2007) for a critical discussion of these approaches and alternative models of inflation inertia.

[2] Other research on inflation in Switzerland investigates shifts in the mean of inflation. Huwiler (2007), Rapach and Wohar (2005), and Corvoisier and Mojon (2005) document that the mean of Swiss inflation exhibits a significant break in 1993. Moreover, several authors investigate price setting behavior of firms. Using disaggregate price data underlying the Swiss consumer price index, Kaufmann (2008) finds a median price duration of 4.6 quarters during 1993–2005. Both the frequency of price changes and the size of price changes do not exhibit a trend over time. Goette, Minsch, and Tyran (2005) use disaggregate price data to examine price setting in the restaurant sector. Lein (2007) and Zurlinden (2007) investigate price setting behavior using survey data.

of sectoral inflation rates.[3] Moreover, results for disaggregate series serve as a robustness test for the results on headline inflation. We further capitalize on the disaggregate data by estimating a factor model. This model disentangles sectoral persistence into persistence due to a common macroeconomic component and persistence due to a sectoral component of inflation. Although our focus lies on exploring the data without prior assumptions, we also investigate whether inflation persistence has changed under the new monetary policy concept which has been adopted by the Swiss National Bank in December 1999. The three main elements of the new concept are: (i) a quantitative definition of price stability, (ii) a conditional inflation forecast as the main indicator for monetary policy, and (iii) the announcement of a target band for the 3-month CHF Libor.[4] Introducing a quantitative definition of price stability and emphasizing the inflation forecast may have altered how economic agents form their expectations. Under the new monetary policy concept, an increasing share of agents might form forward looking expectations, such that the autoregressive component of inflation diminishes at the aggregate. In fact, this is suggested by results of Benati (2008). He finds that in an estimated hybrid New Keynesian model, the backward indexation parameter falls to nearly zero during 2000–2006.

Only few papers have investigated inflation persistence using disaggregate data. Employing price data that underlies the U.S. CPI, Bils and Klenow (2004) show that price changes are more frequent than calibrated sticky price models suggest. Moreover, they find that the frequency of price changes and inflation persistence are virtually uncorrelated. Relying on similar data, Clark (2006) finds that inflation persistence is lower the more disaggregate the price data is. The results of Clark (2006) suggest that short-lived idiosyncratic shocks predominate at disaggregate levels, whereas at more aggregate levels, a persistent common macroeconomic component determines the dynamics of inflation. This reasoning is consistent with Boivin, Giannoni, and Mihov (2009). They find that

[3]In contrast, persistence of aggregate inflation is an inconsistent estimator of average persistence at disaggregate levels. See Pesaran and Smith (1995) on the estimation of heterogeneous dynamic panels and Zaffaroni (2004) on the aggregation of linear dynamic models.

[4]The Swiss National Bank's new monetary policy concept defines price stability as an annual CPI inflation rate of less than 2%. See Baltensperger, Hildebrand and Jordan (2007) and Jordan and Peytrignet (2001) for an overview.

common macroeconomic shocks explain only about 15% of the volatility of disaggregate inflation rates in the U.S. While common macroeconomic shocks have persistent effects on inflation rates, sector specific shocks are short-lived. Boivin, Giannoni, and Mihov (2009) show that, in line with sticky price models, persistence due to the common factors and the volatility of sectoral inflation rates are negatively correlated. Altissimo, Mojon, and Zaffaroni (2007) confirm the results of Clark (2006) for three European countries.

We find that inflation persistence significantly declines in the early 1990s. This is suggested at all aggregation levels by median unbiased estimates of the sum of autoregressive coefficients using the grid bootstrap estimator of Hansen (1999) and the approximately median unbiased estimator of Andrews and Chen (1994). Breakpoint tests signal a significant break in the sum of autoregressive coefficients in Q3/1993. During 1993–2008, inflation is clearly a stationary process. In line with the literature, we find that inflation persistence is lower at more disaggregate levels. An estimated factor model provides an explanation for this result. The common macroeconomic component that drives sectoral inflation rates is highly persistent, whereas sectoral components are not. Both the relevance and the persistence of the common macroeconomic component decline over time. Due to the small number of observations, estimations for the new monetary policy regime are associated with high uncertainty. Our results indicate, however, that relative to the period 1993–1999, the persistence of inflation does not significantly change in the period 2000–2008.

This paper is structured as follows. Section 2 presents the disaggregate CPI data. Section 3 discusses how to define and estimate persistence and presents estimation results of aggregate and disaggregate inflation persistence. Section 4 investigates structural breaks in the inflation process. Section 5 estimates a factor model that relates aggregate and disaggregate results. Section 6 concludes.

2 Data

We use disaggregate CPI data provided by the Swiss Federal Statistical Office (FSO). Table 1 shows the hierarchical structure of the data. The Swiss CPI comprises 12 main groups. These can be broken down into 83 product groups and 218 index positions for which expenditure weights are available.[5] The CPI is subject to regular index revisions.[6] To obtain consistent data we restrict the sample period to 1983–2008. For this period, the FSO provides recalculated historical series in accordance with the index revision of 2005. In line with most of the literature on inflation persistence, we employ quarterly data. Using quarterly data also reduces the amount of sampling error as not all prices are collected on a monthly basis. We obtain a sample of 102 quarters spanning Q2/1983–Q3/2008. Inflation is defined as the annualized quarterly log-difference in the price index given by $\pi_{i,t} = 400ln(P_{i,t}/P_{i,t-1})$, where $P_{i,t}$ denotes the level of index series i in quarter t.

For consistency reasons we only consider series that cover the entire sample period Q1/1983–Q3/2008. Due to the index revisions in May 1993, May 2000, and December 2005, some components at product group level and index position level are not continuously available. To maximize coverage, incomplete series are replaced by their higher level aggregate. An exceptional example is the main group 12 ("other goods and services") which accounts for 4.63% of consumption expenditures in 2008. Thereof, 2.65 percentage points are accounted for by product groups and index positions that are available only from Q2/2000.[7] The highest level aggregate available for the entire sample horizon is the main group 12. Therefore, the main group aggregate is included as the only product group and as the only index position. Only a small number of series for which no reasonable aggregation is possible is dropped from the sample. This results in an omission of 12

[5]To denote the hierarchical levels, we use the FSO terminology, which differs from the COICOP standard. The FSO aggregation levels "main groups", "product groups", and "index positions" roughly correspond to the COICOP levels "divisions", "groups", and "classes". We employ the structure of the 2005 index revision that has become effective in December 2005. A further break-down of the index positions includes 1046 components for which no expenditure weights exist. See FSO (2008) for more details.

[6]Since the introduction of the CPI in 1922, 8 revisions have been implemented (in 1926, 1950, 1966, 1977, 1982, 1993, 2000, 2005).

[7]The product groups and index positions of main group 12 that are not available before Q2/2000 cover financial services, insurance, social protection services, and (residual) other personal effects.

Table 1: Structure of the Swiss CPI

Aggregation level	No. of series	Example	COICOP	Weight
Main group	12	Food and non-alcoholic beverages	01	11.091
Product group		Food	01.1	10.119
Product group	83	Bread, flour and food products	01.1.1	1.696
Index position	218	Flour		0.061
Survey position	1046	White flour		n.a.

Notes: The last column shows 2008 consumption expenditure weights.

product groups and 21 index positions. The omitted series account for 4.16% and 5.85% of consumption expenditures at product group and index position level, respectively. The final data comprises 12 main groups, 64 product groups, and 149 index positions.

At all aggregation levels, the index series have been seasonally adjusted using the X-12-ARIMA method (Findley et al., 1998). Due to the index revisions, some series exhibit structural breaks in their seasonal pattern. Consequently, we seasonally adjust series over subperiods with distinct seasonality.[8]

Part of our analysis relies on aggregating estimation results that are obtained at disaggregate levels. Unless otherwise indicated, all aggregates are weighted using constant consumption expenditure shares in 2008. Due to the omission of some series, we recompute the official weights to sum up to 100%. Tables A.1 through A.3 in the Appendix list the series in our dataset and the adjusted weights. We also report results for special aggregates listed in Table A.4, namely durables, semidurables, nondurables, services, and index excluding petroleum products.

Figure 1 shows the annualized quarterly CPI inflation rate and deciles of inflation rates across the 149 index positions. Annualized quarterly inflation averages at 1.89% between 1983 and 2008. Inflation peaks at 7.50% in Q3/1990, but falls back to levels below 2%

[8]E.g., main group 3 (clothes and shoes) and corresponding product groups and index positions exhibit seasonality only after 2000 due to the inclusion of sales prices. For these series, we link the seasonally adjusted Q1/1983–Q1/2000 series to the seasonally adjusted Q2/2000–Q3/2008 series. Moreover, series that clearly do not exhibit any seasonality, e.g. communications (main group 8) or education (main group 10), are not seasonally adjusted.

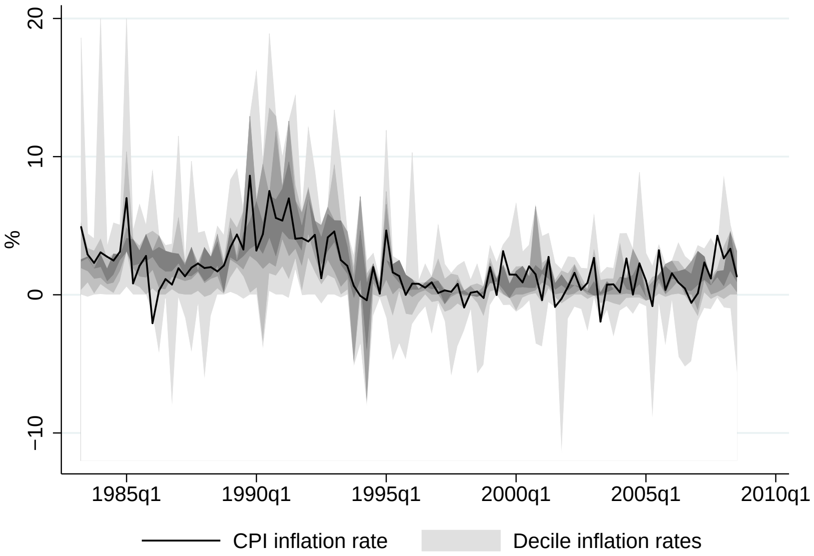


Figure 1: CPI inflation rate

Notes: This figure shows the annualized quarterly CPI inflation rate together with deciles of inflation rates on index position level. The lightest grey regions depict 10–20 and 80–90 percentile ranges, the darkest region shows the 40–60 percentile range. The percentiles are based on weighted inflation rates using constant 2008 consumption expenditure shares. The graphs' range of [-10, 20] does not fully cover the spike in the 90th percentile of 23.68% in Q1/1985.

after Q3/1993.[9] Since then, inflation has generally remained below 2%, with notable exceptions in Q1/1995, caused by the introduction of the value added tax, and during Q4/2007–Q2/2008, mainly reflecting rising oil prices.[10] Quarterly inflation rates average at about 1.1% in the period 1993–2008. Not only average inflation, but also relative price variability is lower in the second half of the sample, as Figure 1 further indicates. The average interquartile range of inflation rates at index position level declines from 3.75% in the period 1983–1992 to 2.25% in the period 1993–2008.[11] Regarding the dynamics of inflation, Figure 1 suggests that persistence is low in the second half of the sample period. Moreover, the apparent declines in mean and variability of inflation indicate that when assessing persistence, potential structural breaks need to be taken into account.

[9]The year-over-year inflation rate attains its maximum of 6.35% in Q2/1991.

[10]The VAT has been raised from 6.5% to 7.5% in Q1/1999 and 7.6% in Q1/2001.

[11]See Huwiler (2007), Appendix C, for a detailed discussion of the cross-sectional distribution of relative prices in Switzerland.

3 Aggregate and Disaggregate Persistence

3.1 Estimating Persistence

We define persistence as the cumulative long run effect of a shock to inflation. As the underlying process of the annualized quarterly inflation rate y we consider an AR(p)-model:

$$y_t \;=\; \mu + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \epsilon_t \tag{1}$$

with intercept μ and AR-coefficients $(\phi_1, \phi_2, \ldots, \phi_p)$. The cumulative long-run effect of a one time shock to inflation is given by the cumulative impulse response function (CIR):

$$CIR \;=\; \sum_{h=0}^{\infty} \frac{\partial y_{t+h}}{\partial \epsilon_t} \tag{2}$$

From the theory of difference equations we know that this sum converges if all eigenvalues of Equation (1) are smaller than 1 in modulus, i.e. if y is stationary. In this case, the cumulative long-run effect can be obtained from the sum of autoregressive coefficients:[12]

$$CIR \;=\; \frac{1}{1 - \sum_{i=1}^{p} \phi_i} \tag{3}$$

In line with much of the literature on inflation persistence, we thus measure persistence by the sum of autoregressive coefficients (SARC).[13] We directly obtain the SARC by estimating the augmented-Dickey-Fuller representation of Equation (1):

$$y_t \;=\; \mu + \alpha y_{t-1} + \psi_1 \Delta y_{t-1} + \cdots \psi_{p-1} \Delta y_{t-p+1} \; + \epsilon_t \tag{4}$$

where $\alpha = \sum_{i=1}^{p} \phi_i$. The SARC is a reasonable measure of persistence for stationary processes only. To identify whether y is stationary, we additionally assess whether the

[12]See Hamilton (1994) for a derivation.

[13]Less commonly used concepts and measures of persistence are the largest autoregressive root and the half-life. See Andrews and Chen (1994) and Pivetta and Reis (2007) for critical appraisals.

largest eigenvalue of the process is smaller than 1 in modulus.

We report median unbiased estimates of α computed with the grid bootstrap procedure of Hansen (1999). Employing this estimator is motivated by the negative bias of the OLS estimator of α. It is well known that this bias is particularly pronounced for persistent processes and that it may be substantial in small samples. Hansen (1999) builds on the finding that bootstrap quantile functions are not constant for α close to 1. Therefore, generating a simulation estimate of a bootstrap confidence interval using the OLS estimate $\hat{\alpha}$ as the true parameter is misleading. The Hansen (1999) bootstrap procedure considers a grid of true values instead. The resulting median unbiased estimates of the SARC have an equal probability of over- and underestimating the true persistence. We additionally report 90% grid-t bootstrap confidence intervals.[14] To select the optimal lag length p, we employ the Akaike-information criterion (AIC). In line with the literature on quarterly data, the number of lags is restricted to $p = 1, ..., 6$.

We alternatively use the approximately median unbiased estimator of Andrews and Chen (1994). Rather than considering a grid of true values, this estimator relies on an iterative procedure. In a first step, Equation (4) is estimated by OLS. In a second step, series for various α given $(\hat{\psi}_1, ..., \hat{\psi}_{p-1})$ are simulated and the α_{MU} is selected for which the median of OLS estimates corresponds to the initial OLS estimate. In a third step, parameters $(\psi_1, ..., \psi_{p-1})$ are re-estimated given α_{MU}. Steps 2 and 3 are repeated until convergence is achieved.[15] Unlike Hansen's (1999) grid bootstrap, the approximately median unbiased estimator does not simulate using estimated residuals but draws normally distributed residuals. Under the assumption of normally distributed residuals, Hansen's (1999) grid-α bootstrap generates the same results as the estimator of Andrews and Chen (1994). As shown in the Appendix, results with the approximately median unbiased estimator of Andrews and Chen (1994) are in line with the grid-bootstrap results.

[14]For computing grid-bootstrap confidence intervals we use Matlab codes provided by Bruce Hansen. We compute the grid-t confidence intervals based on 2,000 bootstrap replications at 200 grid-points.

[15]Matlab and R codes are available from the authors. Each simulation is based on 5,000 bootstrap replications. Convergence is achieved if the difference between the initial OLS estimate and the OLS estimate based on the simulated series is less than 0.005 in absolute terms.

3.2 Persistence at the Aggregate Level

Table 2 shows results on the persistence of headline inflation and some key aggregates for the periods 1982–2008, 1993–2008, and 2000–2008. The table shows separate results for the sample 1993–2008, motivated by the observed decline in the level and variability of inflation in the early 1990s. The sample 2000–2008 is defined by the introduction of the new monetary policy concept. We find that the median unbiased estimate of the SARC over the entire sample period is 0.85, with the 90% grid bootstrap confidence interval including the unit root case. Persistence substantially declines to levels of 0.22 during 1993–2008 and 0.08 during 2000–2008. In the period 1993–2008, the 90% confidence interval lies far left to the unit root case. Due to a low number of observations, results for the shorter sample spanning 2000–2008 are associated with higher uncertainty, reflected in a broad confidence interval.

The finding that inflation persistence declines over the sample period is robust, as results for the other aggregates indicate. The second column in each panel of Table 2 presents estimates for a constant weight aggregate. The constant weight aggregate is computed from 149 seasonally adjusted index positions and constant 2008 consumption expenditures weights. Considering this aggregate corroborates our results in two respects. First, the constant weight aggregate signals whether the decline in persistence is caused by a potential increase in the weight of index positions with low persistence. Second, the constant weight aggregate is based on index positions which have been individually seasonally adjusted. Due to the distinct seasonality of the underlying series, we expect that this is mirrored in a higher quality aggregate as compared to seasonally adjusting the aggregate itself. Consistent with the previous results, persistence of the constant weight aggregate declines substantially over time, indicating that the shift in persistence is not caused by changing weights. The constant weight aggregate is somewhat more persistent than aggregate CPI inflation in the samples 1993–2008 and 2000–2008. Also, the confidence interval for the constant weight aggregate is narrower due to a shorter lag structure.

The key aggregates durables, semi-durables, and nondurables share the common pattern

Table 2: Persistence of aggregate inflation

	SARC	90% CI	p	AC	R	AR(1)	Weight
			1983–2008				
Total	0.848	(0.671, 1.053)	3	0.852	0.872	0.456	100.000
Constant weight aggregate	0.819	(0.633, 1.047)	3	0.817	0.862	0.415	100.000
Nondurable goods	-0.064	(-0.437, 0.317)	6	-0.062	0.967	-0.051	26.368
Semidurable goods	0.657	(0.428, 0.919)	3	0.663	0.706	0.050	7.914
Durable goods	0.998	(0.804, 1.085)	4	0.975	0.951	0.640	9.211
Services	0.916	(0.797, 1.041)	2	0.919	0.906	0.734	56.507
Index ex. petroleum products	0.917	(0.803, 1.040)	2	0.922	0.910	0.764	95.314
			1993–2008				
Total	0.222	(-0.353, 0.477)	4	0.264	0.779	0.011	100.000
Constant weight aggregate	0.279	(-0.009, 0.578)	2	0.280	0.235	-0.011	100.000
Nondurable goods	-0.706	(-1.294, 0.197)	6	-0.711	1.012	-0.147	26.368
Semidurable goods	0.078	(-0.270, 0.436)	2	0.075	0.470	-0.281	7.914
Durable goods	0.458	(0.215, 0.703)	2	0.470	0.565	0.301	9.211
Services	0.159	(-0.110, 0.435)	3	0.166	0.622	0.271	56.507
Index ex. petroleum products	0.178	(-0.142, 0.486)	3	0.178	0.574	0.150	95.314
			2000–2008				
Total	0.083	(-0.712, 1.128)	4	0.020	0.741	-0.100	100.000
Constant weight aggregate	0.269	(-0.185, 0.813)	2	0.272	0.282	-0.075	100.000
Nondurable goods	-0.207	(-0.504, 0.092)	1	-0.203	0.224	-0.224	26.368
Semidurable goods	-0.258	(-0.561, 0.043)	1	-0.261	0.274	-0.274	7.914
Durable goods	0.061	(-0.246, 0.374)	1	0.060	0.028	0.028	9.211
Services	0.458	(0.196, 0.738)	1	0.465	0.406	0.406	56.507
Index ex. petroleum products	0.296	(-0.022, 0.630)	1	0.291	0.243	0.243	95.314

Notes: Quarterly data, Q2/1983–Q3/2008, Q1/1993–Q3/2008, and Q1/2000–Q3/2008. *SARC* denotes the median unbiased estimate of the sum of autoregressive coefficients, estimated with Hansen's (1999) grid bootstrap. *CI* is the 90% confidence interval of the sum of autoregressive coefficients. p is the lag order of the estimated AR model. AC denotes the approximately median unbiased estimate of the sum of autoregressive coefficients following Andrews and Chen (1994). R is the largest eigenvalue in modulus. *AR(1)* is the autoregressive coefficient in an AR(1) model estimated with OLS, *Weight* denotes the 2008 consumption expenditure weight. The constant weight aggregate is computed from index positions using 2008 consumption expenditure weights.

of a decline in persistence. But Table 2 also shows that the level of persistence substantially varies between these aggregates. In the period 1982–2008, durable goods inflation is markedly more persistent than nondurable and semi-durable goods inflation.[16] Furthermore, persistence of services inflation is higher than persistence of goods inflation. This is in line with evidence from the inflation persistence literature that price setting for labor intensive services is more rigid due to inflexible wages. Also, services include the highly persistent rents, which account for about 20% of consumption expenditures. Over the sample horizon, persistence tends to decline across all aggregates. Consistent with the notion that petroleum prices are highly volatile, persistence of aggregate inflation slightly increases once these prices are being excluded.

Table 2 further shows the largest eigenvalue in modulus and the autoregressive coefficient from an estimated AR(1) model. The largest eigenvalue is generally smaller than 1 in modulus, indicating that the SARC is a valid measure of persistence.[17] The decline in the SARC is mirrored in a decline of the autoregressive coefficients in an AR(1) model. For headline inflation, this coefficient drops from 0.456 in the full sample to around zero in the samples 1993–2008 and 2000–2008. Persistence as measured by the AR(1) coefficient is generally below persistence measured by the SARC. Moreover, the table shows that results based on the estimator of Andrews and Chen (1994) are in line with the grid bootstrap estimates.

Finally, the measured decline in persistence is not driven by a potential structural break in the inflation process in the early 1990s.[18] This conclusion is based on additional persistence estimates for the 1982–1992 period presented in Table A.5. We find that persistence over the full sample period lies between persistence in the subperiods 1982–1992 and 1993–2008. Also, that the optimal lag length for headline inflation varies only

[16]The most important components of semi-durable goods are clothing and footwear, smaller electric household appliances, games and toys, equipment for sport, and books.

[17]The only exception is nondurable goods inflation, 1993–2008. For this series, the largest eigenvalue is larger than 1 in modulus.

[18]The potential relevance of breaks in deterministic trends is highlighted by Perron (1989). In particular, Perron (1989) shows that a break in the intercept of the true data-generating process leads to overestimating persistence in a model that does not account for a break.

between 3 and 4. Hence, the SARC declines due to a change in coefficients rather than due to a change in the lag structure.

In sum, our results clearly show that headline inflation is stationary in the period 1993–2008.[19] Persistence is substantially higher in the period 1983–1992, for which the median unbiased estimate indicate that inflation is a unit root process. The magnitude and change in persistence is consistent with results of Benati (2008), although Benati (2008) considers Q1/2000 as the break date. Benati (2008) finds that persistence is substantially lower under the new monetary policy regime than in the period 1972–1999. Moreover, the 90% grid bootstrap confidence intervals reported by Benati (2008) also include the unit root case in both periods. Our results indicate, however, that persistence of headline inflation has declined earlier in the 1990s.

3.3 Persistence at the Disaggregate Level

This section examines persistence at more disaggregate levels. Table 3 presents summary statistics for the periods 1983–2008, 1993–2008, and 2000–2008. Unless otherwise indicated, all statistics are weighted aggregates using constant 2008 consumption expenditure weights. The statistics confirm the declining tendency of persistence over time. Mean persistence at the index position level declines from 0.49 during 1983–2008 to 0.12 during 1993–2008 and 0.10 during 2000–2008. Moreover, the table shows that the share of series for which the 90% confidence interval does not include the unit root case increases from 0.56 during 1983–2008 to 0.87 during 1993–2008 and 0.79 during 2000–2008. We further observe that the unweighted mean of persistence is generally lower than the weighted mean, indicating that more persistent series tend to have a higher weight. This is confirmed by the positive correlation of persistence with consumption expenditure weights. Finally, the share of series with eigenvalues lower than 1 in modulus lies always above 94%, indicating that the SARC is a valid measure of persistence.

Table 3 also indicates that the more disaggregated the underlying series are, the lower is

[19] The 99% grid-bootstrap confidence interval for the SARC is (-0.606, 0.763), the 90% confidence interval shown in Table 2 is (-0.353, 0.477).

Table 3: Persistence by aggregation level

	Main Groups		Product Groups		Index Positions	
	SARC	90% CI	SARC	90% CI	SARC	90% CI
			1983–2008			
Mean	0.630	(0.367, 0.887)	0.518	(0.287, 0.767)	0.486	(0.265, 0.720)
Median	0.588	(0.328, 0.883)	0.656	(0.429, 0.934)	0.656	(0.416, 0.862)
75th percentile	0.844	(0.602, 1.046)	0.853	(0.710, 1.037)	0.853	(0.710, 1.037)
90th percentile	0.993	(0.684, 1.128)	0.853	(0.710, 1.088)	0.853	(0.710, 1.088)
Unweighted mean	0.587	(0.338, 0.835)	0.426	(0.163, 0.704)	0.207	(-0.063, 0.490)
SARC < a.SARC	0.726		0.717		0.713	
CI < 1	0.720		0.562		0.558	
R < 1	1.000		0.984		0.993	
r(SARC, weight)	0.209		0.099		0.175	
			1993–2008			
Mean	0.247	(-0.026, 0.477)	0.103	(-0.206, 0.421)	0.112	(-0.199, 0.436)
Median	0.184	(-0.030, 0.349)	0.182	(-0.116, 0.485)	0.182	(-0.124, 0.489)
75th percentile	0.408	(0.102, 0.722)	0.356	(0.035, 0.619)	0.309	(-0.010, 0.672)
90th percentile	1.070	(0.620, 1.245)	0.468	(0.216, 1.061)	0.468	(0.210, 1.061)
Unweighted mean	0.175	(-0.100, 0.417)	0.031	(-0.313, 0.383)	-0.111	(-0.459, 0.251)
SARC < a.SARC	0.596		0.727		0.726	
CI < 1	0.849		0.871		0.873	
R < 1	1.000		0.941		0.942	
r(SARC, weight)	0.240		0.067		0.133	
			2000–2008			
Mean	0.235	(-0.186, 0.618)	0.129	(-0.282, 0.543)	0.095	(-0.311, 0.518)
Median	0.199	(-0.103, 0.461)	0.257	(-0.190, 0.532)	0.189	(-0.226, 0.553)
75th percentile	0.352	(-0.023, 0.958)	0.355	(0.067, 0.787)	0.355	(0.067, 0.661)
90th percentile	1.168	(0.267, 1.487)	0.623	(0.183, 1.274)	0.497	(0.128, 1.235)
Unweighted mean	0.104	(-0.319, 0.514)	-0.057	(-0.541, 0.433)	-0.210	(-0.679, 0.271)
SARC < a.SARC	0.603		0.516		0.572	
CI < 1	0.849		0.756		0.786	
R < 1	1.000		0.993		0.991	
r(SARC, weight)	0.442		0.154		0.144	
No. of series	12		64		149	

Notes: Quarterly data, Q2/1983–Q3/2008, Q1/1993–Q3/2008, and Q1/2000–Q3/2008. *SARC* denotes the median unbiased estimate of the sum of autoregressive coefficients, estimated with Hansen's (1999) grid bootstrap. *CI* is the 90% confidence interval of the sum of autoregressive coefficients. All statistics are weighted aggregates using constant 2008 consumption expenditure shares unless otherwise indicated. *SARC < a.SARC* is the share of series for which the SARC is smaller than the SARC of the constant weight aggregate inflation. *CI < 1* denotes the share of series for which the SARC 90% confidence interval lies below unity. *R < 1* is the share of series for which the the largest eigenvalue in modulus is smaller than 1. *r(SARC, weight)* is the Pearson correlation coefficient between SARC and weight.

mean persistence. Mean persistence at disaggregate levels is consistently below persistence of the constant weight aggregate shown in Table 2. The share of disaggregate series for which persistence is lower than aggregate persistence varies between 0.52 and 0.73, mainly depending on the sample horizon. Both patterns are in line with the aggregation result outlined by Zaffaroni (2004), according to which aggregate persistence is to some extent a statistical artefact of aggregation. Consistent with our results, Clark (2006) and Altissimo, Mojon, and Zaffaroni (2007) show that similar patterns hold for U.S. and euro area data.

Regarding the change in persistence over time, Table A.6 in the appendix provides further evidence that persistence has declined several years before the introduction of the new monetary policy concept. In fact, the estimates for the period 1993–1999 are very similar to the estimates for the period 2000–2008. The next section investigates the nature and date of a potential structural break in more detail.

4 Structural Breaks in Persistence

4.1 Structural Break at the Aggregate Level

The above results suggest that aggregate persistence declines in the second half of the sample. To further investigate changes in persistence over time, we start by discussing rolling estimates of the SARC over 8-year windows. Figure 2 presents the rolling median unbiased estimate together with a 90% grid bootstrap confidence interval for headline inflation. The estimated model includes 4 lags, which corresponds to the average lag length chosen by the AIC over the subperiods discussed above. The figure indicates that persistence begins to decline in the sample 1991–1998. However, the flexibility of the rolling estimates comes at the price of wide confidence intervals which include the unit root case for most of the time. The figure also shows that persistence of headline inflation falls to -0.96 in the sample Q3/1999–Q2/2007. Although this sudden fall does not alter the general finding of a decline in persistence, it reinforces our approach to consider disaggregate data for testing robustness of the results on headline inflation.

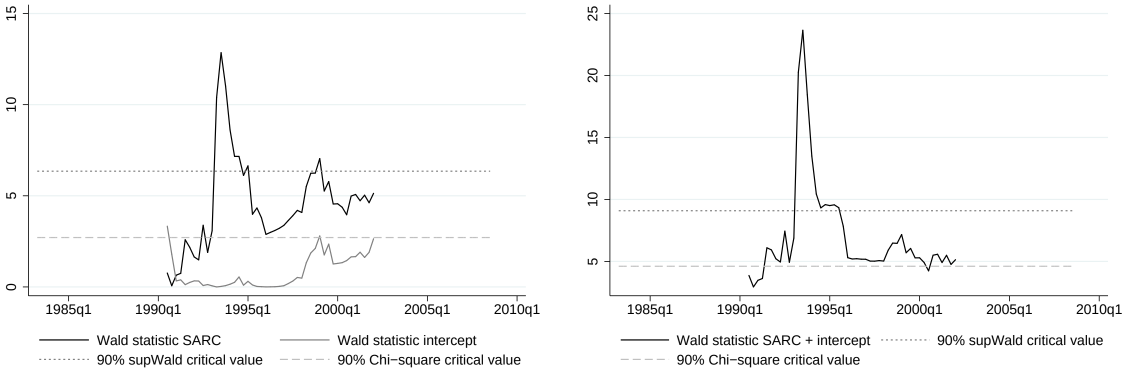
Figure 2: Rolling 8-year median unbiased estimates of persistence

Notes: This figure shows rolling median unbiased estimates of the SARC in an AR(4) model and 90% confidence bands, estimated with Hansen's (1999) grid bootstrap. The windows span 32 quarters, ranging from $t-16$ to $t+15$.

To formally test whether inflation persistence has declined we employ the sup-Wald test with critical values given by Andrews (1993b, 2003). We test for a break in the SARC, for a break in the intercept term, and for a joint break in the SARC and intercept of an AR(4) model of inflation.[20] Figure 3 shows the Wald-test statistics together with 90% critical values. The Wald statistic for a break in persistence peaks in Q3/1993 and is highly significant. The statistic exhibits a second peak in Q1/1999. Meanwhile, the Wald test statistic for a break in the intercept term is insignificant. The joint test for a break in the SARC and in the intercept mirrors the pattern of the separate test for a break in the SARC.

Table 4 summarizes results of the sup-Wald test. The table also reports test results for the constant weight aggregate computed from 149 index positions. The sup-Wald test for

[20] Due to the relatively short sample horizon we use 25% trimming rather than the usual 15% trimming. For the AR(4) model the period in which a structural break may occur spans Q3/1990–Q1/2002. As shown by Andrews (1993b), the higher trimming results in a higher power of the sup-Wald test against alternative hypothesis of a structural break close to the lower or upper boundary of the sample.



(a) Separate tests

(b) Joint test

Figure 3: Wald test statistics for a break in the SARC and intercept

Notes: These figures show Wald test statistics for the equality of SARC and/or intercept in an AR(4) model between interval t_l to $(t-1)$ and interval t to t_h. The Wald statistics are heteroscedasticity-robust and include a degree of freedom correction. The lower and upper limits t_l and t_h are chosen to implement 25% trimming. Critical values for the sup-Wald statistic are taken from Andrews (2003).

Table 4: Tests for structural break in aggregate inflation

	CPI inflation rate			Constant weight aggregate		
	SARC	Mean	Both	SARC	Mean	Both
Unknown breakdate						
supWald statistic	12.85***	3.33	23.65***	7.27*	3.43	11.25**
Date	Q3/93	Q3/90	Q3/93	Q3/93	Q1/02	Q2/93
Break in Q1/2000						
Wald statistic, 1993–2008	0.89	0.62	0.45	0.37	1.72	0.90
Wald statistic, 1983–2008	4.56**	1.29	2.65*	3.00*	1.54	1.5

Notes: Quarterly data, Q2/1983–Q3/2008 and Q1/1993–Q3/2008. All statistics are based on an estimated AR(4) model. The constant weight aggregate is computed from index positions using 2008 consumption expenditure weights. The trimming parameter for the sup-Wald test is set to 25%. *Date* denotes the quarter in which the break occurs. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

a structural break at an unknown date yields consistent results for both the conventional and the constant weight aggregate. For both series, the test rejects the null hypothesis of no change in the SARC and identifies Q3/1993 as the break-date. Moreover, the sup-Wald tests indicate that the intercept term of the inflation process does not change between Q3/1990–Q1/2002. This further supports our results on persistence which do not seem to be affected by a structural break in the mean.

Table 4 additionally presents Wald tests of the null hypothesis that inflation persistence during 2000–2008 is not different from inflation persistence in earlier periods. The results depend on the pre-break sample period. Not surprisingly, the null is rejected employing the 1983–2008 sample. Using the shorter 1993–2008 sample, however, we find no evidence that inflation persistence changes between 1993–1999 and 2000–2008.

4.2 Structural Break at the Disaggregate Level

The above results are confirmed at disaggregate levels. Table 5 presents summary statistics of sup-Wald tests carried out for main groups, product groups, and index positions. All statistics are weighted using constant 2008 consumption expenditures weights. The lag structure of the estimated AR models is chosen individually for each series based on the AIC. The table shows that the share of series with a significant structural break in the SARC lies between 0.47 for main groups and 0.31 for index positions. The median break date roughly corresponds to the break date of aggregate inflation. But the interquartile range of the quarter in which a break occurs indicates that the series are highly heterogeneous. The interquartile range spans about 8 years on all three aggregation levels.

Consistent with the results for headline inflation, Table 5 shows that the share of series with a break in the intercept term is lower than the share of series with a break in the SARC. The weighted share lies at about 0.30. Table 5 also presents the unweighted share and the share of series for which an AR(4) model exhibits a break. These statistics confirm the above findings. Moreover, the difference between the share of breaks in the SARC and the share of breaks in the intercept is more pronounced for the AR(4) model than for a

Table 5: Breakpoint tests with an unknown date

	Main Groups			Product Groups			Index Positions		
	SARC	Mean	Both	SARC	Mean	Both	SARC	Mean	Both
Share of breaks	0.473	0.298	0.495	0.348	0.296	0.608	0.309	0.297	0.594
Unweighted share	0.500	0.333	0.667	0.422	0.344	0.688	0.456	0.282	0.604
Share, $p = 4$	0.442	0.163	0.495	0.376	0.145	0.757	0.304	0.170	0.761
Median date	Q4/93	Q1/91	Q3/93	Q2/95	Q1/92	Q3/91	Q1/93	Q1/92	Q3/91
IQR quarter	33	10	11	37	21	18	30	21	19
No. of series	12			64			149		

Notes: Quarterly data, Q2/1983–Q3/2008. *Share of breaks* is the share of series for which the sup-Wald test rejects the null hypothesis of no structural break at the 10% level. The lag order is chosen using the AIC with p ranging from 1 to 6. *Share, p=4* is the share of series for which the null hypothesis is rejected for an AR(4) model. *Median date* denotes the median of the quarter in which the break occurs. *IQR quarter* is the interquartile range of the break dates. All statistics are weighted aggregates using constant 2008 consumption expenditure shares unless otherwise indicated.

Table 6: Tests for structural break in Q1/2000

	Main Groups			Product Groups			Index Positions		
1993–2008	SARC	Mean	Both	SARC	Mean	Both	SARC	Mean	Both
Share of breaks	0.113	0.113	0.113	0.069	0.093	0.127	0.127	0.096	0.159
Unweighted share	0.083	0.083	0.083	0.141	0.109	0.219	0.174	0.107	0.215
Share of breaks, p=4	0.000	0.000	0.000	0.051	0.057	0.103	0.054	0.058	0.093
1983–2008									
Share of breaks	0.392	0.124	0.318	0.460	0.125	0.372	0.428	0.176	0.313
Unweighted share	0.417	0.167	0.417	0.391	0.172	0.531	0.362	0.128	0.416
Share of breaks, p=4	0.198	0.269	0.349	0.513	0.137	0.572	0.501	0.161	0.571
No. of series	12			64			149		

Notes: Quarterly data, Q2/1983–Q3/2008. *Share of breaks* is the share of series for which the Wald-test rejects the null hypothesis of no structural break at the 10% level. The lag order is chosen using the AIC with p ranging from 1 to 6. *Share of breaks, p=4* is the share of series for which an AR(4) model exhibits a structural break. All statistics are weighted aggregates using constant 2008 consumption expenditure shares unless otherwise indicated.

model with an idiosyncratic lag order.

We also use disaggregate data to investigate whether a structural break coincides with the introduction of the new monetary policy concept. The summary statistics in Table 6 confirm the results for the aggregate, suggesting that no such break has occurred. In the sample 1993–2008, the share of series with a break in the SARC ranges between 0.07 and 0.13. This share increases to between 0.39 and 0.46 in the sample 1983–2008, again reflecting that the actual break occurs earlier in the 1990s.

We thus arrive at a different conclusion than Benati (2008). Benati (2008) rejects the null hypothesis that persistence has not changed between 1972–1999 and 2000–2008. We also reject this hypothesis, both on aggregate and disaggregate levels as Tables 4 and 6 show. Our results clearly indicate, however, that a structural break in persistence has occurred earlier in the 1990s. The sup-Wald test signals a structural break in Q3/1993. Comparing the samples 1993–1999 and 2000–2008, we find that inflation persistence does not significantly decline under the new monetary policy regime.

Moreover we find that, while the sum of autoregressive coefficients significantly changes, the intercept term does not. This is in line with Levin and Piger (2004) who detect no break in the intercept of CPI inflation but find evidence of a change in persistence during 1984–2003.[21] Using the Bai and Perron (1998) methodology, Huwiler (2007) and Rapach and Wohar (2005) find that the mean of inflation exhibits a significant break in 1993. Corvoisier and Mojon (2005) confirm this result using a different test approach. Our results suggest that the decline in the mean of inflation reflects a change in persistence rather than a change in the intercept term of the AR process.[22]

5 Decomposing Persistence in a Factor Model

The above sections discuss persistence of inflation in general and do not discriminate responses to specific shocks. In this section we take the analysis one step further by estimat-

[21] See Tables 2 and 9 in Levin and Piger (2004). The results of Levin and Piger (2004) are different for other measures of inflation.

[22] From Equation (4) we see that the unconditional mean of inflation is given by $E(y_t) = \frac{\mu}{1-\alpha}$.

ing an approximate factor model of sectoral inflation rates. The factor model decomposes sectoral inflation rates into a common component and a sectoral component. The common component has the interpretation of reflecting factors with a general impact across sectors, such as monetary policy shocks. In contrast, the sectoral component captures idiosyncratic factors, such as sectoral demand and technology shocks. As will be shown, this model also provides an explanation for the previous sections' finding that average inflation persistence is lower at disaggregate levels than at aggregate levels.

Along the lines of Stock and Watson (2002), we consider an approximate factor model of the following form:

$$y_{it} = \lambda_i f_t + u_{it} \tag{5}$$

where f_t is the common component which corresponds to the first principal component of the sectoral inflation rates. The corresponding loadings are given by λ_i. The sectoral components u_{it} are obtained as the residuals from a regression of sectoral inflation rates on the common component.

Table 7 shows persistence of the common and sectoral components at the three aggregation levels. As in the previous sections, persistence is estimated using the grid bootstrap of Hansen (1999). The table reports median unbiased estimates and 90% confidence intervals. Additionally, the appendix provides results based on the estimator of Andrews and Chen (1994), which are in line with the grid bootstrap results. The left panel shows weighted means of the persistence of sectoral components. We find that during 1983–2008, the common component is highly persistent at all aggregation levels. The confidence interval includes the nonstationary case at all aggregation levels. Persistence of the common component declines substantially in 1993–2008. In the shorter 2000–2008 sample, persistence increases again at the level of product groups and index positions. As will be discussed below, this increase should not be over-interpreted since it is accompanied by a substantial decline in the relevance of the common component.[23] At all aggregation levels and in all

[23]Table 8 indicates that during 2000–2008 the R-squared drops to 0.105 and 0.087 for product groups and

Table 7: Persistence of common and sectoral components

	Common Component		Sectoral Components	
	SARC	CI	SARC	CI
		1983–2008		
Main Groups	0.886	(0.752, 1.033)	0.291	(-0.046, 0.656)
Product Groups	0.940	(0.832, 1.039)	0.134	(-0.079, 0.432)
Index Positions	0.877	(0.761, 1.029)	0.135	(-0.136, 0.411)
		1993–2008		
Main Groups	0.119	(-0.084, 0.302)	0.246	(-0.040, 0.469)
Product Groups	0.340	(0.137, 0.493)	0.068	(-0.243, 0.403)
Index Positions	0.249	(0.030, 0.413)	0.109	(-0.207, 0.443)
		2000–2008		
Main Groups	0.143	(-0.098, 0.408)	0.110	(-0.277, 0.409)
Product Groups	1.037	(0.577, 1.205)	-0.004	(-0.408, 0.429)
Index Positions	0.612	(0.221, 1.124)	-0.038	(-0.454, 0.400)

Notes: Quarterly data, Q2/1983–Q3/2008, Q1/1993–Q3/2008, and Q1/2000–Q3/2008. Common and sectoral components are estimated following Stock and Watson (2002). In a first step, the common component is obtained as the first principal component of standardized inflation rates. In a second step, time series of sectoral components are obtained as the residuals from regressing the sectoral inflation rate on the common component. *SARC* denotes the median unbiased estimate of the sum of autoregressive coefficients, estimated with Hansen's (1999) grid bootstrap. *CI* is the 90% confidence interval of the sum of autoregressive coefficients. The statistics for the sectoral components are weighted means using constant 2008 consumption expenditure shares.

sample periods, the common component absorbs the persistence of sectoral inflation rates. Consequently, the sectoral components are stationary with a persistence of close to zero.[24] Hence, the factor model provides an explanation for the lower persistence at disaggregate levels. At disaggregate levels, short-lived sectoral factors predominate. In aggregating sectoral inflation rates, the sectoral factors average out and the persistent common factor determines the dynamics of inflation. Similar results are reported by Clark (2006) and Boivin, Giannoni, and Mihov (2009) for the U.S. and by Altissimo, Mojon, and Zaffaroni (2007) for the euro area.

The relevance of the common component declines over time. This is suggested by the

index positions, respectively. In this period, the common component mainly represents certain persistent variables from the two main groups food and non-alcoholic beverages and housing and energy.

[24]Note that all findings are consistent with results for 1983–1992 and 1993–1999 shown in Table A.8.

left panel of Table 8 which shows the fraction of variance of sectoral inflation rates explained by the common component. The R-squared averages between 0.25 and 0.33 in the period 1983–2008, depending on the aggregation level. In the period 2000–2008, the R-squared falls to between 0.09 and 0.14. Table A.8 in the Appendix presents estimation results for further subperiods. These indicate that the R-squared gradually declines over time, with the decline being most pronounced between 1993–1999 and 2000–2008. Hence, while the persistence in the common factor declines after 1993, the relevance of the common factor markedly declines after 2000.

The left panel of Table 8 also reports the correlation between the standard deviation and the persistence of sectoral components of inflation (u_{it}). As argued by Bils and Klenow (2004), New Keynesian sticky price models predict a strong and negative correlation. We find a positive correlation at main group level and a negative correlation at product group and index position level. The correlations are relatively low in absolute terms. We also consider the correlation of the standard deviation and persistence of sectoral inflation rates (y_{it}). These are negative and much more pronounced. Both findings are consistent with results of Boivin, Giannoni, and Mihov (2009) for the U.S.[25] Finally, the right panel of Table 8 shows the standard deviation of annualized quarterly inflation rates due to the common and sectoral component. This panel mirrors the pattern in the R-squared statistics and shows that roughly 70 to 90 percent of the variance in sectoral inflation rates is accounted for by sectoral components.

As a robustness test we employ the weighted principal component analysis following Boivin and Ng (2006). We use a weighting scheme that accounts for cross-sectional correlation among sectoral components. The weighted principal component analysis confirms the above results, as can be seen from Table A.9.[26] Notable difference is that the persistence of the common component at index position level remains low during 2000–2008.

[25]Note that Boivin, Giannoni, and Mihov (2009) report a negative correlation of the standard deviation and the persistence of the common component of inflation, whereas we consider the total sectoral inflation rates (y_{it}).

[26]The underlying assumptions of the strict factor model can be relaxed for $N \to \infty$, see, e.g., Boivin and Ng (2006). In particular, one can allow for weak serial-correlation and cross-correlation of the idiosyncratic errors.

Table 8: Variance explained by the common component

	R-squared			Standard Deviation		
	Main Groups	Product Groups	Index Positions	Common	Sectoral	Total
			1983–2008			
Mean	0.339	0.283	0.254	1.866	5.507	5.981
Median	0.205	0.183	0.088	1.382	4.599	4.876
Unw. Mean	0.320	0.211	0.140	1.508	6.636	6.931
SD	0.252	0.181	0.150	0.818	7.127	7.052
ri(SD, SARC)	0.170	-0.283	-0.273			
rt(SD, SARC)	-0.602	-0.420	-0.727			
			1993–2008			
Mean	0.204	0.124	0.111	0.959	5.148	5.374
Median	0.156	0.034	0.016	0.742	4.411	4.576
Unw. Mean	0.195	0.104	0.093	1.069	6.825	7.036
SD	0.230	0.144	0.177	0.994	7.042	6.985
ri(SD, SARC)	0.030	-0.186	-0.207			
rt(SD, SARC)	-0.157	-0.299	-0.599			
			2000–2008			
Mean	0.135	0.105	0.087	1.651	7.456	5.389
Median	0.018	0.037	0.042	1.017	4.297	4.318
Unw. Mean	0.171	0.112	0.098	1.621	7.456	7.722
SD	0.242	0.158	0.143	2.010	8.134	8.294
ri(SD, SARC)	0.082	-0.044	-0.084			
rt(SD, SARC)	-0.513	-0.204	-0.492			

Notes: The *R*-squared statistic in the left panel measures the fraction of variance explained by the common component. *SD* is the standard deviation of sectoral *R*-squared, *ri(SD, SARC)* is the correlation between the standard deviation and the persistence of sectoral components (u_{it}). *rt(SD, SARC)* denotes the correlation between the standard deviation and the persistence of sectoral inflation (y_{ti}). *Unw. Mean* is the unweighed mean. The right panel shows summary statistics about the standard deviation of annualized quarterly inflation rates on index position level. We report statistics on the total sectoral standard deviation, the standard deviation attributed to the common component ($\lambda_i f_t$), and the standard deviation attributed to the idiosyncratic, sectoral component (u_{it}).

In sum, the factor model reveals that inflation persistence primarily stems from a persistent macroeconomic component that is common to inflation rates across sectors. In contrast, sectoral components have low persistence. This is consistent with the finding of the previous sections according to which inflation persistence is lower at disaggregate levels. Our results further suggest that both the persistence and the relevance of the common component decline over time.

6 Conclusion

In this paper, we investigate persistence of Swiss consumer price inflation using aggregate and disaggregate inflation data spanning Q2/1983–Q3/2008. Our results consistently indicate that inflation persistence significantly declines in the early 1990s. This is suggested by median unbiased estimates of the sum of autoregressive coefficients and confidence intervals using the grid-bootstrap estimator of Hansen (1999). Formal tests of structural change signal a significant break in the sum of autoregressive coefficients in Q3/1993. Both the point estimates of persistence and confidence intervals decline substantially at all aggregation levels. During 1993–2008, headline inflation is clearly stationary with a low persistence of 0.22. In this period, 87% of inflation rates at index position level are stationary. The tests further indicate that the intercept of the inflation process does not change. This suggests that the mean of headline inflation has declined due to a change in persistence only.

Due to the small number of observations, estimations for the new monetary policy regime are associated with high uncertainty. Our results indicate, however, that relative to the period 1993–1999, the persistence of inflation has not significantly changed in the period 2000–2008. We conclude that inflation persistence significantly declines in the first half of the 1990s, several years before the announcement and implementation of the new monetary policy concept.

Moreover, we document that inflation persistence is substantially lower at disaggregate levels than at aggregate levels. Specifically, while aggregate headline inflation has a persistence of 0.97 during 1983–1993, mean persistence at index position level is only 0.43. This finding is in line with theoretical results and empirical evidence of the literature on inflation persistence. An estimated factor model provides an explanation. The factor model decomposes sectoral inflation rates into a common component and a sectoral component. The common component represents macroeconomic factors with a general impact across sectors, such as monetary policy shocks. The sectoral component captures idiosyncratic factors, such as sectoral demand and technology shocks. Depending on the sample period and aggregation level, about 70 to 90 percent of the variance in sectoral inflation rates is accounted for by sectoral factors. We find that the common macroeconomic component is highly persistent, whereas sectoral components are not. Both the relevance and the persistence of the common component decline over time. This finding is consistent with the observed decline of persistence in sectoral inflation rates.

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Appendix

Disaggregate Data

Table A.1: Components at aggregation level 1 (main groups)

Official ID	Component	Weight
1	Food and non-alcoholic beverages	11.091
2	Alcoholic beverages and tobacco	1.785
3	Clothing and Footwear	4.434
4	Housing and energy	25.212
5	Household furniture and furnishings	4.762
6	Health	14.467
7	Transport	11.285
8	Communications	2.938
9	Recreation and culture	10.607
10	Education	0.674
11	Restaurants and hotels	8.142
12	Other goods and services	4.603

Table A.2: Components at aggregation level 2 (product groups)

Official ID	Component	Weight
1002	Bread, flour and food products	1.790
1074	Meat, cold cuts and sausages	2.628
1179	Fish, crustaceans and seafood	0.401
1198	Milk, cheese and eggs	1.812
1284	Fats and edible oils	0.293
1306	Fruit	0.939
1359	Pulses and potatoes	1.298
1448	Sugar, jam, honey/other sugary foods	0.730
1481	Other food products	0.787
1518	Coffee, tea, cocoa and nutritional beverages	0.363
1544	Mineral waters, soft drinks and juices	0.663
2002	Spirits	0.134
2017	Wine	0.880
2064	Beer	0.134
2075	Tobacco	0.736
3002	Articles of clothing	3.537
3168	Other articles of clothing/fabrics	0.220
3189	Dry-cleaning and repair of garments	0.088
3211	Footwear	0.816
3237	Shoe repairs	0.020
4001	Rent	19.957
4010	Products for housing maintenance and repair	0.214
4020	Services for housing maintenance and repair	0.889
4050	Gas	0.656

Official ID	Component	Weight
4070	Electricity	2.116
4090	Heating oil	2.101
5002	Furniture and furnishings	1.926
5060	Floor coverings and carpets	0.093
5070	Household textiles	0.350
5101	Major household appliances	0.376
5120	Smaller electric household appliances	0.311
5140	Glassware, tableware and household utensils	0.359
5181	Motorized tools for DIY and garden	0.101
5200	Tools for house and garden	0.497
5221	Goods for routine household maintenance	0.587
6001	Medical products and appliances	3.181
6031	Medical services	3.626
6036	Dental services	1.594
6059	Hospital services	5.798
7002	Purchase of cars motorcycles, bicycles	4.645
7082	Spare parts and accessories	0.397
7105	Fuels	2.844
7113	Repair services and work	1.372
7201	Public transport services by rail and road	1.545
8	Communications	3.101
9002	Television sets and audiovisual appliances	0.514
9029	Photographic equipment and optical instruments	0.156
9046	Personal computers and accessories	0.584
9085	Recording media	0.271
9120	Repair and installation	0.030
9211	Games, toys and hobbies	0.455
9230	Equipment for sport, camping and open-air recreation	0.418
9300	Plants and flowers	0.572
9320	Pets and related products	0.318
9351	Sporting and recreational services	0.771
9435	Cultural and other services	2.208
9501	Books and brochures	0.404
9525	Daily newspapers and periodicals	0.696
9555	Writing and drawing materials	0.176
9570	Package holidays	3.221
10	Education	0.711
11002	Restaurants and cafs	5.830
11170	Accommodation	0.901
12	Other goods and services	4.858

Table A.3: Components at aggregation level 3 (index positions)

Official ID	Component	Weight
1003	Rice	0.045
1008	Flour	0.065
1015	Bread	0.551
1027	Small baked goods	0.182
1036	Viennese pastries, pastry products	0.335

Official ID	Component	Weight
1048	Biscuit/rusk products	0.276
1058	Pasta	0.156
1065	Other cereal products	0.192
1076	Beef	0.430
1088	Veal	0.144
1097	Pork	0.372
1107	Lamb	0.089
1115	Poultry	0.336
1133	Other meat	0.237
1144	Processed meat and sausages	1.037
1180	Fresh fish	0.235
1187	Frozen fish	0.078
1192	Tinned fish and smoked fish	0.091
1200	Whole milk	0.181
1207	Other type of milk	0.151
1218	Hard and semi-hard cheese	0.502
1230	Fresh, soft and melted cheese	0.357
1246	Other dairy products	0.343
1265	Cream	0.134
1278	Eggs	0.156
1285	Butter	0.135
1293	Margarine, fats, edible oils	0.160
1307	Fresh fruit	0.772
1347	Dried, frozen and tinned fruit	0.173
1361	Fruiting vegetables	0.291
1369	Root vegetables	0.180
1379	Salad vegetables	0.275
1391	Brassicas	0.064
1400	Onions	0.067
1407	Other vegetables	0.065
1417	Potatoes	0.092
1423	Dried, frozen, tinned vegetables, etc,	0.142
1449	Jam and honey	0.106
1455	Chocolate	0.351
1468	Ice-cream	0.118
1475	Sugar	0.042
1482	Soups, spices, sauces	0.529
1505	Ready-made foods	0.263
1530	Coffee	0.268
1532	Tea	0.066
1539	Cocoa and nutritional beverages	0.032
1545	Natural mineral water	0.203
1552	Soft drinks	0.288
1563	Fruit or vegetable juices	0.176
2003	Spirits/brandies	0.079
2010	Liqueurs and aperitifs	0.056
2019	Swiss red wine	0.201
2031	Foreign red wine	0.404
2046	Swiss white wine	0.151
2056	Foreign white wine	0.071

Official ID	Component	Weight
2064	Beer	0.135
2076	Cigarettes	0.706
2082	Other tobaccos	0.034
3004	Coats, jackets	0.221
3015	Suits	0.125
3020	Trousers	0.283
3027	Shirts	0.123
3033	Sweaters	0.170
3041	Underwear	0.121
3061	Coats, jackets	0.059
3067	Costumes, trouser suits, dresses	0.070
3074	Skirts	0.198
3079	Trousers	0.407
3086	Jackets	0.336
3093	Blouses	0.136
3099	Jumpers	0.461
3106	Underwear	0.272
3126	Coats and jackets	0.042
3134	Trousers and skirts	0.093
3141	Jerseys	0.082
3150	Hosiery and underwear	0.063
3300	Sportswear	0.218
3169	Garment fabrics	0.020
3175	Haberdashery and knitting wool	0.046
3190	Garment alterations	0.023
3198	Upkeep of textiles	0.065
3212	Womens footwear	0.444
3220	Mens footwear	0.246
3228	Childrens footwear	0.131
3237	Shoe repairs	0.020
4001	Rent	20.085
4010	Products for housing maintenance and repair	0.216
4020	Services for housing maintenance and repair	0.894
4050	Gas	0.661
4070	Electricity	2.130
4090	Heating oil	2.115
5003	Living room	0.661
5020	Bedroom	0.617
5040	Kitchen and garden	0.274
5050	Furnishings	0.387
5060	Floor coverings and carpets	0.093
5071	Bed linen and household linen	0.259
5090	Curtains and curtain accessories	0.093
5101	Major household appliances	0.378
5120	Smaller electric household appliances	0.313
5141	Kitchen utensils	0.160
5150	Tableware and cutlery	0.114
5181	Motorized tools for DIY and garden	0.102
5200	Tools for house and garden	0.500
5222	Detergents and cleaning products	0.338

Official ID	Component	Weight
5250	Cleaning articles	0.019
5260	Other household articles	0.234
6001	Medical products and appliances	3.201
6031	Medical services	3.650
6036	Dental services	1.604
6059	Hospital services	5.836
7002	Purchase of cars motorcycles, bicycles	4.675
7082	Spare parts and accessories	0.399
7105	Fuels	2.863
7113	Repair services and work	1.381
7210	Public transport: direct service	1.046
7220	Public transport: combined services	0.509
8	Communications	3.121
9002	Television sets and audiovisual appliances	0.517
9029	Photographic equipment and optical instruments	0.157
9046	Personal computers and accessories	0.587
9085	Recording media	0.273
9120	Repair and installation	0.030
9211	Games, toys and hobbies	0.458
9230	Equipment for sport, camping and open-air recreation	0.421
9300	Plants and flowers	0.576
9320	Pets and related products	0.320
9352	Sporting events	0.075
9400	Sports and leisure activities	0.499
9420	Mountain railways and ski lifts	0.202
9436	Cinema	0.135
9450	Theatre and concerts	0.368
9465	Radio and television licences	0.963
9475	Photographic services	0.116
9490	Leisure-time courses	0.641
9501	Books and brochures	0.407
9525	Daily newspapers and periodicals	0.700
9555	Writing and drawing materials	0.177
9570	Package holidays	3.242
10	Education	0.716
11003	Meals taken in restaurants and cafs	3.387
11052	Wine	0.699
11070	Beer	0.414
11075	Spirits, other alcoholic drinks	0.070
11091	Coffee and tea	0.679
11103	Mineral water and soft drinks	0.605
11171	Hotels	0.659
11190	Alternative accommodation facilities	0.249
12	Other goods and services	4.889

Table A.4: Special aggregates

Official ID	Component	Weight
50102	Nondurable goods	26.368

Official ID	Component	Weight
50103	Semidurable goods	7.914
50104	Durable goods	9.211
50105	Services	56.507
50308	Index ex. petroleum products	95.314

Further Results on Disaggregate Persistence

Table A.5: Persistence of aggregate inflation, 1983–1992 and 1993–1999

	SARC	90% CI	p	AC	R	AR(1)	Weight
			1983–1992				
Total	0.970	(0.654, 1.234)	3	1.014	0.858	0.401	100.000
Constant weight aggregate	0.801	(0.488, 1.126)	2	0.788	0.754	0.449	100.000
Nondurable goods	0.750	(0.240, 1.216)	3	0.729	0.562	0.051	26.368
Semidurable goods	0.710	(0.343, 1.117)	4	0.695	0.906	0.009	7.914
Durable goods	0.911	(0.077, 1.364)	6	0.807	1.252	-0.004	9.211
Services	1.034	(0.754, 1.153)	2	1.002	0.891	0.680	56.507
Index ex. petroleum products	0.829	(0.628, 1.065)	1	0.825	0.748	0.748	95.314
			1993–1999				
Total	0.234	(-0.051, 0.486)	1	0.245	0.192	0.192	100.000
Constant weight aggregate	0.007	(-0.284, 0.274)	1	0.019	0.025	-0.025	100.000
Nondurable goods	-1.303	(-2.669, 0.190)	6	-1.371	1.069	-0.067	26.368
Semidurable goods	0.253	(-0.560, 1.247)	4	0.222	1.168	0.310	7.914
Durable goods	0.525	(0.289, 0.751)	1	0.555	0.478	0.478	9.211
Services	0.214	(-0.226, 0.661)	3	0.232	0.717	0.215	56.507
Index ex. petroleum products	0.443	(-0.000, 1.036)	2	0.491	0.222	0.100	95.314

Notes: Quarterly data, Q2/1983–Q4/1992 and Q1/1993–Q4/1999. See footnote of Table 2 for a detailed description.

Table A.6: Persistence by aggregation level, 1983–1992 and 1993–1999

	Main Groups		Product Groups		Index Positions	
	SARC	90% CI	SARC	90% CI	SARC	90% CI
			1983–1992			
Mean	0.501	(0.140, 0.839)	0.477	(0.107, 0.806)	0.431	(0.071, 0.760)
Median	0.622	(0.250, 1.059)	0.512	(0.173, 1.121)	0.477	(0.025, 1.062)
75th percentile	0.809	(0.270, 1.246)	0.997	(0.701, 1.159)	0.997	(0.677, 1.159)
90th percentile	0.809	(0.570, 1.246)	1.035	(0.701, 1.317)	0.998	(0.701, 1.269)
Unweighted mean	0.500	(0.145, 0.848)	0.376	(-0.014, 0.763)	0.278	(-0.086, 0.641)
SARC < a.SARC	0.658		0.614		0.667	
CI < 1	0.463		0.452		0.472	
R < 1	1.000		0.971		0.966	
r(SARC, weight)	0.004		0.102		0.105	
			1993–1999			
Mean	0.323	(-0.145, 0.814)	0.110	(-0.345, 0.578)	0.127	(-0.322, 0.590)
Median	0.187	(-0.160, 0.890)	0.102	(-0.257, 0.452)	0.100	(-0.285, 0.452)
75th percentile	0.574	(0.308, 0.955)	0.349	(-0.080, 0.873)	0.419	(-0.080, 0.873)
90th percentile	1.243	(0.563, 1.611)	0.656	(0.286, 1.150)	0.656	(0.274, 1.267)
Unweighted mean	0.321	(-0.224, 0.850)	0.014	(-0.515, 0.529)	-0.066	(-0.581, 0.468)
SARC < a.SARC	0.129		0.369		0.382	
CI < 1	0.783		0.771		0.769	
R < 1	0.982		0.981		0.969	
r(SARC, weight)	0.006		0.066		0.044	
No. of series	12		64		149	

Notes: Quarterly data, Q2/1983–Q4/1992 and Q1/1993–Q4/1999. See footnote of Table 3 for a detailed description.

Table A.7: Persistence of common and idiosyncratic components, 1983–1992 and 1993–1999

	1983–1992			
	Common Component		Sectoral Components	
	SARC	CI	SARC	CI
Main Groups	1.012	(0.706, 1.136)	-0.092	(-0.310, 0.661)
Product Groups	0.849	(0.643, 1.072)	0.097	(-0.261, 0.573)
Index Positions	0.767	(0.529, 1.066)	0.142	(-0.188, 0.586)
	1993–1999			
	Common Component		Sectoral Components	
	SARC	CI	SARC	CI
Main Groups	0.245	(-0.058, 0.500)	0.202	(-0.225, 0.803)
Product Groups	0.424	(-0.058, 0.500)	0.002	(-0.457, 0.482)
Index Positions	0.259	(-0.051, 0.507)	0.040	(-0.417, 0.480)

Notes: Quarterly data, Q2/1983–Q4/1992 and Q1/1993–Q4/1999. See footnote of Table 7 for a detailed description.

Table A.8: Persistence of common and sectoral components, 1983–1992 and 1993–1999

	R-squared			Standard Deviation		
	Main Groups	Product Groups	Index Positions	Common	Sectoral	Total
			1983–1992			
Mean	0.310	0.285	0.234	1.537	5.302	5.696
Median	0.217	0.170	0.146	1.173	2.600	3.098
Unw. Mean	0.329	0.230	0.192	1.462	5.211	5.546
SD	0.267	0.215	0.172	1.269	7.965	7.974
ri(SD, SARC)	0.211	-0.065	-0.086			
			1993–1999			
Mean	0.319	0.185	0.180	1.223	4.264	4.737
Median	0.366	0.081	0.038	0.597	2.311	2.766
Unw. Mean	0.284	0.177	0.142	1.111	4.581	4.943
SD	0.217	0.198	0.243	1.396	6.186	6.163
ri(SD, SARC)	0.097	-0.055	-0.003			

Notes: See footnote of Table 8 for a detailed description.

Weighted Principal Component Analysis

To verify the robustness of the factor model results we additionally estimate the common component using weighted principal component analysis as proposed by Boivin and Ng (2006). This method rescales variances of the data by the objective function:

$$W(k) = \frac{1}{NT} \sum_{i=1}^{N} w_{iT} \sum_{t=1}^{T} u_{it}^2.$$

We consider the SWb weighting scheme with weights given by the inverse of $\frac{1}{N} \sum_{j=1}^{N} \left| \hat{\Omega}_T(i,j) \right|$. In a first step, the covariance matrix Ω of the residuals u_{it} is estimated. In a second step, a new common component is estimated using the weighted covariance matrix. The results presented in Table A.9 are in line with the results from the conventional principal component analysis presented in Section 5.

Table A.9: Results using weighted principal component analysis

	Common Component		Idiosyncratic Components	
	SARC	CI	SARC	CI
		1983–2008		
Main Groups	0.917	(0.767, 1.059)	0.151	(-0.100, 0.417)
Product Groups	0.925	(0.821, 1.037)	0.114	(-0.145, 0.379)
Index Positions	0.870	(0.746, 1.030)	0.146	(-0.116, 0.413)
		1983–1992		
Main Groups	0.906	(0.633, 1.139)	-0.054	(-0.352, 0.248)
Product Groups	0.762	(0.644, 1.117)	0.083	(-0.316, 0.528)
Index Positions	0.911	(0.611, 1.158)	0.202	(-0.153, 0.543)
		1993–2008		
Main Groups	0.080	(-0.118, 0.277)	0.232	(-0.053, 0.530)
Product Groups	0.452	(0.195, 0.694)	0.096	(-0.220, 0.429)
Index Positions	0.190	(-0.037, 0.390)	0.126	(-0.195, 0.445)
		2000–2008		
Main Groups	-0.017	(-0.322, 0.288)	-0.097	(-0.455, 0.268)
Product Groups	0.744	(0.356, 1.185)	0.025	(-0.395, 0.457)
Index Positions	-0.199	(-0.513, 0.095)	0.103	(-0.356, 0.555)

Notes: Quarterly data, Q2/1983–Q3/2008, Q2/1983–Q4/1992, Q1/1993–Q3/2008, and Q1/2000–Q3/2008. Common and idiosyncratic components are estimated employing weighted principal component analysis. We use the SWb weighting scheme as proposed by Boivin and Ng (2006).

Approximately Median Unbiased Estimates

Table A.10: Persistence by aggregation level, Andrews and Chen (1994)

	Main Groups		Product Groups		Index Positions	
	SARC	90% CI	SARC	90% CI	SARC	90% CI
			1983–2008			
Mean	0.619	(0.367, 0.887)	0.518	(0.287, 0.767)	0.485	(0.265, 0.720)
Median	0.579	(0.328, 0.883)	0.654	(0.429, 0.934)	0.654	(0.416, 0.862)
75th percentile	0.838	(0.602, 1.046)	0.855	(0.710, 1.037)	0.855	(0.710, 1.037)
90th percentile	0.939	(0.685, 1.128)	0.855	(0.710, 1.088)	0.855	(0.710, 1.088)
Unweighted mean	0.628	(0.418, 0.871)	0.542	(0.283, 0.852)	0.267	(0.007, 0.577)
SARC < a.SARC	0.726		0.717		0.713	
CI < 1	0.720		0.562		0.558	
R < 1	1.000		0.984		0.993	
r(SARC, weight)	0.188		0.102		0.177	
			1993–2008			
Mean	0.236	(-0.026, 0.477)	0.112	(-0.206, 0.421)	0.121	(-0.199, 0.436)
Median	0.181	(-0.030, 0.349)	0.205	(-0.116, 0.485)	0.199	(-0.124, 0.489)
75th percentile	0.412	(0.102, 0.722)	0.357	(0.035, 0.619)	0.304	(-0.010, 0.672)
90th percentile	0.494	(0.216, 1.061)	0.030	(-0.313, 0.383)	0.987	(0.620, 1.245)
Unweighted mean	0.124	(-0.084, 0.304)	0.158	(-0.110, 0.393)	0.016	(-0.250, 0.247)
SARC < a.SARC	0.596		0.727		0.718	
CI < 1	0.849		0.871		0.873	
R < 1	1.000		0.941		0.942	
r(SARC, weight)	0.229		0.075		0.138	
			2000–2008			
Mean	0.217	(-0.186, 0.618)	0.125	(-0.282, 0.543)	0.096	(-0.311, 0.518)
Median	0.261	(-0.103, 0.461)	0.264	(-0.190, 0.532)	0.180	(-0.226, 0.553)
75th percentile	0.348	(-0.023, 0.958)	0.351	(0.067, 0.787)	0.351	(0.067, 0.661)
90th percentile	0.988	(0.267, 1.487)	0.494	(0.210, 1.061)	0.528	(0.128, 1.235)
Unweighted mean	0.042	(-0.359, 0.373)	0.045	(-0.333, 0.409)	-0.109	(-0.439, 0.241)
SARC < a.SARC	0.603		0.516		0.572	
CI < 1	0.849		0.756		0.786	
R < 1	1.000		0.993		0.991	
r(SARC, weight)	0.457		0.170		0.151	
No. of series	12		64		149	

Notes: Quarterly data, Q2/1983–Q3/2008, Q1/1993–Q3/2008, and Q1/2000–Q3/2008. *SARC* denotes the approximately median unbiased estimate of the sum of autoregressive coefficients following Andrews and Chen (1994). *CI* is the 90% confidence interval of the sum of autoregressive coefficients based on Hansen's (1999) grid bootstrap. All statistics are weighted aggregates using constant 2008 consumption expenditure shares unless otherwise indicated. *SARC < a.SARC* is the share of series for which the SARC is smaller than the SARC of the constant weight aggregate inflation. *CI < 1* denotes the share of series for which the SARC 90% confidence interval lies below unity. *R < 1* is the share of series for which the the largest eigenvalue in modulus is smaller than 1. *r(SARC, weight)* is the Pearson correlation coefficient between SARC and weight.

Table A.11: Persistence of common and sectoral components, Andrews and Chen (1994)

	Common Component		Sectoral Components	
	SARC	CI	SARC	CI
		1983–2008		
Main Groups	0.879	(0.752, 1.033)	0.114	(-0.046, 0.656)
Product Groups	0.932	(0.832, 1.039)	0.123	(-0.079, 0.432)
Index Positions	0.878	(0.761, 1.029)	0.135	(-0.136, 0.411)
		1993–2008		
Main Groups	0.116	(-0.084, 0.302)	0.275	(-0.040, 0.469)
Product Groups	0.336	(0.137, 0.493)	0.165	(-0.243, 0.403)
Index Positions	0.240	(0.030, 0.413)	0.115	(-0.207, 0.443)
		2000–2008		
Main Groups	0.118	(-0.098, 0.408)	0.273	(-0.277, 0.409)
Product Groups	0.914	(0.577, 1.205)	-0.032	(-0.408, 0.429)
Index Positions	0.600	(0.221, 1.124)	-0.028	(-0.454, 0.400)

Notes: Quarterly data, Q2/1983–Q3/2008, Q1/1993–Q3/2008, and Q1/2000–Q3/2008. Common and sectoral components are estimated following Stock and Watson (2002). In a first step, the common component is obtained as the first principal component of standardized inflation rates. In a second step, time series of sectoral components are obtained as the residuals from regressing the sectoral inflation rate on the common component. *SARC* denotes the approximately median unbiased estimate of the sum of autoregressive coefficients following Andrews and Chen (1994). *CI* is the 90% confidence interval of the sum of autoregressive coefficients based on Hansen's (1999) grid bootstrap. The statistics for the sectoral components are weighted means using constant 2008 consumption expenditure shares.