

# Consumer price adjustment under the microscope: Germany in a period of low inflation

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**WORK IN PROGRESS**  
**PRELIMINARY AND INCOMPLETE**

**Abstract:** We analyse the adjustment of retail prices in a period of low inflation, using a set of individual price data from the German Consumer Price Index that covers the period January 1998 to January 2004.

**Keywords:** price rigidity, price flexibility, Consumer Price Index, Germany

**JEL-Classification:** E31, D43, L11



## **Non-Technical Summary**

There are several reasons why the examination of price dynamics at the level of individual items is of interest. Firstly, analysing price developments at the level of product categories or even at the economy-wide level might give the misleading impression that price adjustment is smooth. Secondly, only at the individual item level the full degree of heterogeneity in price setting – which may give rise to inflation persistence – can be identified. Thirdly, at the item price level the origins of price rigidity can be analysed in detail and related to structural factors. And fourthly, evidence on patterns of price adjustment at the item level can give valuable insights for the microfoundation of macro models.

This paper provides empirical information on the pattern of price adjustment at the retail level in Germany for the years 1998 to 2003, based on a large set of individual consumer price data collected for the computation of the German CPI. The data refer to 52 mostly narrowly defined products (11 types of foodstuff, unprocessed and processed, five sources of energy, 18 industrial goods and the same number of services including two types of rental housing). As we will show, even this restricted sample of goods and services approximates the overall CPI and its main components reasonably well if suitable weights are chosen. Hence, we are quite confident that other weighted measures based on this sample are also approximately representative of the German CPI. The focus of our analysis is on the frequency and the size of price changes since the period covered is relatively short and price spells are relatively long. Evidence on price durations is provided supplementary.

Breaks in price trajectories caused by emerging and disappearing items and outlets are a major nuisance for the analysis of price adjustment at the item level. We are in the fortunate position of being able to provide information based on both exactly matched models and samples including item and outlet replacements, referring either to unadjusted market prices or to quality-adjusted prices. We find that while there are partly marked differences in the estimates of the frequency and the size of price adjustments, estimates of the determinants of the cross-section pattern and the temporal variation in the frequency and size of price adjustments are quite robust with respect to

the price concept chosen. We focus our analysis mainly on changes in quality-adjusted prices, which correspond closely to the actually measured rate of inflation

In Germany, as in other euro area countries, prices of most products change infrequently, but not incrementally. Pricing seems to be neither continuous nor marginal. In our sample, prices last on average two years, but change by 10% on average. The longest price durations are found for housing rents, which last on average for four years. The outstanding rigidity of housing rents is probably related to the peculiarities of long-term contracting, asymmetric information and transaction costs resulting in tenancy discounts and regulation. Excluding housing rents, gas and electricity prices reduces the mean duration of prices to 15 to 20 months, depending on the method of computation. This estimate is more in line to what is reported in other European country studies, which typically do not cover housing. Concerning the direction of price changes, downs are only slightly less frequent than ups, which leads us to the conclusion that there is no general downward rigidity in prices.

We find enormous heterogeneity in price variability across products. Prices of unprocessed food and fuels change frequently, while for many services price adjustments are observed only from time to time. Even within narrowly defined product categories, there is substantial heterogeneity in price durations. The quite pronounced cross-sectional differences in the frequency of price changes are found to be related to structural factors and to the volatility, but not to the level of sector-specific inflation rates. Concerning the temporal dimension, in each period we observe a certain level of price changing activity, but in some periods a bunching of price adjustments occurs, which often can be related to shocks. For many narrowly defined products, price increases and price decreases occur simultaneously, and, at the level of specific items, price decreases are sometimes followed immediately by price increases, indicating that the pricing process is noisy. There is no evidence of persistence in changes of item prices – with the exception of the short-term bouncing of prices – but measures of the frequency exhibit some persistence, hinting at lagged adjustment (and short-term price bouncing).

There seem to be both time-dependent and state-dependent elements in price setting in Germany. The peaks in the distribution of price durations at 12 and 24

months, a low level of synchronisation of price changes and evidence on seasonality in pricing (which is, however, not very pronounced and might also be related to seasonality in marginal costs or in demand) suggest time-dependent elements. The bunching of price changes related to marginal cost shocks or to special events as VAT changes or the cash changeover hint at state-dependent elements. In addition, the trend component and the – albeit weak – autocorrelation in the time series of the frequency of price adjustments can be interpreted as indicating state-dependent price setting practices.

The changeover to euro cash does not seem to have added to nominal rigidities in Germany. Given in the prominence of attractive prices in the D-Mark era, the conversion factor of 1.95583 D-Mark per euro might have reduced the frequency and increased the size of price adjustments. However, the reduction of the number of pricing points by half resulted in a declining importance of attractive prices. Hence, attractive pricing *per se* does not seem to contribute to price rigidity significantly.



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# Consumer price adjustment under the microscope: Germany in a period of low inflation\*

## 1 Introduction

How often are prices changed? Are prices modified by small percentages, or in big chunks? Are prices perfectly flexible, adjusting instantaneously to changes in demand and supply, or is there some rigidity in the price setting process? Is price adjustment symmetric, or are prices more rigid downwards than upwards? Answers to these questions are of substantial relevance to understanding the working of a market economy, especially at low rates of inflation. The degree of price flexibility is one of the most important factors determining the resilience of economies to shocks. The swiftness of price responses to disturbances decides how much quantities adapt. When inflation is close to zero, a substantial part of the adjustment of relative prices to changing market conditions must be brought about by price reductions, which raises the topic of the downward elasticity of prices. Furthermore, heterogeneity in price setting behaviour within and across sectors may give rise to inflation persistence, potentially complicating the conduct of monetary policy.

This paper provides empirical information on the patterns of price setting at the retail level in Germany for the years 1998 to 2003. We analyse a large set of individual consumer price data for 52 mostly narrowly defined products, collected by the German Federal Statistical Office and the statistical offices of the German federal states

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(*Bundesländer*) for the compilation of the national Consumer Price Index (CPI) and the national component of the Harmonised Index of Consumer Prices (HICP).

In the period under review, consumer prices in Germany increased by just 7.8% or 1.3% per year. This was less than in any other six-year period in post-WWII Germany. It was also less than in any other industrialised country in the same period (with the exception of Japan). Even as overall inflation was quite subdued, there was substantial variation in price changes over time and across products. The headline year-on-year rate of inflation varied between 0.2% and 2.7%, the month-on-month rate between –0.4% and 1.0%. Across sectors, prices for industrial goods increased by just 1.5%, whereas the energy subindex rose by nearly 30%. These variations in sectoral inflation rates were related to various shocks stemming from international commodity markets (crude oil prices), international financial markets (exchange rates), agricultural product markets (unusual weather conditions and livestock diseases) and the euro cash changeover. The heterogeneity of price changes across products and over time provides an opportunity to analyse the relationship between the size and the frequency of price changes and the overall and product-specific rates of inflation.

The main results of our study can be briefly summarised as follows: Prices of most products change infrequently, but not incrementally. Pricing seems to be neither continuous nor marginal. In Germany, prices last on average two years, but change by 10% on average. Excluding housing rents and gas and electricity prices, as it is done in studies for many other countries, reduces the mean duration of prices to about 15 to 20 months, depending on the method of calculation. These estimates are more in line to what is observed in other European countries (see Dhyne *et al*, 2004). Price decreases are only slightly less frequent than price increases, indicating that there is no general downward rigidity in prices. In each period, there is a certain level of price change activity, but in some periods a bunching of price adjustments occurs, which often can be related to shocks. For many narrowly defined products, price increases and price decreases occur simultaneously, and price decreases are sometimes followed immediately by price increases, indicating that there is a substantial amount of noise in the pricing process, partly related to sales and promotions. There is no evidence of persistence in changes of individual prices, but measures of the frequency and the

(average) size of price changes exhibit some persistence, hinting at lagged adjustments. [...]

While these results are fairly typical for the majority of products in our sample, there is an enormous heterogeneity in price variability across products. Whereas prices of unprocessed food and fuels change frequently, for many services price adjustments are observed only from time to time. Hence, at first glance, prices for services seem to be much more rigid than those for fuels and food are. Unconditional information on the frequency and the size of price changes alone, however, does not allow us to qualify prices as rigid or as flexible. Observationally there is an equivalence between truly rigid prices and prices, which are essentially flexible, but without reason to change. And, indeed, the much higher incidence of price changes for unprocessed food and fuels can be explained (partly) by the behaviour of product-specific (real) marginal costs, which are much more volatile than those for services are.

Earlier studies on price setting referred mostly to sector or product specific price data. Cecchetti (1986), for example, analyses newsstand prices of magazines, Kashyap (1995) catalogue prices for 12 products and Slade (1998) prices of saltine crackers. Lach and Tsiddon (1992) and Eden (2001) examine the behaviour of foodstuff prices in times of high and variable inflation for Israel. It is only in recent years that large-scale data sets covering nearly the full CPI and an extended period have become available for research purposes. Bills/Klenow (2004) pioneered this research.<sup>1</sup>

For Germany, Fengler/Winter (2000) explore the relationship between the average rate of price change and the degree of price dispersion and of price variability, using weekly individual price data on 23 (mostly food) products during 1995, taken from the GfK (Gesellschaft für Konsumforschung) consumer panel. In a companion paper, Fengler/Weis (2001) investigate the contribution of psychological prices to price rigidity. Loy/Weiss (2002) and (2003) try to give an answer to the question of whether staggering or synchronisation prevails in German grocery stores. They analyse weekly price data for ten fresh food products in sample of 131 retail outlets provided by the ZMP (*Zentrale Markt- und Preisberichtsstelle*) covering the period May 1995 to December 2000. Finally, Herrmann/Möser (2002) analyse weekly scanner data of prices

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<sup>1</sup> In 2002, an earlier version of this paper was published in the NBER Working Paper series, No 9069.

for 20 breakfast products in 38 grocery stores in the period September 1996 to June 1999. Their most important finding is that the substantial variation in the duration of prices is related to the frequency of promotions, which differs significantly among retail chains.

The present research was undertaken as a contribution to the work of the Inflation Persistence Network (IPN) of the Eurosystem. This paper supplements studies on consumer price dynamics in Austria (Baumgartner *et al*, 2004), Belgium (Aucremanne/Dhyne, 2004), in France (Baudry *et al*, 2004), in the Netherlands (Jonker *et al*, 2004), in Italy (Veronese *et al*, 2004), in Portugal (Dias *et al*, 2004a), and in Spain (Álvarez/Hernando, 2004). Papers for other euro-area countries and a study summarising the results of the national studies and analysing a harmonised sample of 50 products (Dhyne *et al*, 2004) are forthcoming. The selection of goods and the statistical methods employed in this paper are, if not mentioned otherwise, mainly those agreed on in the IPN. For technical details and a discussion of the pros and cons of the various approaches, we refer the reader to the papers mentioned above.

While many national studies refer to a broader set of data than the harmonised sample of the comparative study, we are the only ones who include housing. Extending the coverage to actual rents is of considerable importance in the case of Germany, as – partly due to the imputation for owner-occupied housing – actual rents have a sizeable weight in the national CPI. We also analyse the problem of weighting in some detail. We show that aggregate estimates of the incidence of price changes are very sensitive to the choice of weights. In particular, we take care with the correspondence between weights and, firstly, the cumulative rate of inflation, and, secondly, the monthly rate of inflation. The first approach demands base-period weights, the second approach monthly changing weights. Moreover, we try to make full use of the rich amount of meta-data supplied with the individual price data and we check the robustness of various measures of the incidence and the size of price changes with respect to several hypotheses on the relationship between product replacements and price changes. Most importantly, we are able to calculate measures referring to non-adjusted data (as in most of the country studies) and to quality-adjusted price data (as in the country study for Spain).

Earlier studies on related subjects, which also made use of individual price data from the German CPI, were conducted in the context of analysing the consequences of the cash changeover for consumer prices in Germany. Results of this research effort were published in a series of articles in the Monthly Reports of the Deutsche Bundesbank.<sup>2</sup> The present study draws heavily on the findings of this earlier research. However, instead of carrying on with the previous data, we decided to start anew with an extended data set, covering a longer period, more products and taking into consideration meta-information about product and outlet replacements. The earlier data set had been restricted to a sample of just 25 products with exactly matched items and outlets. This sampling strategy helped to circumvent the problem of items and outlet replacements, but resulted in a serious degree of panel attrition when the period covered was stretched out.

In companion papers, Stahl (2004, 2005) analyses the price setting in German manufacturing, making use of individual Ifo business survey data, individual price data collected for the German Producer Price Index and responses to a survey conducted by the Deutsche Bundesbank and Ifo on the price-setting behaviour of German manufacturing. Hoffmann/Hofmann (2005) review the changes in the dynamics of prices in Germany from a macro perspective, taking into account changes in monetary policy, measurement, taxation and regulation.

In the subsequent section, we describe the characteristics of the data and discuss the weighting issue. Section 3 presents empirical material on the frequency and size of price changes and analyses its variation across products and over time. In section 4, the perspective is a different one: we ask what determines the length of price spells. Section 5 discusses the results.

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<sup>2</sup> Most importantly, Deutsche Bundesbank (2002) and Deutsche Bundesbank (2004). On the parallel research effort of the German Federal Statistical Office, see Buchwald *et al* (2002).





## 2 Data characteristics, sample selection and weighting

The analysis in this paper is based on data collected for the compilation of the German CPI.<sup>3</sup> As the German CPI is computed from about 350,000 price quotes for 750 – sometimes broadly, sometimes narrowly defined – products, an analysis of the full data set would have been very time-consuming.<sup>4</sup> We therefore decided to restrict the investigation to a relatively small number of products, which, as we hope, can be considered as being representative in terms of pricing behaviour for other products as well. Basically, we follow the agreement reached in the IPN on a common sample of 50 products for purposes of comparative analysis, which includes products of each of the main components of the CPI (Dhyne *et al.*, 2004).

While we were broadly successful in matching products and services in the German CPI basket to the common sample,<sup>5</sup> for the present (“national”) study we decided to depart from this selection in two important respects: Firstly, as housing has a substantial importance in the German CPI, we include actual rents for two types of dwellings. Secondly, since prices of electricity and gas for household consumption display a different pattern than those of crude oil products, we extend the coverage to these two types of energy. In many other euro-area countries individual data on housing rents are unobtainable for pricing studies and the prices for electricity and gas are often regulated and do not show much regional variation and, hence, no additional insights can be expected at the individual price level. For Germany, however, the representativity of the sample is clearly enhanced by the inclusion of these products.

In its final version, the product sample underlying this study consists of 11 types of foodstuff, unprocessed and processed, five sources of energy, 18 (non-energy) industrial goods, ranging from men’s socks to colour television sets, and 18 services, including two types of rental housing (see Table 1). By choosing such a wide array of products, we hope to take adequate account of the heterogeneity of price developments in the German economy.

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<sup>3</sup> The German component of the HICP is assembled from the same data set.

<sup>4</sup> The German CPI sample is much larger than those of other countries are. According to Klenow/Kryvtsov (2004), the BLS, for example, surveys the prices of “only” 85,000 items for the non-shelter portion of the US-CPI.

<sup>5</sup> We achieved a close match for 40 products and an approximate match for eight products. No match was possible for two products (see Annex Table A1 for details).

**Table 1: The product sample**

Product	Main component	Weight in %ot	Observations per month
Filet of beef	UN	25.33	647
Cod	UN	3.93	121
Lettuce	UN	6.81	647
Banana	UN	7.54	694
Spinach, frozen	UN	5.31	200
Milk	PRO	31.08	212
Sugar	PRO	16.38	714
Mineral water	PRO	18.72	499
Coffee	PRO	10.11	207
Whisky	PRO	4.58	563
Bottled beer	PRO	21.44	500
Regular fuel	EN	18.77	652
Premium grade fuel	EN	21.28	653
Heating oil	EN	7.84	326
Gas	EN	12.09	146
Electricity	EN	23.86	152
Shirt	IND	32.51	188
Jeans	IND	49.53	165
Socks	IND	9.32	474
Sport shoes	IND	18.71	155
Acrylic paint	IND	6.63	136
Filler	IND	6.42	136
Toaster	IND	3.42	178
Electric bulb	IND	7.37	209
Suite	IND	54.11	261
Towel	IND	9.71	382
Steel radial tyre	IND	8.75	157
Hi-fi system	IND	3.63	127
Television set	IND	8.41	145
Dog food	IND	7.51	172
Football	IND	5.71	108
Construction game	IND	6.14	115
Toothpaste	IND	20.97	221
Suitcase	IND	6.03	117
Dry-cleaning	SER	3.04	368
Sanding and sealing of parquet flooring	SER	2.24	75
Repair of washing machine	SER	2.24	81
Car main service	SER	31.58	166
Car wash	SER	1.22	176
Brake service	SER	29.11	168
Taxi journey	SER	5.13	40
Cinema admission	SER	22.09	263
Video hiring	SER	10.58	95
Photo processing	SER	10.95	156
Overnight accommodation	SER	24.50	77
Glass of beer	SER	28.89	112
Meat dish	SER	60.52	105
Glass of non-alcoholic beverages	SER	7.67	110
Hairdressing services for men	SER	6.84	736
Hairdressing services for women	SER	20.37	736
Rent for privately financed apartments	SER	218.29	2237
Rent for subsidised apartments	SER	14.78	2858

Sources: German Federal Statistical Office and authors' calculations.

Notes: Main components: UN Unprocessed food, PRO Processed food, EN Energy, IND Non-energy industrial goods, SER Services; weights: average monthly weight in the period February 1998 to January 2004; four-digit COICOP weights price-updated from the 1995 and 2000 CPI baskets and rescaled to the original main-components weights.

In addition to actual prices, the data set provided by the German Federal Statistical Office includes further price information (the actual price in the previous months, a comparable price in the previous month if a replacement has taken place, indices capturing the directly observable and the quality-adjusted price development), and metadata including the COICOP (Classification of individual consumption according to purpose) ten-digit code, a location code (which we were not allowed to make use of), a code describing the outlet type, and, most importantly, a variable termed “reason of change” (*Änderungsgrund*). This variable may take 16 different values, describing whether a change in the price or in the characteristics of an item has taken place.<sup>6</sup> We learn, for example, whether a replacement is considered comparable or not and whether a price reduction corresponds to a promotion.

Usually two variants of replacements are distinguished, forced replacements and voluntary replacements. Most of the replacements in the German CPI sample are of the forced type. Typically, the price collectors stay with sampled items (outlets) until they disappear from the market. If that happens, a replacement item (outlet) is chosen, and the price series for the old and the new product variant (outlet) are linked via an explicit quality adjustment – if the replacement item (outlet) is of the non-comparable type.<sup>7</sup> In February 2000, a redesign of the product and outlet sample of the German CPI became effective, which resulted in numerous purposive (voluntary) replacements aiming at maintaining the representativity of the CPI product and outlet sample. In this case, prices for the old and the new product variants were often chain-linked in the overlapping period, meaning that the within-period price difference was fully taken out for the measurement of inflation.

In the temporal dimension, the data refer to the years 1998 to 2003. Prior to 1998 individual price data are available only at the level of the German federal states and follow a different classification, which would have made linking these data to our sample very cumbersome. With the exception of housing rents, prices for the German CPI are collected on a monthly basis, typically in the middle of the month. This implies that price variations within a month are not observed, which might distort measures of the incidence of price adjustments for products with frequent price changes such as

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<sup>6</sup> For details, see Annex Table A.2.

<sup>7</sup> On the quality adjustment procedures in the German CPI, see Hoffmann (1999).

heating oil and fuel or fresh fruits and vegetables. It is not very likely, however, that the monthly frequency of price recording substantially biases the estimate of the incidence of price adjustments for the core components, as, for example, Herrmann/Möser (2002) report that the duration of prices for processed food products varies between three and 140 weeks. Rents are also collected on a monthly basis, but with a rotating sample, meaning that only one-third of rents are actually observed each month. Rents that are not actually observed are carried forward from the previous month. We also include January 2004 in our sample. By doing this, we balance the number of price changes for each month of the year. Overall, our panel consists of price level data for 73 months and we observe 72 transitions.

For summarising the product specific results to broader categories, we employ the breakdown of the HICP used by the ESCB for monetary policy purposes. The results are presented separately for unprocessed food, processed food, energy, non-energy industrial products and services (including rents).<sup>8</sup> When aggregating the product-specific results to the main components or to the total index, the problem of weighting arises. The products were sampled at the ten-digit COICOP level, which is the deepest available breakdown. For most products, this guarantees that the collected prices correspond to relatively homogenous goods and services. For instance, the definition of milk reads “UHT milk, in stable packages, 3.5% fat content; 1 litre”.<sup>9</sup> When trying to generalise the estimates, it might seem a straightforward matter to take the corresponding ten-digit weights. Most likely, however, such an approach would result in distorted estimates at the aggregate level, since the ten-digit weights vary with the number of price representatives available for specific expenditure categories. For instance, prices for many different products are traditionally collected in the categories fresh fruit and vegetables, because there is substantial short-run variation in relative prices. On the other hand, there are only four types of fuel available in Germany, of which three are sampled for the CPI. Taking ten-digit weights without any adjustments would give excessive weight to fuels and too small weights to unprocessed food.

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<sup>8</sup> The unprocessed food index is defined as the weighted mean of the indices for fruit and vegetables and for meat and fish, whether processed or not. The processed food index summarises the price development of dairy products, oils and fats, and other foodstuff, as well as alcoholic and non-alcoholic beverages and tobacco products.

<sup>9</sup> For a detailed description of the products in the sample, see Table A1 in the Annex.

**Table 2: The coverage of the main components**

Main component	CPI	Common sample		National sample	
		ten-digit level	four-digit level	ten-digit level	four-digit level
Unprocessed food	45	4	45	4	45
Processed food	95	18	47	18	47
Energy	81	32	42	46	70
Industrial goods	264	19	133	19	133
Services	516	37	101	117	313
Overall	1000	110	368	203	608

Sources: German Federal Statistical Office and authors' calculations.

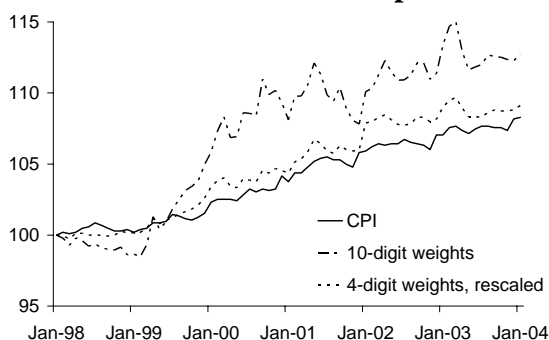
Notes: 2000 CPI basket weights (%); level: COICOP level; services including imputed rent for owner-occupied housing.

Hence, we derive weights from the four-digit COICOP level. If there is only one price representative for a four-digit COICOP category in our product sample, it gets the full four-digit weight. If two or more products are representing a four-digit COICOP category, the weight is either allocated proportional to the ten-digit weights, or weights are distributed following *a priori* information. For example, in the COICOP category “Hairdressing saloons and personal grooming establishments”, we have chosen for our investigation the single price representative for hairdressing services for men, but only one out of three price representatives for hairdressing services for women. Hence, the surplus four-digit weight is allocated to hairdressing services for women.

The 48 products in the common sample correspond to about 11% of the household expenditure represented in the year 2000 basket of consumption (see Table 2). Unprocessed food is clearly underrepresented, as are industrial goods and services. A relatively excessive weight is attached to energy. Changing to weights from the four-digit level improves the coverage with respect to unprocessed food and industrial goods, but the weight attached to services is still much too small. Adding gas and electricity and, more importantly, rents for two dwelling types, results in a better-balanced sample.

For the common analysis it was decided to use weights rescaled to reproduce of weights of the main components in the CPI (see Dhyne *et al* 2004), which might also improve the representativity of the aggregate results. Within the main components, we apply therefore four-digit weighting, and then rescale the weights to the original main components weights. Only the 4-digit-weight of housing rents is not inflated.

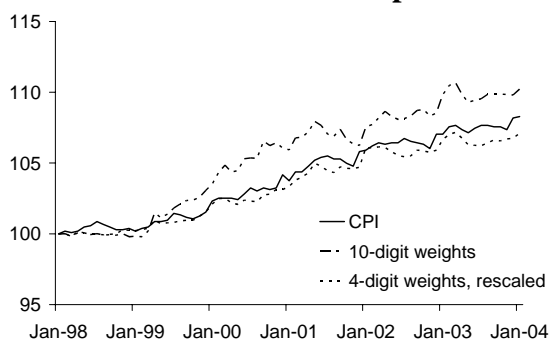
**Figure 1: Price developments according to the common sample**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Price-updated 1995 weights to up to 2000, afterwards 2000 weights. Official product price series. Rebased to January 1998=100.

**Figure 2: Price developments according to the national sample**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Price-updated 1995 weights up to 2000, afterwards 2000 weights. Official product price series. Rebased to January 1998=100.

The 52 products – the national sample – track total CPI inflation surprisingly well with four-digit weights rescaled in the described way (Figure 2) and the quality-adjusted product-specific price indices as published by the Federal Statistical Office.<sup>10</sup> This gives us some confidence that other weighted measures for this sample are also approximately representative of the full CPI. Choosing ten-digit COICOP weights results in a disproportional influence of components with an above-average price trend. The common sample, which excludes housing rents and gas and electricity prices, displays a much more volatile pattern of price developments (Figure 1). Furthermore, even with rescaled four-digit weights its track record with respect to total CPI inflation is inferior to that of the national sample.

The 1995 and 2000 basket weights are exact only for the measurement of inflation with respect to the weight reference years. Year-on-year inflation rates or month-on-month inflation rates calculated by dividing indices imply different sets of weights, which can be obtained from the original set of weights by price updating [ILO et al, 2004, 1.28 to 1.29, 9.92 to 9.130]. When referring to monthly rates of inflation, we use price-updated weights of the 1995 basket of consumption for the period up to December 1999, afterwards the price-updated weights of the 2000 CPI basket. Table 1 reports the product-specific average weights.

<sup>10</sup> The index for the 52-product sample is calculated from the quality-adjusted product-specific price indices as published by the Federal Statistical Office. On a similar exercise for Italy, see Veronese *et al* (2004)

Our data are a subset of the price data assembled at the Federal Statistical Office for reviewing the quality adjustment procedures in the German CPI. It is not the data set from which the CPI is compiled. In Germany, the product-specific CPI aggregates are computed by the statistical agencies of the federal states, and the final data from which the CPI is compiled are kept at the level of the federal states only. The federal states report, however, preliminary data to the Federal Statistical Office. From this data set, the staff of the Federal Statistical Office extracted the price records for our study. As the data especially for the earlier years under review were incomplete and sometimes inconsistent or defective, the data set had to be cleaned and edited – a job that was performed by the experts of the Federal Statistical Office.

The main problems were caused by missing price observations and outlets vanishing from the market. If a price was missing, but the price observed in the preceding period was identical to the price in the consecutive period, the missing observation was imputed by carrying the price forward. If the price observations were missing for two or more consecutive periods, the specific item in the specific outlet was discarded. Items were also discarded if the prices in the periods neighbouring the missing observations were not exactly identical. Quite often, the observation of prices in a specific outlet came to a sudden end because the outlet closed. If a substitute outlet was identifiable, the price series was linked with a flag signalling an outlet replacement. Unfortunately, it was often impossible to identify the replacing outlet. We had to discard entirely the observations for three small German states, as these were particularly defective.

Before editing, the data set consisted of about 47,000 trajectories, of which nearly 20,000 were complete but sometimes defective. After imputing missing values, linking strings with outlet replacements and discarding strings with inconsistent information, the cleaned data set contained nearly 19,000 full trajectories. 28,000 strings were still either broken or were delivering conflicting information. Assuming that strings are broken only once, the cleaned data set includes nearly 60% of the prices collected for the sampled products.

**Table 3: The number of monthly price observations in the cleaned data set**

Main component	Cleaned data set	
	Overall	per product
Unprocessed food	2,309	462
Processed food	2,695	449
Energy	1,929	386
Industrial goods	3,446	191
Services	8,559	476
excluding rents	3,464	217
Overall	18,938	364

Sources: German Federal Statistical Office and authors' calculations.

The number of monthly price observations per product is quite uneven. It ranges from 40 for taxi journeys to 2,858 for rents for subsidised apartments (see Table 1). Generally, the number of price observations per product is higher in the case of housing, energy and food than for industrial products and services (Table 3). These discrepancies imply that the estimates for some products might be more reliable than for other products. Furthermore, they underline the necessity of adequate weighting. Over the period under review, the nearly 19,000 monthly price quotes add up to 1.4 millions.

The breaks in the price trajectories caused by item replacements are a major nuisance for intertemporal price comparisons in general and for the analysis of price adjustments at the micro level in particular. When the price of a specific item in a specific outlet can no longer be observed, a replacement has to be chosen and the price series of the old and the new item linked by means of an implicit or explicit quality adjustment (ILO *et al*, 2004, Chapter 7). In an investigation of the 1995 US CPI, Moulton/Moses (1997) found that replacements explained nearly half of the aggregate increase in prices. Only half of the measured price increase was related to continuously priced items. For some products, as for apparel and upkeep, for which retailers tend to discount prices before dropping them and increase prices with the introduction of new models, the price change for matched-models was, in fact, negative. Only the inclusion of replacements turned the measured rate of inflation positive. Hence, disregarding item replacements probably leads to distorted measures of price adjustments.



**Table 4: The effect of quality adjustment on the rate of inflation**

Main component	Unadjusted price change	Quality-adjusted price change	Effect of quality adjustment
Unprocessed food	+1.0	+0.9	-0.1
Processed food	+0.0	+0.3	+0.3
Energy	+4.3	+4.5	+0.2
Industrial goods	+0.9	+0.1	-0.8
Services	+1.8	+1.5	-0.3
Overall	+1.5	+1.2	-0.3

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, rescaled four-digit weights, average annualised rate of change (%). Effect of redesign product and outlet sample in February 2000 taken out.

As the IPN decided to consider voluntary replacements as equivalent to true price changes, if they could be identified. The analysis of price adjustments was to be based either on raw unadjusted or quality-adjusted price data, depending on data availability. We are in the fortunate position of having information on both actual market price data and quality-adjusted price data. The latter correspond more closely to the actually measured rate of inflation, but also reflect the decisions of the statistical agency on how to link price series for items with different characteristics. In our product sample, the differences between the measures of unadjusted price change and of the quality-adjusted price change are significant, but not huge, when disregarding the effects of the redesign of the product and outlet sample in February 2000.

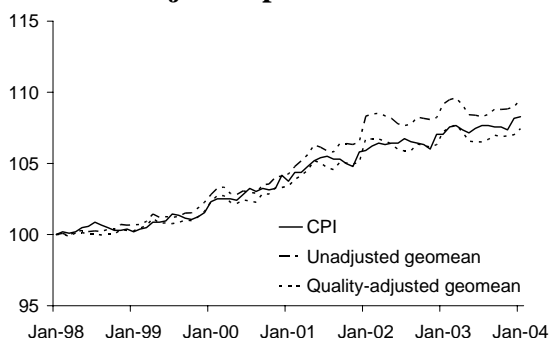
As expected, the biggest effect of quality adjustment is found in the industrial goods component where nearly the full increase in market prices is considered to be quality-related and neutralised for the calculation of the CPI (Table 4). The “decline” in quality of processed food and energy is probably related to outlet replacements.<sup>11</sup>

The inflation measure based on unadjusted market prices as well as the measure based on the sampled quality-adjusted prices, weighted as described above, track the CPI rather well (Figure 3).<sup>12</sup> Even more encouraging is the fact that – as can be seen in

<sup>11</sup> In the period under review, Germany experienced rapid structural change in retailing, with low-price discount shops gaining market shares at the expense of more traditional outlets. When outlets are replaced in the German CPI sample, usually the full price difference between the outlets is regarded as quality-related and taken out for the measurement of inflation. See Hoffmann (1998).

<sup>12</sup> Admittedly, at the main components level the differences are more pronounced than at the aggregate level. For unprocessed food, the actual annual average rate of price of price change is 0.5% instead of

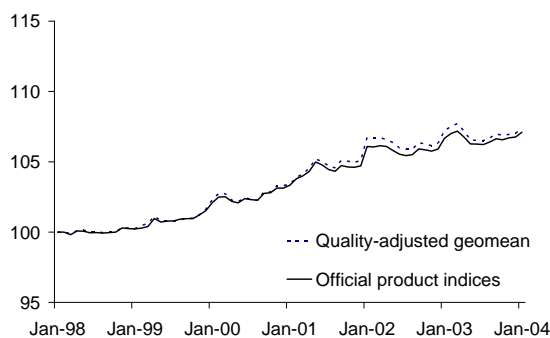
**Figure 3: Unadjusted and quality-adjusted price trends**



Sources: German Federal Statistical Office and authors' calculations.

Notes: CPI: Official CPI. Unadjusted geomean (Quality-adjusted geomean): Weighted average (rescaled four-digit COICOP weights) of the product-specific geometric mean of non-adjusted (quality-adjusted) item price series in the cleaned 52 product sample. Rebased to January 1998=100.

**Figure 4: Official and estimated product indices**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Official product indices for the 52-product sample weighted with rescaled four-digit COICOP weights. Quality-adjusted geomean: Weighted average (rescaled four-digit COICOP weights) of the product-specific geometric mean of quality-adjusted item prices series in the cleaned 52-product sample. Rebased to January 1998=100.

Figure 4 – the index derived from our cleaned data set is nearly indistinguishable from an identical weighted average of the official product price indices. The data loss resulting from the cleaning process does not seem to have affected the representativity of our results negatively.<sup>13</sup>

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0.9%, for processed food 1.4% instead of 0.3% (this is the effect of tobacco products not included in our sample), for energy 4.3% instead of 4.5%, for industrial goods 0.2% instead of 0.1% and for services 1.6% instead of 1.5%. For the total CPI, the average annual rate of inflation was 1.3% instead of 1.2%.

<sup>13</sup> Veronese et al (2004) arrive at a similar conclusion when comparing an index based on 48 products for a subset of reporting cities to an index based on the same set of products but with the full regional coverage.

### 3 The frequency and the size of price changes

#### 3.1 Measurement issues

A simple but quite robust and efficient measure of the “extensive margin” (Klenow/Kryvtsov 2004) of the inflation process is the frequency or incidence of price changes, defined as the number of price changes per 100 price observations.<sup>14</sup> The corresponding indicator of the “intensive margin” is the average size of price changes. In a “static universe” (Sellwood, 2001), these two measures can be defined without ambiguity. This is no longer true in a “dynamic universe” with newly appearing and disappearing products and outlets. Restricting the analysis to continuously priced items biases the estimate of the incidence of price changes downwards and probably also distorts the estimate of the size of price adjustments.

Consider, for example, apparel which changes with the seasons and the whims of fashion. Typically a new model is introduced at a high price, which is discounted only late in the season. After the end-of-season sales, the old product is withdrawn from the market, and a new model appears. When restricting the investigation to continuously priced items, we would probably observe only a price reduction related to the end-of-season sales (if it is not missed by the statistical office). The price increase related to the introduction of the new model would be ignored.

We therefore report four measures of price change activity and, correspondingly, four exactly matching measures of the size of price changes. The first pair relates to continuously observed items only.<sup>15</sup> This is the matched-models (M) sample. The second and the third pairs also include observations related to forced items replacements, but no outlet replacements and no voluntary items replacements.<sup>16</sup> The measure of the size of price changes is calculated either from the unadjusted market prices (replacement sample 1, R1), thus reflecting directly the pricing decisions on the

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<sup>14</sup> For a discussion of the pros and cons of using applying the frequency approach, among others, see Aucremanne/Dhyne (2004), Baudry *et al* (2004), Dias *et al* (2004).

<sup>15</sup> Including comparable replacements, that is replacement items whose prices are considered directly comparable to those of the replaced items because the items are judged nearly identical.

<sup>16</sup> This is the measure also employed for the comparative analysis in Dhyne *et al* (2004). As the variable “reason of change” does not give us unambiguous indication of the cause of a replacement, we consider all replacements as being of the forced type with the exception of some replacements that took place in February 2000 when the product and outlet sample was redesigned. For the products affected by the voluntary replacements, we impute estimates of the incidence and the size of price changes based on the analysis in section 3.3.

market, or from the quality-adjusted prices (replacement sample 2, R2).<sup>17</sup> The fourth estimate corresponds closely to the official inflation figures by deriving the measures of the frequency and the size of price changes directly from the item-specific quality-adjusted price series. Most of the country studies for the euro area – as, for example Baudry *et al*, 2004 – report measures of the incidence of price changes including (involuntary) replacements (R1), but consider only matched models (M) for the measurement of the size of price changes.<sup>18</sup> The study for Spain (Álvarez/Hernando, 2004) refers to quality-adjusted data. Hence, the results of Spanish study are directly comparable to our fourth measure.

## **3.2 Variation across sectors and products**

### **3.2.1 The frequency of price changes – statistical findings**

#### **3.2.1.1 Statistical findings**

In the matched-models sample (M), the monthly incidence of price changes varies between 1.6% for rents (privately financed apartments) and nearly 92.5% for heating oil (Annex Table A3). In the quality-adjusted sample (Q), the incidence of price changes tends to be higher, the difference being related to item and outlet replacements resulting in (quality-adjusted) price changes. It ranges from 1.8% to 92.9%. The estimates for the replacement sample referring to unadjusted market prices (R1) are even somewhat higher than those for the quality-adjusted sample are. The replacement sample with quality-adjusted prices (R2) results in an estimate of price changes close to the sample including all replacements (Q), the small differences being brought about by outlet replacements.<sup>19</sup>

Properly weighted (four-digit COICOP weights rescaled with the original main components weights), the average monthly incidence of price adjustments is estimated 10.1% in the matched-models sample and 10.8% in the quality-adjusted sample (Table

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<sup>17</sup> The pre-January 2002 prices were converted into euro by rounding to the 2<sup>nd</sup> decimal place. For the quality-adjusted item-specific price indices no conversion was required.

<sup>18</sup> More precisely, they presume that a price change has taken place when an item is replaced.

<sup>19</sup> The incidence of price changes was computed mechanically for all four price concepts by the number of price changes per 100 price observations. An exact measure would no include price observations related to product and outlet replacements in the denominator if they were not also included in the nominator. It is, however, only the measure for the matched models that is distorted in a perceptible degree by our procedure.

**Table 5: The frequency of price changes**

Main component	Price adjustments				Price increases				Price decreases			
	M	R1	R2	Q	M	R1	R2	Q	M	R1	R2	Q
Unprocessed food	27.1	28.7	28.5	28.4	14.1	15.0	14.9	14.9	13.0	13.7	13.6	13.5
Processed food	9.5	10.2	10.1	10.1	4.8	5.1	5.1	5.1	4.8	5.2	5.0	5.0
Energy	56.6	57.3	57.1	57.1	31.4	31.8	31.8	31.8	25.3	25.6	25.3	25.3
Industrial goods	5.6	7.9	7.2	7.2	3.2	4.5	4.2	4.2	2.5	3.5	3.0	3.0
Services	3.1	3.7	3.4	3.4	2.5	2.8	2.7	2.7	0.7	0.9	0.7	0.7
Overall	10.1	11.2	10.8	10.8	5.9	6.5	6.4	6.4	4.2	4.7	4.5	4.5

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, monthly incidence of price changes (percentage), four-digit weights rescaled to the original main-components weights. M: Matched models, actual prices. R1: Including item replacements, actual prices. R2: Including item replacements, quality-adjusted prices. Q: Including all replacements, quality adjusted prices. Effects of redesign of item and outlet sample in February 2000 taken out.

5). Taking the exact ten-digit COICOP weights would give an estimate of the incidence of price adjustments of 17.2% for the matched models and of 19.2% in the quality-adjusted universe. The corresponding estimates for the ten-digit weights rescaled with the main components – this weighting scheme was chosen for some national studies – are 11.1% and 11.6% respectively. These results suggest that measures of price changing activity are quite sensitive to the price concept and the weights chosen for aggregation.

There are substantial differences in the prevalence of price adjustments between sectors. About 60% of the energy prices are adjusted each month, whereas only about 3% of the services prices change. The corresponding figures for industrial goods and processed food are also more at the low end, but substantially above those for services. In the unprocessed food component the incidence of price changes is rather high (nearly 30%), but still significantly lower than in the energy sector.

There is also substantial heterogeneity within sectors. In the unprocessed food segment, on average less than 10% of the prices of a filet of beef change per month, whereas typically more than 80% of the prices of lettuce and more than 50% of the banana prices differ from the previous period. In the energy sector, prices for heating oil and fuels change frequently, whereas prices for electricity and gas were much less often adjusted. In the processed food segment, coffee stands out with an incidence of price changes of more than 20%, whereas on average less than 10% of the prices of the other

**Table 6: The incidence of item and outlet replacements**

Main component	Item replacements	Outlet replacements	Total replacements	
			Full period	Per month
Unprocessed food	38.2	6.0	44.2	0.6
Processed food	40.8	5.8	46.6	0.6
Energy	12.0	0.8	12.8	0.2
Industrial goods	170.3	2.5	172.8	2.4
Services	30.3	8.6	38.9	0.5
Overall	67.3	5.9	73.2	1.0

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, four-digit weights rescaled to the original main-components weights. Item replacements excluding comparable replacements. Figures as percentage of total observations. Effects of redesign product and outlet sample in February 2000 taken out. Some double counting of replacements as combinations of variants of item and outlet changes occur.

foodstuff are modified per month.<sup>20</sup> The patterns in the industrial goods and in the services component are more uniform. Nevertheless, there are still substantial differences, with the more “flexible” services such as the car main service displaying a higher incidence of price changes than the less “flexible” industrial goods such as electric bulbs.

As already mentioned in the introduction to this section, the lowest rate of price adjustment is reported for housing rents. In the subsidised part of the housing market, rents were changed at a rate of just 2.1% per month if only continuously prices flats without any modifications are considered. In the more important privately financed market segment, the rate of price adjustment stood at just 1.6% per months. Quality-adjusted rents were modified at rates of 2.9% and 2.1% per month, respectively, indicating that rent adjustments are often related to renovation and reconstruction measures. Excluding housing increases the average incidence of price adjustment to 12.7% for the matched models and 13.6% for the quality-adjusted prices. These figures correspond more closely to the estimates for other euro area countries, which typically do not cover housing.

For many products, taking account of product and outlet replacements does not make a significant difference. However, there are some notable exceptions. Most of the

<sup>20</sup> The exceptional volatility of coffee prices is probably related to fierce competition between coffee roasters and to the (partial) vertical integration of roasters and specialised outlets. On the German coffee market, see Koerner (2002).

replacements take place in the industrial goods segment (Table 6), where technical progress changes the characteristics of products rapidly. For instance, television sets and Hi-fi systems were replaced on average four times in the period under review, implying a monthly replacement rate of nearly 6% (Annex Table A.4). Jeans, sport shoes, toasters, three-piece suites and construction games were replaced twice (or at a rate of nearly 3% per month). Overall, in the sample only about 1% of the items were exchanged per month, reflecting the rather low rates of item replacement in the non-industrial goods components. Outlets changed even less often than item characteristics. In our sample, only 4.3% of the reporting units were replaced in the period under review, which is less than 0.1% per month. However, as many breaks in the price trajectories were caused by outlets vanishing from the market, the cleaning of the data set probably biases the estimate of the rate of outlet replacements significantly downwards.

The incidence of replacements corresponds relatively closely to the difference between the frequency of price adjustments for matched models and for the quality-adjusted sample including replacements (Table 5). This correspondence is, however, not perfect, as replacements do not necessarily result in a (quality-adjusted) price change. In the case of industrial goods, for example, 2.4% of the items are replaced each month, but the difference in the incidence of price changes between the matched-models sample and the replacement sample with quality-adjusted prices comes to just 1.6%.<sup>21</sup>

Estimates of the product-specific average duration of prices can be computed by inverting the frequency measure.<sup>22</sup> Table A.5 reports the product-specific estimates of the duration of prices implied by the different frequency measures.<sup>23</sup> Prices for fuels and fresh vegetables are rather volatile and typically last about a month, whereas housing rents tend to be extremely stable and remain on average unchanged for more than four years.

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<sup>21</sup> In contrast to this investigation, in some studies for euro-area countries (see, for example Aucremanne/Dhyne, 2004 or Baudry *et al*, 2004) it is simply stipulated that a price change occurs when an item is (involuntarily) replaced. This practice most likely results in an overestimation of the incidence of price changes.

<sup>22</sup> For a discussion of the limits and the potential pitfalls of this approach, see Baharad/Eden (2004), Baudry *et al* (2004) and Dias *et al* (2004a).

<sup>23</sup> Results are reported for the replacement samples (R1 and R2) and the quality-adjusted sample (Q) only; inferring durations from the matched-models frequencies is not really meaningful.

**Table 7: The implied duration of prices**

Main component	Average of implied product-specific durations			Inverse of component-specific frequencies		
	R1	R2	Q	R1	R2	Q
Unprocessed food	7.3	7.5	7.6	3.0	3.0	3.0
Processed food	10.8	11.0	11.0	9.3	9.4	9.4
Energy	4.2	4.3	4.3	1.2	1.2	1.2
Industrial goods	13.0	14.4	14.4	12.1	13.5	13.5
Services	32.5	37.6	37.7	26.2	28.8	28.8
Overall	21.5	24.5	24.6	8.4	8.7	8.7

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, four-digit weights rescaled with original main-components weights. Average duration in months computed from the average incidence of price changes by using the formula  $T=1/F$ . R1: Including item replacements, actual prices. R2: Including item replacements, quality-adjusted prices. Q: Including all replacements, quality adjusted prices. Effects of redesign of sample in February 2000 taken out.

The pronounced heterogeneity in the frequency of price changes across sectors and products has the unfortunate consequence that estimates of the implied average duration of prices is strongly influenced by the ordering of inversion and aggregation of the product-specific results. Averaging product-specific durations gives a much higher estimate of the mean length of price spells than inverting the weighted mean frequency (Table 7). In our sample, (quality-adjusted) price spells last on average two years, whereas the mean incidence of price changes implies a duration of just nine months. As pricing is probably more homogenous within than across sectors, we follow Dias *et al* (2004a) in preferring the first of the two measures. The estimate will, however, still be biased if there is heterogeneity in price durations across outlets (Baharad/Eden, 2004). Inferring the mean duration of prices from unadjusted prices gives a lower estimate of 21 months since some product replacements disrupt non-adjusted price spells but leave quality-adjusted price spells unaffected. Disregarding housing rents and electricity and gas prices reduces the average of the implied price durations to about 16 months.

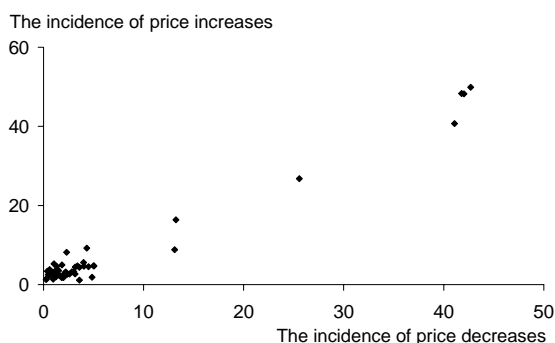
Concerning the direction of price adjustments, we find that price decreases are nearly as frequent as price increases, indicating that there is no general downward rigidity in prices. According to our weighted 52-product sample, more than 40% of the price changes are downwards, less than 60% upwards.<sup>24</sup> As with the overall incidence

<sup>24</sup> This division is not influenced very much by the price concept chosen. For quality-adjusted prices, the balance shifts slightly in favour of prices increases compared to the measures based on unadjusted prices.



of price adjustments, there is substantial heterogeneity across sectors (Table 5, page 19). In the processed food segment, downs are as frequent as ups, whereas prices changes of services are predominately upwards (about 80%) and only to a small extent downwards (about 20%). Most interestingly, even for housing rents we find evidence of reductions (Annex Table A.3).

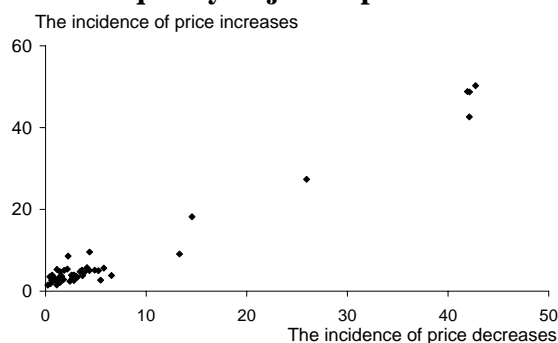
**Figure 5: Price increases and price decreases: matched models**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period February 1998 to January 2004. Average incidence price increases and decreases as percentage of monthly observations. Matched models only.

**Figure 6: Price increases and decreases: quality-adjusted prices**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period February 1998 to January 2004. Average incidence price increases and decreases as percentage of monthly observations. Quality-adjusted prices.

Even without a thorough investigation of the differences in the incidence of price changes, we can detect a weak positive correlation between the frequency of price changes and the share of price reductions in total price adjustments across products. There is a much stronger positive correlation between the incidence of price reductions and the incidence of price adjustments. At first glance, this finding seems to be trivial, as the total incidence of price changes equals the sum of price increases and decreases. However, with a steady trend in product price indices we would expect to observe either frequent price increases or frequent price decreases, with the number of price adjustments depending on the product specific rate of price change and the typical product-specific size of price adjustments. Without short-run volatility in prices, the average incidence of price increases should not be correlated with the incidence of price decreases. Actually, the correlation is close to one (Figures 5 and 6), a phenomenon which is also observed by Baudry et al (2004). Even taking the “outliers” out (here defined as products with an incidence of price increases and price decreases above 10) leaves the coefficient of correlation above 0.5.

The strong correspondence of price increases and price decreases across products hints at a substantial short-run volatility in prices. Bouncing of prices might be related either to the volatility of important cost factors – as might be the case with energy or unprocessed food – or to deliberate pricing strategies at the retail level. For example, it may pay for outlets to randomise prices if there are informed consumers who know the distribution of prices and uninformed consumers who choose a store at random. By charging high prices most of the time and low prices intermittently, outlets may try to discriminate prices between informed and uninformed buyers (Varian, 1980). Coordinated season sales can be rationalised by the attempt of outlets to discriminate prices between buyers with low and high reservation prices (Sobel, 1984). Moreover, there are price rebates for heterogeneous goods facing uncertain demand and clearance sales for goods losing attractiveness over time (Lazear, 1986). The "thick market" hypothesis of Warner/Barsky (1995) tries to rationalise the high incidence of promotions on weekends or before public holidays.

In the German consumer price statistics, temporary price reductions related to promotions, sales and end-of-season sales are covered in principle. However, prices are recorded in the middle of the month only. As end-of-season sales traditionally start in the second half of the affected months, most of the price-reducing effects of end-of-season sales are not captured by the German CPI, which biases the estimates of the frequency of price adjustments downwards for Germany.

In our sample, the variable "reason of change" is supposed to indicate promotions, but not sales. There are, however, strong indications that even promotions are often not properly flagged. Hence, we try to identify sales and promotions indirectly. We term a sequence of prices with  $P_{t+1} < P_t$  and  $P_{t+2} = P_t$  "promotion" and a sequence with  $P_{t+2} > P_t$  and  $P_{t+1} < P_t$  "sale".<sup>25</sup>

Table 8 and Annex Table A.7 report the incidence of "promotions" and "sales" in our sample as identified by this procedure. Sequences with prices returning to or even overtaking their previous level following a one-month discount occur most often in the energy and unprocessed food segment. In these sectors, however, the short-run volatility in prices is most likely related to product-specific price shocks emanating from earlier

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<sup>25</sup> For a similar approach, see Baumgartner *et al* (2004).

**Table 8: The frequency of “promotions” and “sales”**

Main component	“Promotions”	“Sales”	Total
Unprocessed food	1.4	2.1	3.5
Processed food	0.8	0.2	1.0
Energy	1.3	6.2	7.6
Industrial goods	0.3	0.2	0.4
Services	0.0	0.0	0.0
Overall	0.3	0.7	1.0

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Dec 2003, four-digit weights rescaled with original main-components weights. “Promotions” and “sales” identified indirectly: “promotion” if  $P_{t+1} < P_t$  and  $P_{t+2} = P_t$ . “sale” if  $P_{t+2} > P_t$  and  $P_{t+1} < P_t$ . Figures as percentage of total observations.

stages in the value-added chain. In the processed food component, disregarding “sales” and “promotions” reduces the monthly incidence of price changes from about 10% to 8% and in the industrial goods segment from slightly more than 7% to 6½% (as a promotion or a sale implies two price changes, the contribution of the special sales to the frequency of price changes is twice its incidence).<sup>26</sup> Assuming that true sales and promotions occur only in the processed food and industrial goods sectors and in some services, taking these special sales out lowers the estimate of the average frequency of price changes for the full CPI by ¼ percentage points and raises the average of the implied durations by 1½ months.

### 3.2.1.2 Exploring the differences

The usual suspects for differences in the incidence of price changes across products are the product-specific rates of inflation and their volatility (respectively the development of important cost factors), the degree of competition, approximated by the prevalence of modern outlets, the degree of regulation and the occurrence of attractive prices.

Let us assume that the size of prices increases and price reductions is uniform and identical across sectors, that product-specific price developments are steady and that there is no idiosyncratic volatility in individual prices. Then there is an exact correspondence between the absolute value of the rate of inflation and the incidence of

<sup>26</sup> Herrmann/Möser (2002) also report a relatively high prevalence of promotions in German grocery stores, with the incidence of promotions varying between the different retail chains. Whereas in the case of one retail chain prices lasted on average for 11 weeks, in another chain an average duration of 87 weeks was recorded for an identical basket of products.

price adjustments across products. Volatility in product-specific price developments, probably caused by short-term changes in marginal costs, should add to the incidence of price adjustments. If the size of price changes is variable, the frequency of price adjustments probably will also vary with the degree of endogenous nominal rigidities. Firstly, if the costs of changing prices are independent of the level of prices, the frequency of price adjustments will increase with the product-specific (average) price level. If it pays to have attractive prices (convenient or threshold prices), price changes tend to be larger. Hence, the incidence of price adjustments is expected to be lower with attractive prices. Modern, well-organised outlets are supposed to have smaller menu costs and to be more competition minded, thus influencing the incidence of price adjustments upwards. The prevalence of short-term fluctuations related to sales and promotions will also add to the incidence of price adjustments. And finally, regulation is supposed to reduce price flexibility.

We proceed in three stages. Firstly, we regress the frequency of price adjustments on the average price level of the product, on indicators for the importance of attractive prices, modern outlets, sales and promotions, and on a dummy variable indicating whether a price is regulated. In a second step, we analyse the cross-sectional differences separately for price increases and price reductions, but add the average product-specific rate of inflation and its standard deviation. Finally, we will replace the actual inflation rates by measures of marginal costs, thus mitigating the endogeneity problem. The regressions are performed separately for full sample and the core sample excluding unprocessed food and energy.

The product-specific inflation rate is exact to the price concept underlying the measure of price adjustment; for example, if the incidence of price adjustments refers to matched models, the same is true of the inflation indicator. Attractive prices are quite common in Germany (Table 9 and Annex Table A.6), with psychological threshold prices having a substantial importance for processed food and industrial goods, whereas convenient prices are often found among services.<sup>27</sup> Modern outlets, here defined as the share of department stores, cash and carry markets, supermarkets, discount shops, gas stations and energy utilities in the sample of the units reporting to the CPI, sell most of

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<sup>27</sup> Fengler /Winter (2001), analysing individual price data of the 1995 wave of the GfK Consumer Panel, also report a high prevalence of psychological pricing points in German groceries.

**Table 9: The prevalence of attractive prices and modern outlets**

Main component	Convenient prices	Threshold prices	Attractive prices	Modern outlets
Unprocessed food	18.3	28.2	46.4	56.3
Processed food	19.0	49.5	68.5	90.9
Energy	19.3	10.3	29.6	100.0
Industrial goods	19.0	54.7	73.7	41.4
Services	42.8	11.6	54.4	0.8
Overall	30.9	27.6	58.5	32.3

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, January 1998 to Dec 2003, four-digit weights rescaled with original main-components weights. Convenient prices: percentage of prices ending on 0 and 5, psychological threshold prices: percentage of prices ending on 9; attractive digits (a): up to DM2 xx.xa, up to DM20, xx.aa, up to DM200 xxa.aa, DM200 and higher, xaa.aa. Modern outlets: share of department stores, cash and carry markets, supermarkets and discount shops, gas stations, energy utilities.

the processed food and energy. Among unprocessed food and industrial goods, traditional shops have a higher importance. In the services sector decentralised structures dominate. The indicators for the importance of sales and promotions are the indirect ones estimated earlier. It is, however, assumed that promotions and sales occur in the processed food and industrial goods segments only.

Qualitatively the results for the matched models and the quality-adjusted prices are nearly identical, and even the quantitative differences are rather small; hence, we discuss only the results for the quality-adjusted prices (Table 10). The incidence of price adjustments seems to be negatively influenced by the importance of attractive prices. Regulation also reduces the frequency of price adjustments. Sales and promotions tend to go hand in hand with an overall increase in the frequency of price adjustments, at least in the core sample, as the estimated coefficients are well above two. In the estimates for the full sample, modern outlets make a significant contribution to the incidence of price adjustments, but this result is probably strongly influenced by fuels. The price level proves to be insignificant in nearly all specifications.

Adding the mean inflation rate and inflations variability to the list of regressors does affect the results for the structural factors only quantitatively. For the full sample, the mean inflation rate seems to increase the frequency of both price increases and price decreases. This counterintuitive result is mainly driven by the energy component. For the core sample, we find an insignificant influence of the product-specific inflation rate

**Table 10: Exploring the differences in the incidence of price changes across products**

<b>Full sample</b>		Endogenous variable		
Exogenous variables	Incidence of price adjustments	Incidence of price increases	Incidence of price decreases	
Constant	21.2 (6.47) ***	3.64 (2.81)	1.52 (2.67)	
Inflation rate		32.75 (8.92) ***	23.48 (8.67) ***	
Inflation variability		1.85 (0.35) ***	1.83 (0.34) ***	
Price level (*100)	0.15 (0.28)	0.25 (0.27)	0.17 (0.29)	
Threshold prices	-0.48 (0.15) ***	-0.11 (0.05) **	-0.09 (0.04) *	
Convenient prices	-0.23 (0.11) **	-0.10 (0.04) **	-0.08 (0.04) **	
Modern outlets	40.92 (11.80) ***	11.0 (4.11) **	10.33 (4.01) **	
Regulated	-20.73 (9.87) **	-8.87 (3.97) **	-8.35 (4.09) **	
Promotions	-22.66 (11.45) *	-5.63 (4.49)	-4.28 (4.32)	
Sales	35.71 (30.00)	32.25 (17.32) *	29.76 (16.49) *	
Adj. R-squared	0.39	0.76	0.68	
Number of observations	52	52	52	
<b>Core sample</b>		Endogenous variable		
Exogenous variables	Incidence of price adjustments	Incidence of price increases	Incidence of price decreases	
Constant	5.37 (0.94) ***	4.30 (0.73) ***	1.81 (0.49) ***	
Inflation rate		2.62 (1.77)	-7.46 (1.33) ***	
Inflation variability		0.95 (0.62)	2.09 (0.55) ***	
Price level (*100)	0.01 (0.05)	0.08 (0.02) ***	0.02 (0.02)	
Threshold prices	-0.03 (0.01) ***	-0.03 (0.01) ***	-0.02 (0.01) ***	
Convenient prices	-0.03 (0.01) **	-0.03 (0.01) ***	-0.01 (0.01)	
Modern outlets	1.00 (0.85)	0.21 (0.45)	1.19 (0.37) ***	
Regulated	-2.10 (1.03) **	-1.87 (0.48) ***	-0.51 (0.21) **	
Promotions	3.34 (0.60) ***	1.41 (0.36) ***	1.73 (0.26) ***	
Sales	12.75 (2.50) ***	3.88 (1.86) **	1.42 (1.48)	
Adj. R-squared	0.87	0.72	0.96	
Number of observations	42	42	42	

Sources: German Federal Statistical Office and authors' calculations.

Notes: Ordinary least squares. White heteroscedasticity-consistent standard errors in parenthesis. \*\*\* significant 1% level, \*\* significant 5% level, \* significant 10% level. Quality-adjusted price sample. Inflation rate (inflation variability): mean (standard deviation) of monthly matched-models product-specific inflation rates. Price level: average of monthly price levels. Threshold (even) prices: mean of monthly incidence of threshold (even) prices. Modern outlets: share of modern outlets. Regulated: dummy = 1 if price is regulated.

on the incidence of price increases. The inflation rate however, reduces the frequency of price reductions significantly. Inflation variability increases the frequency of price adjustments, especially of prices reductions. For the core sample, the constant turns out to be highly significant, indicating a certain rate of price adjustments not related to the factors accounted for in this estimation.

In the next stage, the product-specific inflation rates are replaced by estimated changes in marginal costs ...

### **3.2.2 The size of price changes**

#### **3.2.2.1 Statistical findings**

If price are to be changed, the change tends to be rather substantial. Marginal price changes are rare. More typically, prices are adjusted by a two-digit percentage. In our sample, on average prices for matched-models are modified by 10½% (Table 11).<sup>28</sup> Also taking into account unadjusted price differences between old and new items – these can be rather sizeable if there is a substantial variation in quality – the average size of price changes increases to 11%. After correcting for changes in quality, the estimate of the average size of price adjustments is reduced to 9%. This pattern, which is also visible at the level of the individual products (see Annex Table A.7), suggests that measures of the size of price changes based on quality-adjusted prices tend to give a lower figure than those derived from matched models or samples including unadjusted replacements.

As with the incidence of price changes, there are substantial differences in the size of price adjustments across products and sectors. The most sizeable adjustments are to be found among unprocessed food, with lettuce displaying the biggest changes. Price changes of industrial goods also tend to be sizeable, whereas in the services and – even more so – in the energy component, price changes are smaller.

Overall, price increases seem to be broadly of the same order of magnitude as prices reductions. For the full CPI, we find that price increases are, on average, somewhat less intense than price decreases, thereby counteracting the higher incidence

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<sup>28</sup> Calculating the average size of price changes is not a trivial exercise. Simply averaging monthly mean price changes would not result in a measure that corresponds to the mean frequency. The time-varying average size of price changes has to be weighted by the time-varying incidence of price changes.

**Table 11: The size of price changes**

Main component	Price adjustments				Price increases				Price decreases			
	M	R1	R2	Q	M	R1	R2	Q	M	R1	R2	Q
Unprocessed food	28.9	25.1		24.5	27.8	24.2		23.5	30.1	26.1		25.6
Processed food	11.6	10.9		9.9	11.8	11.0		10.1	11.3	10.8		9.7
Energy	4.3	3.8		3.8	4.5	4.0		4.0	4.1	3.6		3.6
Industrial goods	13.2	16.6		11.6	10.8	15.4		10.1	16.1	18.0		13.8
Services	9.8	12.0		7.5	9.2	10.7		7.0	12.2	15.4		9.2
Overall	10.4	10.9		9.0	9.7	10.3		8.5	11.3	11.4		9.8

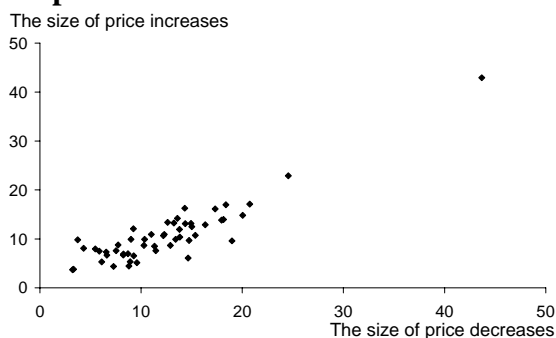
Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, percentage change in prices computed from first difference in logs, four-digit weights rescaled with original main-components weights. M: Matched models, actual prices. R1: Including item replacements, actual prices. R2: Including item replacements, quality-adjusted prices. Q: Including all replacements, quality adjusted prices. Effects of redesign of sample in February 2000 neutralised.

incidence of price increases to some extent. At the sectoral level, for processed food and energy price increases are bigger than price reductions, whereas for industrial products and services price reductions seem to be much more sizeable than price increases.

The dominance of attractive prices implies that prices are typically adjusted in discrete steps of 0.05 or 0.10 currency units (Ratfai, 2003b). And we do indeed find that the most frequent price changes in the late D-Mark period were multiples of 10 Pfennig. With the introduction of the euro cash, uneven price changes became more prevalent. This suggests that the retail trade and the services providers adjusted their price setting behaviour flexibly to the smaller number of euro pricing points.

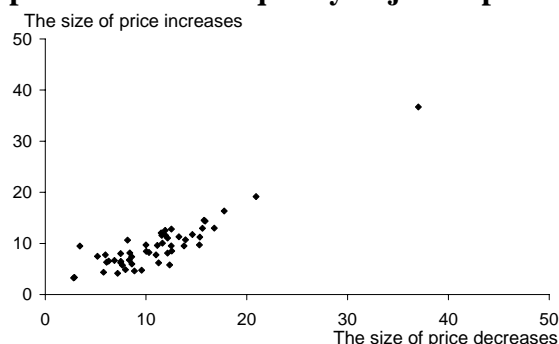
**Figure 7: The size of price increases and price reductions: matched models**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period February 1998 to January 2004. Average size of price increases and decreases as percentages (computed from first differences in logs). Matched models only.

**Figure 8: The size of price increases and price reductions: quality-adjusted prices**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period February 1998 to January 2004. Average size of price increases and decreases as percentages (computed from first differences in logs). Quality-adjusted prices.



As with the frequency of price changes, we find a close correlation between the size of price increases and price reductions across products (Figures 7 and 8). For the full sample, the correlation coefficient is about 0.9; with energy and unprocessed food taken out it is still slightly above 0.7. Whereas the rather strong positive correlation between the frequency of price increases and price decreases is rather puzzling, at least at first glance, the high correlation between the size of price increases and price reduction suggests approximately symmetric product-specific menu costs.

### **3.2.2.2 Exploring the differences**

We replicate with respect to the size of price changes the same econometric estimations as with the frequency of adjustments. In the first stage, the average size of price adjustments is regressed on “structural” factors. In a second stage, the mean and the standard deviation of product-specific rates of inflation are added to the list of regressors. In a third stage, the rate of own-price inflation will be replaced by a marginal cost measure.

The parameter estimates for the matched-models estimates and for quality-adjusted prices are qualitatively identical. Even quantitatively, the results are very close. Hence, we report only the findings for the quality-adjusted sample (Table 12). Of the “structural” factors, it is now the product-specific price-level, which is consistently statistically significant at a high level. According to our estimation, prices adjustments tend to be smaller in percentages with higher prices. This finding would support the suggestion that there are some fixed components in menu costs. Then, however, the frequency of price adjustment should vary positively with the level of prices. This, however, could not be found in our data. Attractive prices tend to increase the size of prices changes, which is consistent with the finding that attractive prices tend to reduce the frequency of price adjustments. The share of modern outlets seems to affect neither the size nor the frequency of prices adjustments. Regulation increases the size of price changes (as it reduces the frequency of price adjustments). The prevalence of sales and promotions are not related to the size of price changes, which is also a sensible outcome.

**Table 12: Exploring the differences in the size of price changes across products**

<b>Full sample</b>		Endogenous variable		
Exogenous variables	Incidence of price adjustments	Incidence of price increases	Incidence of price decreases	
Constant	6.01 (1.71) ***	5.08 (1.49) ***	8.81 (1.76) ***	
Inflation rate		-8.65 (4.60) *	-12.36 (4.50) ***	
Inflation variability		1.07 (0.09) ***	0.93 (0.09) ***	
Price level (*100)	-0.26 (0.07) ***	-0.27 (0.10) **	-0.22 (0.15)	
Threshold prices	0.07 (0.04) *	0.07 (0.03) **	0.06 (0.03) *	
Convenient prices	0.05 (0.03) *	0.07 (0.02) ***	0.05 (0.03) *	
Modern outlets	2.53 (2.58)	-0.11 (1.71)	-0.36 (1.68)	
Regulated	-1.76 (1.93)	1.13 (1.18)	-2.43 (1.20) *	
Promotions	-0.84 (2.66)	1.74 (2.18)	-1.09 (2.68)	
Sales	1.71 (9.99)	-6.67 (9.10)	-3.10 (10.77)	
Adj. R-squared	0.04	0.74	0.67	
Number of observations	52	52	52	
<b>Core sample</b>		Endogenous variable		
Exogenous variables	Incidence of price adjustments	Incidence of price increases	Incidence of price decreases	
Constant	3.46 (0.91) ***	2.32 (1.09) **	6.93 (1.91) ***	
Inflation rate		0.96 (3.84)	0.76 (4.43)	
Inflation variability		2.11 (1.95)	-1.99 (2.76)	
Price level (*100)	-0.21 (0.05) ***	-0.18 (0.05) ***	-0.17 (0.08) **	
Threshold prices	0.07 (0.03) ***	0.07 (0.03) **	0.06 (0.04) *	
Convenient prices	0.09 (0.02) ***	0.08 (0.02) ***	0.06 (0.03) **	
Modern outlets	2.16 (1.73)	2.21 (1.66)	0.81 (2.31)	
Regulated	1.17 (0.59) *	2.02 (0.73) ***	-3.29 (1.21) **	
Promotions	-1.04 (1.87)	0.14 (1.65)	-1.91 (2.27)	
Sales	10.05 (10.05)	5.36 (8.70)	13.78 (11.04)	
Adj. R-squared	0.52	0.54	0.32	
Number of observations	42	42	42	

Sources: German Federal Statistical Office and authors' calculations.

Notes: Ordinary least squares. White heteroscedasticity-consistent standard errors in parenthesis. \*\*\* significant 1% level, \*\* significant 5% level, \* significant 10% level. Quality-adjusted price sample. Inflation rate (inflation variability): mean (standard deviation) of monthly matched-models product-specific inflation rates. Price level: average of monthly price levels. Threshold (even) prices: mean of monthly incidence of threshold (even) prices. Modern outlets: share of modern outlets. Regulated: dummy = 1 if price is regulated.

The results for the “structural” factors are not changed qualitatively if the level and the variability of inflation are included in the list of regressor. For the full sample, the mean rate of inflation seems to reduce the size of price changes, whereas inflation variability has the opposite effect. This estimate is, however, strongly influenced by a small number of outliers, namely fuels, heating oil and lettuce. In the core sample, neither the mean rate of inflation nor inflation variability makes a statistically significant contribution to explaining the differences in the average size of price changes across products.

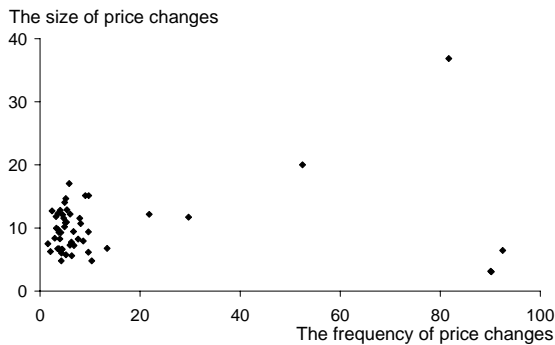
In the next stage, the product-specific inflation rates are replaced by estimated changes in marginal costs ...

### **3.2.3 Connecting the incidence and the size of price changes**

Given the conflicting evidence on the factors influencing the frequency and the size of price adjustments, a direct look on the relationship between the “extensive” and the “intensive” margin of the inflation process seems to be promising. Following Baudry *et al* (2004) and Jonker *et al* (2004), we compute the correlation between the frequency and the size of price changes. Without a strongly diverging behaviour of marginal costs, we would expect to find a strictly negative relationship between the size and the frequency of price changes. However, we find no significant correlation at all (Figure 11 and 12). For the full sample, the correlation is weak and but positive (+0.2). Taking unprocessed food out, for which frequent and sizeable price changes are common, results – as with the Dutch data – in a somewhat stronger, this time negative correlation (-0.4). For the core sample also excluding energy, however, we find that the correlation is once again much weaker and positive (0.24). Baudry *et al* (2004) also report weak correlations only.

The missing correlation across products is probably due to product-specific factors. For homogenous products, Powers/Powers (2001) find a close correlation between the size and the frequency of price across outlets ...

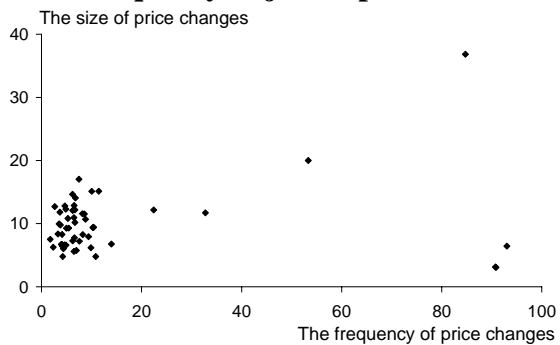
**Figure 9: The correlation between the size and the frequency of price changes: matched models**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period February 1998 to January 2004. Average size of price increases and decreases as percentages (computed from first differences in logs). Matched models only.

**Figure 10: The correlation between the size and the frequency of price changes: quality-adjusted prices**



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period February 1998 to January 2004. Average size of price increases and decreases as percentages (computed from first differences in logs). Quality-adjusted prices.

### 3.3 Variation over time

#### 3.3.1 The frequency of price changes

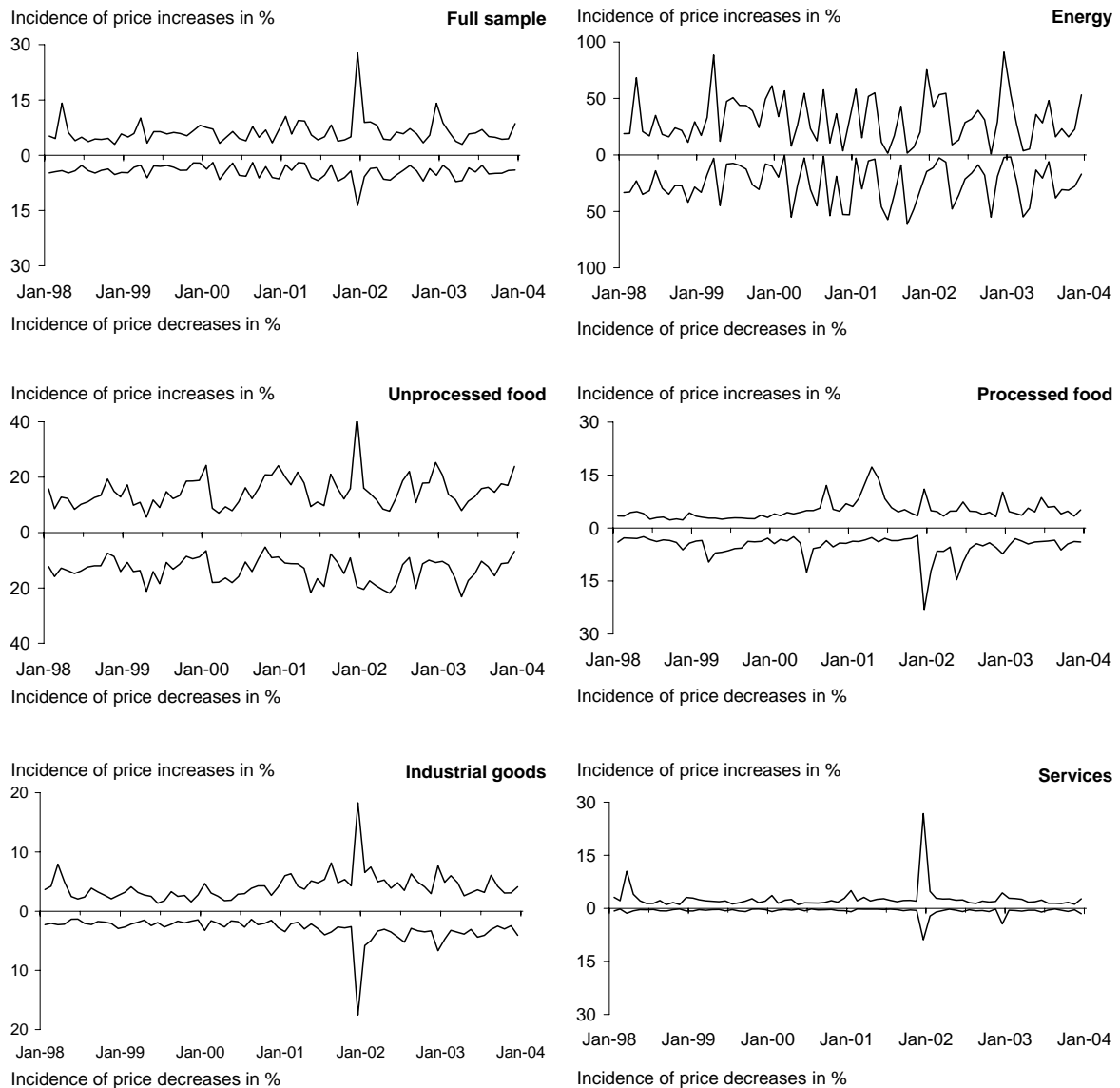
##### 3.3.1.1 A visual inspection

After exploring the cross-sectional differences in the frequency and the size of price adjustments, we turn now to the temporal dimension. A preliminary visual inspection of the time series of quality-adjusted price increases and decreases (Figure 11) suggests a certain degree of simultaneity of price increases and price decreases.<sup>29</sup> On the other hand, price increases and price reductions seem to be to some extent negatively correlated, with the exception of January 2002. And finally, apart from some albeit noticeable peaks, there seems to be a rather steady level of price changing activity.

At the aggregate level, we do not find a single period with either zero price increases or zero price decreases. The lowest incidence of price decreases was observed in September 2000, but even then still 1.9% of the prices were adjusted downwards. Even at the level of the main components, which are more homogeneous than the full sample, there is not a single period with zero price decreases (or increases). It is only at

<sup>29</sup> As there are no visually noticeable differences between the time series of the incidence of price adjustments for the matched-models and the quality-adjusted sample, we present only the latter.

**Figure 11: The varying incidence of price adjustments**



Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, quality-adjusted prices, monthly incidence of price changes (percentage), four-digit weights rescaled to the original main-components weights.

The level of the 52 products that we find months without any price adjustments, with episodes devoid of price reductions being more numerous than periods without price increases. Frequent periods without price decreases occur mostly among products with a low intensity of price adjustments in general as many services and some industrial products.

The simultaneity of price increases and price decreases at the aggregate level can partly be explained by the heterogeneity of price developments at the product level.

**Table 13: The correlation between price increases and price reductions over time**

Main component	Including January 2002		Excluding January 2002	
	Component-specific	Average of products	Component-specific	Average of products
Unprocessed food	-0.56	+0.13	-0.80	-0.12
Processed food	+0.12	+0.17	-0.08	+0.03
Energy	-0.86	-0.56	-0.88	-0.57
Industrial goods	+0.81	+0.55	+0.53	+0.26
Services	+0.88	+0.65	+0.46	+0.31
Overall	+0.18	+0.45	-0.50	+0.17

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, quality-adjusted prices, four-digit weights rescaled to the original main-components weights. Component-specific: correlation between weighted averages of the frequencies of price increases and decreases. Average of products: weighted average of products-specific correlations.

Even at the level of relatively homogeneous products, however, it is quite common that in periods in which the majority of outlets adjusts prices upwards (downwards), some outlets reduce (increase) prices. For example, the share of outlets cutting prices for bananas never drops below 5%. In the month with the lowest incidence of price reductions for bananas (April 2001, 5.3%), 42% of the outlets increased prices. In other periods, we find 25% of the outlets adjusting prices upwards and a 25% adjusting prices downwards. Similar phenomena can be observed for other products, especially in the food and industrial product components.

Despite the (partial) coincidence of price increases and price decreases, we find at the aggregate level a correlation of -0.5 between the frequency of price increases and decreases if January 2002 is taken out. This result is, however, mainly driven by the strong negative correlation for some unprocessed food and energy products (Table 13, Annex Table A.8). Only for seven products we find a negative correlation of -0.5 or stronger. For most of the products, the temporal correlation between price increases and price reductions is rather weak and sometimes even positive, meaning that in periods in which a relatively large number of price increases a relatively large number of price reductions also occur. The weighted average of the product-specific correlation coefficients is positive and close to zero.

The relatively steady intensity of price adjustments found for many products hints already at a low level of synchronisation across outlets. It is only in a few periods that a bunching of price changes is observed, most notably in January 2002. For a more

**Table 14: The synchronisation of price changes**

Main component	Including January 2002						Excluding January 2002					
	Component specific			Average of products			Component specific			Average of products		
	AD	IN	DE	AD	IN	DE	AD	IN	DE	AD	IN	DE
Unprocessed food	0.11	0.16	0.12	0.19	0.24	0.21	0.06	0.14	0.12	0.13	0.20	0.18
Processed food	0.15	0.13	0.15	0.20	0.20	0.19	0.12	0.13	0.11	0.17	0.19	0.15
Energy	0.21	0.45	0.39	0.41	0.68	0.55	0.20	0.44	0.39	0.41	0.68	0.54
Industrial goods	0.16	0.12	0.12	0.19	0.15	0.15	0.09	0.08	0.07	0.13	0.12	0.10
Services	0.23	0.20	0.13	0.24	0.21	0.14	0.10	0.08	0.07	0.12	0.12	0.10
Overall	0.13	0.14	0.09	0.23	0.24	0.18	0.07	0.10	0.07	0.16	0.18	0.14

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, quality-adjusted prices. Component specific: component specific synchronisation ratios (actual standard deviation of the incidence of price changes)/(standard deviation of the incidence of price changes with perfect synchronisation). Average of products: weighted average of product-specific synchronisation ratios. four-digit weights rescaled to the original main-components weights. AD: price adjustments; IN: price increases; DE: price reductions.

formal investigation of whether prices adjustments are more adequately described as staggered or synchronised, we apply the synchronisation measure proposed by Fisher/Konieczny (2000), which that relates the actual standard deviation of the frequency of price changes to a hypothetical one with 100% synchronised price adjustments.

Overall, the degree of synchronisation in price setting seems to be rather small (Table 14, Table A.8).<sup>30</sup> Price increases tend to be slightly stronger synchronised than price reductions. Among the main components, energy stands out with a synchronisation coefficient of about 0.40, whereas the estimates for the other components point towards a very low degree of synchronisation, which is further reduced if January 2002 with its outstanding behaviour of prices is excluded. Industrial goods and services, in particular, are affected by the high degree of synchronisation induced by the changeover to euro prices. At the level of individual products, the highest degree of synchronisation of price increases is observed for electricity, fuels and heating oil. There is also a relatively high degree of synchronisation for unprocessed

<sup>30</sup> Here again we have to face the problem of the appropriate sequence of aggregation and computing the indicator. In Table 14, we report averages of product-specific synchronisation measures and the synchronisation ratios for aggregated time series for the main components. The latter result in much lower estimates of synchronisation since there is not much synchronisation across products.

food and some services, even when January 2002 is taken out.<sup>31</sup> Price reductions are also relatively strongly synchronised for energy products and unprocessed food, but not for services.

There are some further episodes beneath the cash changeover in which price adjustments were synchronised to a higher degree than usual. The spike in spring 1998 is probably related to the increase in VAT, which took place at this time, the peak in April 1999 to an increase in energy taxes. The downward peaks for processed food in 1999 and 2001 were related to the struggle for market shares provoked by the market entry of Wal-Mart in 1999. The upward spikes in late 2000 and in 2001 might be related to a decision by the German competition authority to outlaw prices below costs, which effectively ended the price war, and to several livestock health crises, which pushed food prices upwards. The extraordinary increase in the incidence of price adjustment in January 2002 seems to have been neither preceded nor followed by a period with fewer price modifications.

### **3.3.1.2 Some econometric explorations**

For a preliminary analysis of the temporal variation in the frequency of price adjustments, we regress the overall incidence of price changes and, separately, the incidence of price increases and price decreases on several explanatory variables such as seasonal factors and dummies for special events. At a later stage, we will also consider indicators for the development of marginal costs.

The econometric set-up for the first stage of our exploration has some similarities with that in Àlvarez/Hernando (2004), who, however, also include the rate of inflation as measured by the year-on-year changes in the corresponding price index. The list of explanatory variables encompasses a trend variable, dummies for increases in VAT (in April 1998; food was excluded but not alcoholic beverages) and in energy taxes (in

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<sup>31</sup> Loy/Weiss (2003) also report a relatively high degree of synchronisation for unprocessed food in Germany. They analyse weekly price data provided by the ZMP for 10 fresh food products in 108 grocery stores – which belong to 6 different retail chains – using a fixed-effects probit approach. Loy/Weiss find strong evidence for synchronisation within retail chains, weaker evidence for synchronisation across retail chains and relatively strong evidence of synchronisation between products within the same store. With our data, we cannot identify specific shops across products or specific retail chains. For Italy, Veronese *et al* (2004) report a high degree of synchronisation at the local level, especially among services.



April 1999, January 2000, January 2001, January 2002, January 2003).<sup>32</sup> There are three dummy variables related to the changeover to prices denominated in euro in January 2002. The first one captures the price effects exactly in January 2002. The second one is introduced for testing whether in a period six months preceding and following the cash changeover the incidence of price adjustments was different from the remainder of the period under review. And, finally, the POSTDM dummy tests whether price adjustments in the euro period are as frequent as in the D-Mark period. Furthermore, seasonal dummies are included, which, if statistically different from zero, might either indicate time-dependent pricing strategies or seasonal variations in supply and demand.

When estimating this set-up without further modifications, we find, as Àlvarez/Hernando (2004) do, frequent serial correlation in the residuals. We try to model the serial correlation structurally by adding to the list of regressor the lagged incidence of price changes or the lagged incidence of price increases and price reductions, respectively. These terms are supposed to capture lagged adjustment and bouncing of prices.<sup>33</sup> We then proceed from very general to component-specific specifications by successively dropping variables statistically insignificant at the 5% level. Thus, we end up with relatively parsimonious specifications, which seems to be appropriate given the relatively small number of observations.

As the results for the matched-models sample are close to those for quality-adjusted prices, we report only the latter. For the full sample, we find that VAT and energy tax increases have a relatively strong contemporaneous effect on the frequency of price adjustments (Table 18). The changeover to the euro led to a significant increase in price changes in January 2002. As Baudry *et al* (2004) and Jonker *et al* (2004), we find that the period 6 months before and after the changeover was characterised by an above-average intensity of price adjustments, a finding that seems to be at variance with pure menu-costs explanations of the bunching of price changes in January 2002.<sup>34</sup> There is a small positive trend in the frequency of price adjustments, and in January and in April prices are changed more often than in the other months of the year. Most

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<sup>32</sup> For a similar exercise, see also Veronese *et al* (2004).

<sup>33</sup> Dias *et al* (2004c) regress the seasonally adjusted time series of the frequency of price adjustments on a time trend and an AR(1) term.

<sup>34</sup> For an application of the menu cost model to the changeover, see Hobijn *et al* (2004).

**Table 15: Factors affecting the frequency of price changes**

	CPI			UN			EN		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
Trend	+			+	+		+		
VAT	+	+					+	+	
ET	+	+	-	na	na	na	+	+	-
EURO1	+	+	+	+	+	+	na	na	Na
EURO12	+		+		-	+			
POSTDM						+	+		
AD(-1)	+	na	na	+	na	na	+	na	na
IN(-1)	na	+		na			na		
DE(-1)	na			na			na		
SEASON	Jan April	Feb		Jan Feb May	March April May June July Aug Oct	March April May June July	Jan April		

	PRO			IND			SER		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
Trend				+	+				
VAT		+	-	+	+	+	+	+	+
EURO1	+	+	+	+	+	+	+	+	+
EURO12				+	+	+			
POSTDM						+			
AD(-1)	+	na	na		na	na	+	na	Na
IN(-1)	na	+		na	+		na	+	+
DE(-1)	na		+	na	+		na		
SEASON				Feb March Sept	Feb March Sept	Feb Aug	Jan Feb April	Jan Feb March April May Nov	May June

Sources: German Federal Statistical Office and authors' calculations.

Notes: CPI: Full Sample. Quality-adjusted prices. UN: Unprocessed food. EN: Energy. AD: Incidence of price adjustments. IN: Incidence of price increases. DE: Incidence of price decreases. VAT=1 in April 98. ET=1 in April 1999, Jan 00, Jan 01, Jan 02, Jan 03. EURO1=1 in January 2002. EURO12=1 in July 2000 to June 2001. POSTDM=1 in January 2002 to January 2004. +: positive influence significant at 5% level. -: negative influence significant at 5% level.

interestingly, we find – as the Dias *et al* (2004c) do – some persistence in price adjustments at the aggregate level. The coefficient of the lagged frequency of price adjustments is highly significant, but small (0.18). Turning again to Figure 11, we can indeed see that periods with an increase in the incidence of price adjustments are followed by a relatively large number of price adjustments in the next period.

The results for the main components are rather diverse, especially with respect to the seasonal dummies, thus reflecting the peculiarities of the product assembled in these components. There are, however, some important similarities across sectors. Firstly, the euro effect is highly significant in all components. In January 2002, there were substantially more price increases and price reductions than in any comparable period.<sup>35</sup> As the POSTDM variable turned out to be statistically significant only in a few specifications, there is no evidence that introduction of the euro contributed to nominal rigidities in Germany. Secondly, VAT contributed to the frequency of price increases in all components with the exception of unprocessed food, for which VAT was not changed. For some components, the change in the VAT increases slightly the incidence of price reductions, thus inducing a bunching of prices adjustments similar to the euro changeover period, but much less intensively. It is only in the processed food segment that we observe fewer price reductions. The increases in energy taxes raise the number of upward price changes and reduce the number of downward changes. Thirdly, in all components – with the exception of industrial goods – the coefficient of the lagged incidence of price adjustments is statistically significant above zero, hinting at some lagged adjustment or bouncing of prices. In the three core segments, we find that the lagged responses seem to occur mostly with price increases; it is only for processed food that we find also some “persistence” in the incidence of price decreases. In the industrial goods segment the frequency of price increases is also positively related to the frequency of price decreases in the previous period, which suggest some short-term bouncing of prices. In services, the incidence of price reductions is positively related to the incidence of price increases in the previous period, which might also indicate some price bouncing.

At the level of products ...

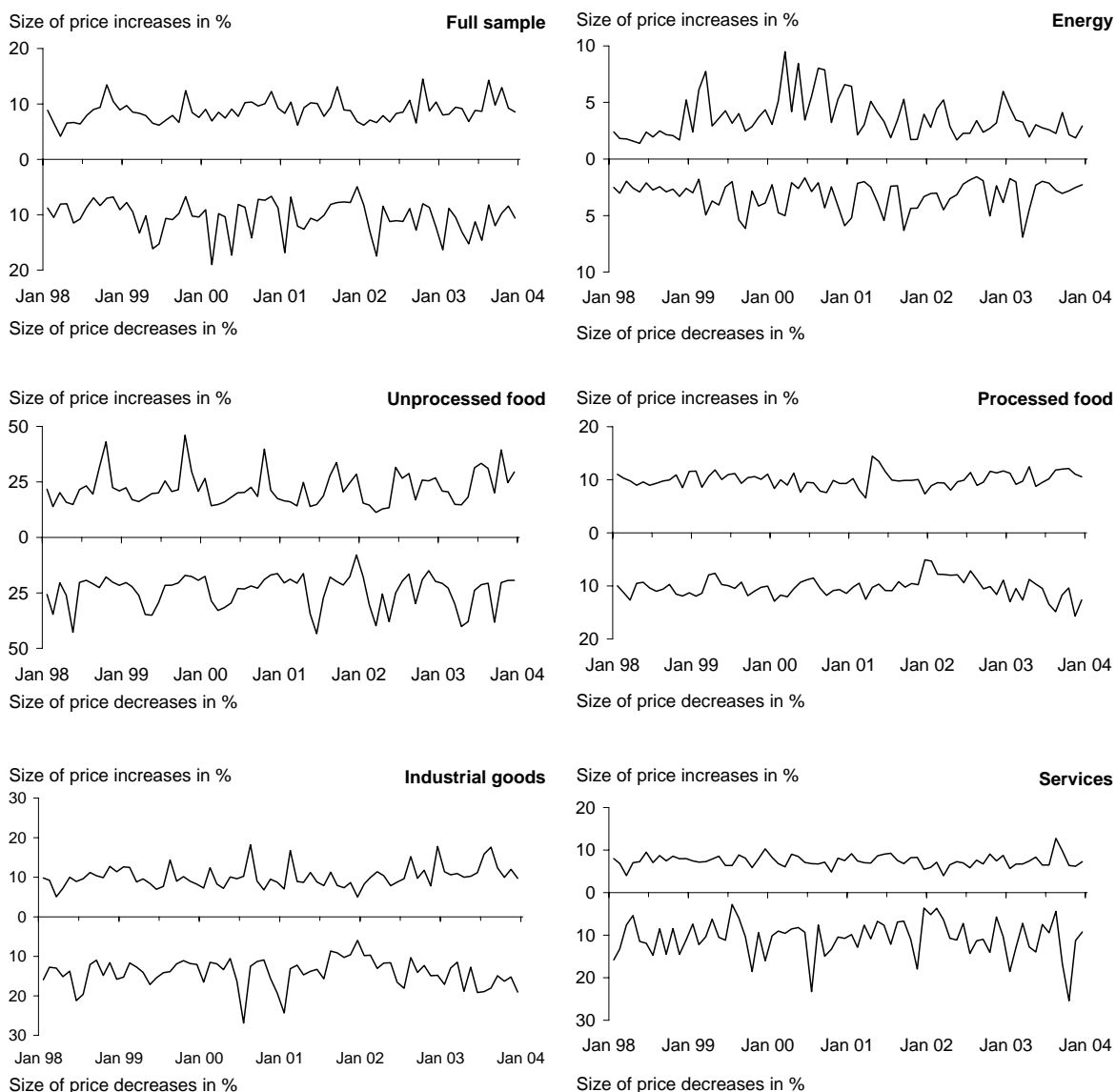
### **3.3.2 The size of price changes**

At the aggregate level, there is substantial variation in the size of price changes over time (Figure 12). This variation can be partly explained by the aggregation procedure, which weights the product-specific size of price adjustments with the

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<sup>35</sup> The euro effect cannot be identified separately for the energy component by this method as energy taxes were increased substantially at the beginning of 2002.

**Figure 12: The varying size of price adjustments**



Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, quality-adjusted prices, percentage change in prices computed from first difference in logs, four-digit weights rescaled with original main-components weights.

product-specific frequency of price changes, thus giving in some periods greater weight to products with above-average or below-average size of price changes. At the level of the main components, the size of price changes for processed food seems to be rather steady, as it is the case with price increases for services. For some product categories, however, we find an even more pronounced variation in the size of price adjustments than for at the aggregate level. Especially in the energy sector and the unprocessed food component is the variation in the size of price changes quite pronounced. The price adjustments for lettuce, for example, vary between 25% and 75%.

**Table 16: Factors affecting the size of price changes**

	CPI			UN			EN		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
Trend	+	+							
VAT	-	-		-	+	-			
ET				na	na	na			
EURO1	-		-		+	-			
EURO12		-			-				
POSTDM		-							
AD(-1)		na	na		na	na			
IN(-1)	na			na					
DE(-1)	na			na		+			
SEASON	June	March April May June	June	June Nov	March April May June Nov	March April June			
	PRO			IND			SER		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
Trend									
VAT	+		+	-	-		-	-	-
EURO1	-	-	-	-	-	-	-	-	-
EURO12	-		-	-		-			
POSTDM				+	+				
AD(-1)	+	na	na	+	na	na	+	na	na
IN(-1)	na			na			na		
DE(-1)	na		+	na			na		+
SEASON			May June				March April	March April	
Additional factors				AD(-2)					

Sources: German Federal Statistical Office and authors' calculations.

Notes: CPI: Full Sample, quality-adjusted prices. UN: Unprocessed food. EN: Energy. AD: Incidence of price adjustments. IN: Incidence of price increases. DE: Incidence of price decreases. VAT=1 in April 98. ET=1 in April 1999, Jan 00, Jan 01, Jan 02, Jan 03. EURO1=1 in January 2002. EURO12=1 in July 2000 to June 2001. POSTDM=1 in January 2002 to January 2004. +: positive influence significant at 5% level. -: negative influence significant at 5% level.

There is no clearly discernible pattern in the temporal variation of the size of price changes. In January 2002, the price adjustments seems to be smaller than in other periods, which might be related to rounding to convenient or psychological threshold prices in euro.<sup>36</sup> There is some evidence, however, that in many cases retail outlets and service providers stayed with unconventional euro prices instead of changing prices. At any rate, as already reported by Brambach (2002) and Deutsche Bundesbank (2002), the importance of attractive prices declined sharply with the changeover, and recovered

<sup>36</sup> For January 2002, price changes were identified at the level of euro cents.

only slowly afterwards (see Figure A.1 in the Annex). Especially prices ending on nine were less common after the changeover.

In the processed food and in the industrial goods components the size of price adjustments seems to be smaller in the months before and after the changeover. There are only some weak indications that the typical price change was larger after the changeover to euro cash than before, which would have been expected with unmodified “psychological” price setting.

As with the frequency of price changes, we regress the time series of the size of price adjustments on a trend variable, on dummies related to the cash changeover and changes in taxation, on seasonal dummies and on lagged variables. Overall, the fit of this rudimentary econometric specification turns out to be much poorer than for the frequency of price changes. Still, there are some remarkable results. Firstly, the mean size of price adjustments was below average not only in the cash changeover period, but also in April 1998 when VAT was increased. Secondly, there is only some weak evidence of an increasing size of price changes. Thirdly, as with the frequency of price adjustments, there is also some evidence of persistence in the size of price changes, which might, however be related to the aggregation procedure.

At the level of products ...

### **3.3.3 What drives inflation?**

In a recent paper Klenow/Kryvtsov (2004) try to identify the part played by the frequency of price adjustments (the “extensive” margin) and the size of price adjustments (the “intensive” margin) in inflation by decomposing the variance of the monthly rate of price change. They find that the “extensive” margin explains almost nothing about the short-term variability in inflation. The “intensive” margin, calculated as the weighted average of price increases and price reductions, accounts for most of the variance in inflation. We can replicate this result for our sample. Taking quality-adjusted prices and including sales and promotions, the “intensive” margin as defined by Klenow/Kryvtsov (2004) explains nearly 85% of the short-term variation in inflation.

It is, however, not so much the variation in the absolute size of price changes but the variation in the composition of price changes that drives this result. The mean

absolute value of the size of price changes is only weakly and negatively correlated with inflation (-0.21), whereas the excess of price increases over price reductions is strongly positively correlated with the rate of inflation. [...]

### **3.3.4 The changing distribution of prices**

If price adjustments are not fully synchronised, they change the shape of the distribution of prices. Among the products in our sample, there are pronounced differences in the shape of price distributions. For relatively homogenous products, we find distributions with few but very prominent peaks. The price distribution of heterogeneous products typically is much flatter...





## 4 Determinants of the length of price spells

### 4.1 Censoring, weighting, and some descriptive statistics

The frequency approach does not make full use of the panel structure of the individual price data. Looking at the individual price spells allows us to analyse the heterogeneity of the price durations within products and the dependence of price adjustments on the duration of prices. Furthermore, the question of whether state- or time-dependent pricing prevails at the outlet level can be addressed more thoroughly.

Before proceeding to a deeper analysis of the determinants of price durations, we start with some summary statistics. Our matched-models sample consists of 265,285 price spells, of which 209,277 are uncensored (price spells starting with a change in price and ending with a change in price not related to a replacement of items or outlets). 56,008 price spells are censored. In the following analysis, we distinguish two main forms of censoring.<sup>37</sup>

Firstly, all the 18,938 price spells beginning in January 1998, the first month of our sample, are strictly left-censored, as we do not know whether the price spell actually started at this point in time. Furthermore, all 18,938 price spells ending in January 2004, the last month of our sample, are strictly right-censored, as we do not know whether the price spell actually ended in this month. We observe in our sample 1,010 strictly double-censored price spells lasting from January 1998 to January 2004.<sup>38</sup> These spells refer mostly to housing rents (Annex Table A.9), but some are also found among other services and industrial goods. This leaves us with 17,928 purely strictly left-censored and with the same number of purely strictly right-censored spells.

Secondly, price spells may start or/and may end with an item (or outlet) replacement. We observe 19,142 of such spells in our sample. The reason for item replacements in the CPI sample can stem either from a deliberate choice of the pricing agent of the statistical agency, or a deliberate decision of the store manager, or a mixture of both. For example, a pricing agent may come to the conclusion that an item previously priced for the CPI is no longer representative and exchange it for another

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<sup>37</sup> On this subject, see also Aucremanne/Dhyne (2004) and Baudry (2004) *et al.*

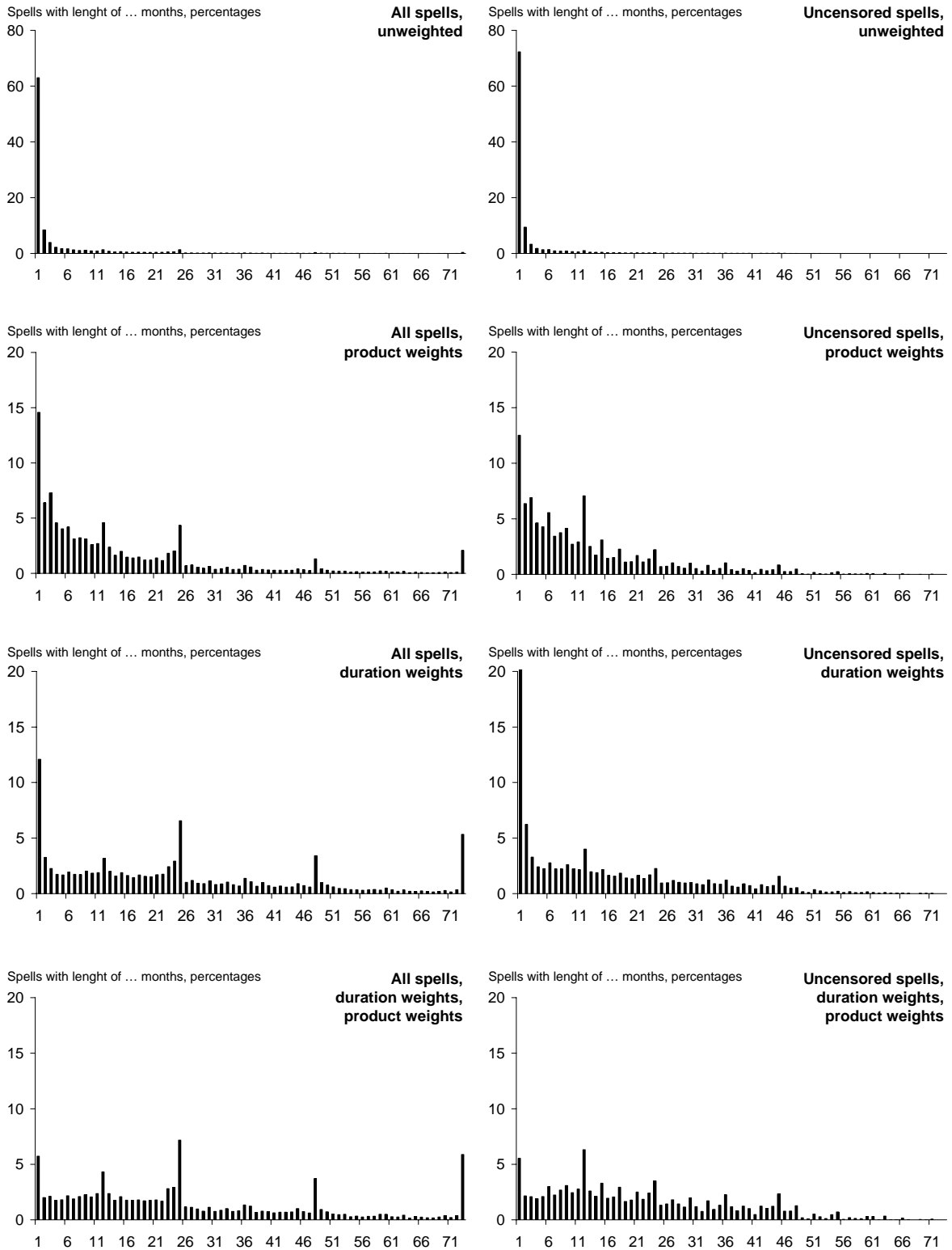
<sup>38</sup> Veronese *et al* (2004) also find extremely long price durations.

product. Then the actual price spell of the old item does not end in the month of the replacement, and the actual price spell of the new item does not start in this period. If a store manager decides to remove an item from the shelf and replace it with a similar but different item, the actual price spell of the old item ends, and the actual price spell of the new item starts with this period. And, finally, if a specific item was removed, and the pricing agent chooses one of the remaining close substitutes, the price spells of the old item ends in this period, but the price spell of the substitute does not start in this period (it started earlier). As the item replacements – with the exception of the purposive exchange of items in the CPI sample by the pricing agent – are closely related to the price setting process on the market (for example, the introduction of new product variants is often linked to a change in price), we term these spells weakly censored.

There are pros and cons of restricting the analysis to uncensored (or uncensored plus weakly censored) price spells. Excluding the strongly censored spells would not bias the results if the period under review were much longer than the maximal price duration. The relatively large number of strictly double-censored spells (5.3% of the price spells starting in January 1998 lasted until January 2004) indicates that we would miss a quite substantial number of long price spells by disregarding strongly censored spells, and estimates of the average length of price spells would be biased downwards. Excluding also weakly censored spells leaves us with uncensored spells only. Estimates of the average duration of prices derived from this sample will give us unbiased estimates, but only for the population of uncensored spells. If weakly censored spells typically have a different duration than uncensored spells, the estimate for the uncensored spells will not be representative of the full sample.

Further problems of the analysis of price spells relate to weighting. Firstly, the CPI item sample is unbalanced. There is not exactly one price observation per (fixed) percentage of expenditure for the CPI basket of consumption. Typically, products with volatile prices (that is short price durations), such as fuels, fruits and vegetables, are deliberately oversampled. Hence, abstaining from weighting the observations would give an undue weight to products with short price durations. In our sample, 63% of the price spells (72.3% of the uncensored price spells) last only one month (Figure 13, at

**Figure 13: Weighting the length of price spells**



Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample; January 98 to January 04; actual prices; product weights: four-digit weights rescaled with original main-components weights; duration weights: adjustment for oversampling of short spells as described in the main text.

the top). Averaging per product and weighting with the product weights reduces the share of price spells with one-period-length to 14.6% (12.5% for uncensored spells) (Figure 13, in the middle). But even this weighting procedure gives undue weight to short spells if our perspective is that of a typical period. By simply averaging the length of price spells in our sample we would not take into account the fact that short price spells are more often observed than long price spells. Instead of computing the fraction of price spells  $Q_T$  lasting  $T$  periods by dividing the number of price spells of length  $T$   $n_T$  by the total number of price spells

$$Q_T = \frac{n_T}{\sum_T n_T}$$

we modify the formula to

$$Q_T^* = \frac{n_T T}{\sum_T n_T T}$$

which adjusts for the excessive weights given to short spells. The corresponding formula for the average duration of price spells is given by

$$\bar{T} = \frac{n_T T^2}{\sum_T n_T T}.$$

This weighting scheme originally was proposed by Baharad/Eden (2004) and results for time-invariant product- and outlet-specific price durations in the same estimate of the average price duration as averaging the product- and outlet-specific mean price durations as it is done by Baudry *et al* (2004) and Álvarez/Hernando (2004).<sup>39</sup>

After the this adjustment the fraction of price spells with a length of one month is reduced to 12.1% (23.8% for uncensored sample) (Figure 13, in the middle). Combining both weighting schemes results in a share of one-month-spells of just 5.7% (5.5% for uncensored spells) (Figure 13, at the bottom).

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<sup>39</sup> For a discussion of various methods of averaging durations, see also *Veronese et al* (2004).

**Table 17: The average length of price spells**

Across products	Unweighted	Weighted	Unweighted	Weighted
Across durations	Unweighted	Unweighted	Weighted	Weighted
Unprocessed food	2.2 (1.9)	6.4 (5.3)	10.0 (6.2)	14.8 (11.4)
Processed food	9.1 (7.4)	9.3 (7.4)	22.0 (16.7)	20.6 (15.8)
Energy	1.3 (1.3)	3.8 (4.5)	2.6 (2.7)	5.3 (6.0)
Industrial goods	11.0 (10.6)	10.8 (11.0)	24.0 (20.8)	23.3 (20.7)
Services	20.0 (16.4)	21.0 (16.7)	34.7 (26.1)	34.2 (26.1)
Overall	5.2 (3.0)	14.9 (12.7)	24.7 (14.8)	26.5 (21.2)

Sources: German Federal Statistical Office and authors' calculations.

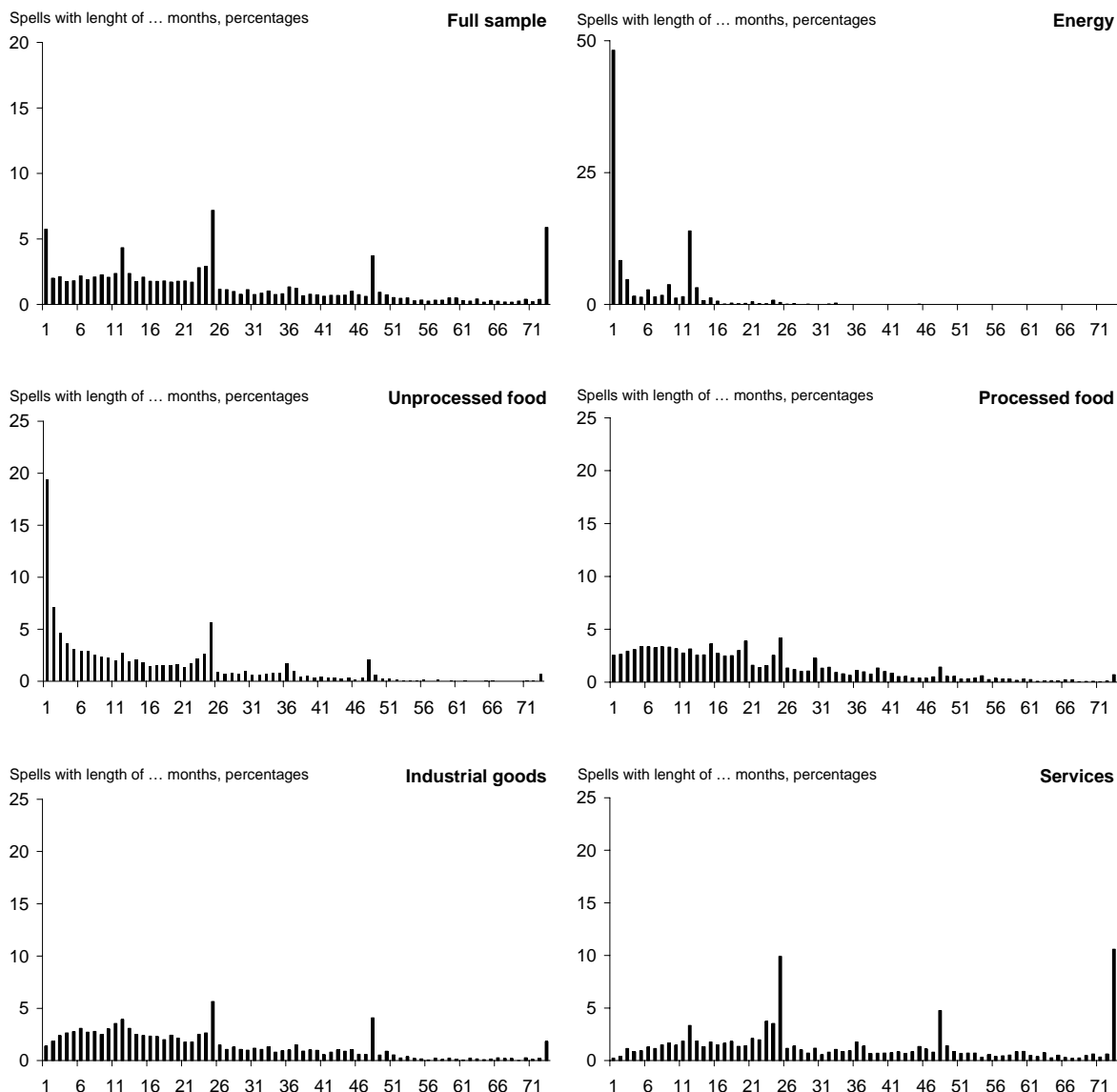
Notes: National sample, January 1998 to January 2004, mean duration in prices, actual prices, all price spells, uncensored price spells in brackets, product weights: four-digit weights rescaled with original main-components weights; duration weights.

Correspondingly, the estimates of the average duration of prices vary with the weighting system chosen for aggregation. Unweighted, the average length of price spells is just 5.2 months. Applying product weights gives an estimate of 14.9 months. Adjusting for the overrepresentation of short spells increases the estimate to 24.7 months. Combining both weighting schemes results in our preferred measure of 26.5 months. Disregarding all censored spells tends to give smaller estimates of the average duration of prices. Double weighted, uncensored price spells last on average 21.2 months (Table 17). The estimates are broadly in line with the implied durations inferred from the mean incidence of price changes if these were computed as the average of the implied product-specific durations (see Table 7, page 21).

As there is a substantial share of spells, which is strictly double-censored, these estimates may still underestimate the true average duration of prices. Most importantly, 8.6% of the rents in the private sector of the German housing market, which has a substantial weight in the CPI, were never modified in the six-year period under review. Also, for some services and some industrial goods we find only one price spell for the full period. On the other hand, as we cannot observe changes in prices within a month, the estimates of average durations might be biased upwards for products with volatile prices.

Looking at the distributions of price spells in more detail, we see that the patterns of durations are broadly similar for the full set of observations and for the uncensored

**Figure 14: The distribution of price spells – all observations**

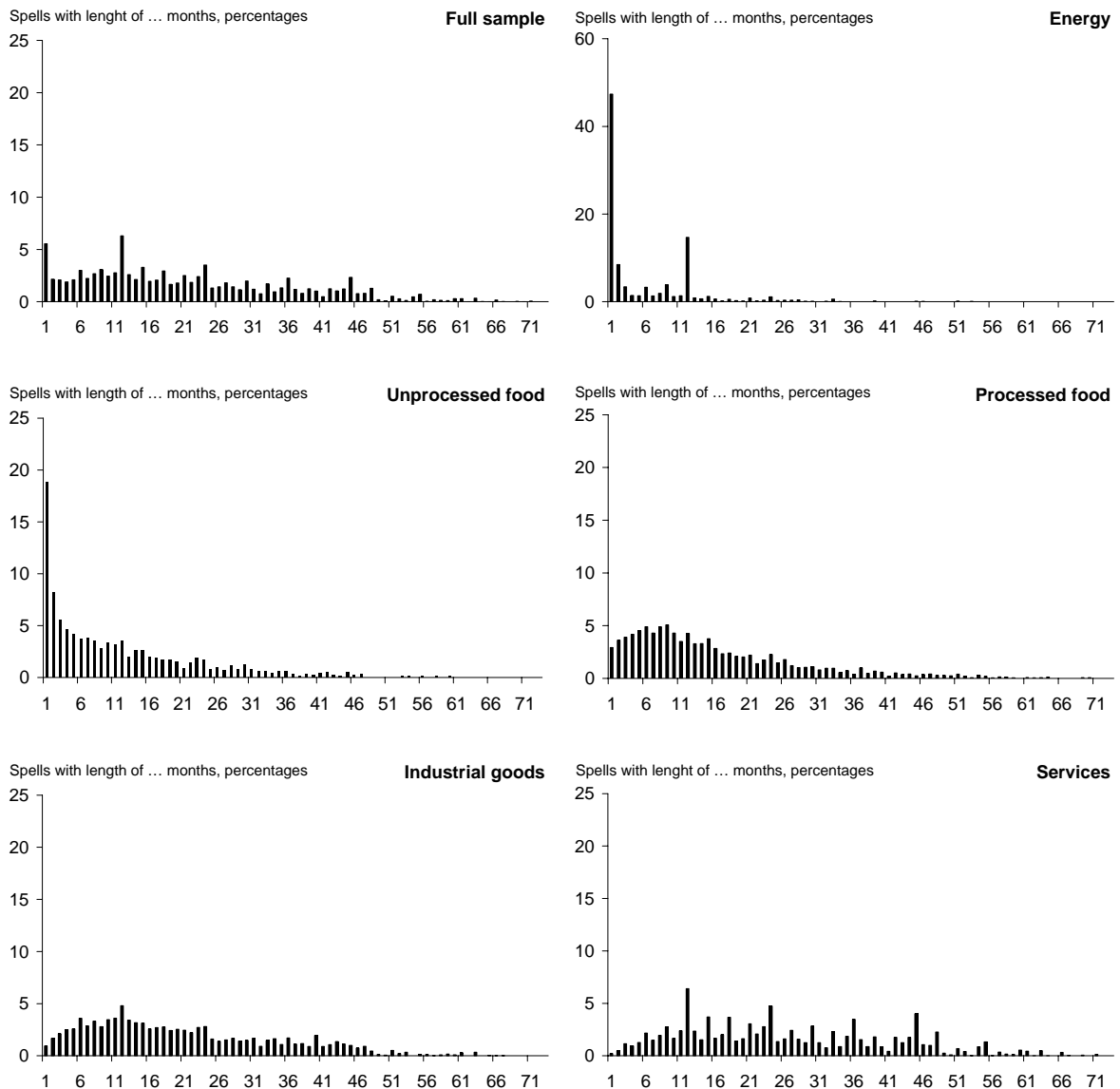


Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample; January 98 to January 04; actual prices; product weights: four-digit weights rescaled with original main-components weights; duration weights: adjustment for oversampling of short spells as described in the main text.

spells (see Figure 14 for the full set of price spells and Figure 15 for the censored price spells). There are only two major differences. Firstly, there is a spike at 25 months in the full sample, which is not apparent in the uncensored sample. This peak is related to the redesign of the product and outlet sample, which resulted in numerous purposive product replacements and which became effective in February 2000, that is 25 months

**Figure 15: The distribution of price spells – actual prices, uncensored spells**



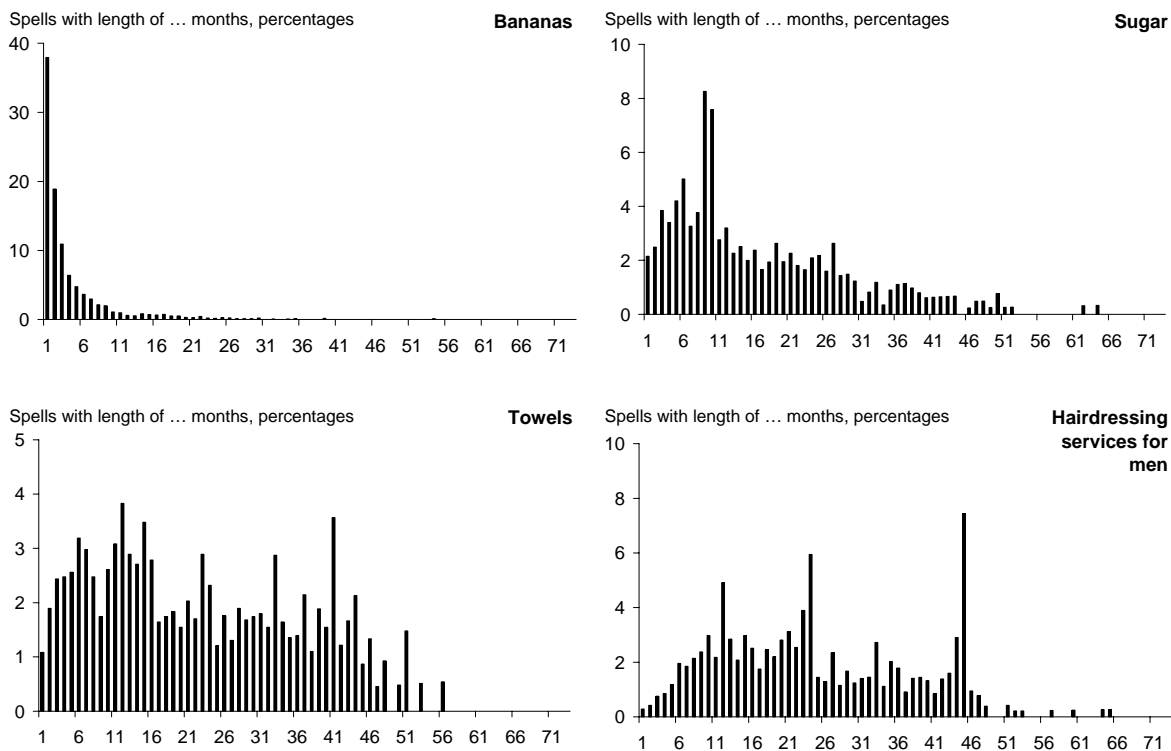
Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample; January 98 to January 04; actual prices; product weights: four-digit weights rescaled with original main-components weights; duration weights: adjustment for oversampling of short spells as described in the main text.

after the start of our sample. The second difference is the peak at 73 months, which stems from double-censored spells.

Overall, pricing patterns seem to be highly diverse. We find a substantial share of short price spells, but also many price durations between 12 and 48 months. Even price durations of more than 48 months are not uncommon. For both the full and the

**Figure 16: The distribution of price spells for some selected goods and services**



Sources: German Federal Statistical Office and authors' calculations.

Notes: January 98 to January 04; actual prices; adjusted for oversampling of short spells as described in the main text.

uncensored sample, we find peaks at 1, 12, 24 and 36 months. The peak at 1 month stems predominately from unprocessed food and energy. Peaks at 12 months are relatively pronounced for energy – this is the effect of electricity and gas prices –, industrial goods and services. For food, the 12-month peak is hardly discernible. It is only for services that peaks at 24 and 36 months are clearly identifiable by visual inspection.<sup>40</sup> The distribution of price spells for unprocessed food is extremely skewed with a concentration on short durations. The distribution for unprocessed food is much flatter, with durations between one to 16 months being of broadly similar importance. The distribution for industrial goods is even flatter than that for processed food; its main mass lying between four and 24 months. As with the distribution for processed food, however, it stretches out well behind the duration of 50 months. The distribution of the services price spells is characterised by the already-mentioned spikes at multiples of three and 12 months, its main mass lying between six and 48 months, and afterwards it

<sup>40</sup> The spikes at multiples of three months in the services component stem from housing rents, which are recorded only quarterly.



flattens out. There is, most interestingly, an additional peak at 45 months. Why, we may ask, at 45 months, and not at 48? In April 1998, an increase in VAT became effective. 45 months later the changeover to the euro cash took place. This peak stems from services providers adjusting the price with the increase in VAT, and then, nearly four years later, with the changeover to the euro, which explains some of the bunching of price changes in January 2002.

With quality-adjusted prices ...

#### **4.2 Disentangling the heterogeneity in price durations**

The differences in the duration of prices within narrow product categories are probably partly related to differences in the behaviour of outlets and services providers. Herrmann/Möser (2002) report that the mean duration of coffee prices in Germany varied in the period 1996 to 1999 strongly between retail chains, with prices lasting on average less than 3 weeks for the most flexible retail chain and 18 weeks for the most rigid one. Also Powers/Powers (2001) find substantial heterogeneity in price durations for homogenous products across outlets. But there may also be a time-varying component ...



## 5 Discussion of the results

As this is still work in progress, at this stage some tentative conclusions only.

- The present weighting scheme results in a close approximation of the German CPI. Cutting the relative importance of housing by half – this would mean taking imputed rent for owner-occupied housing out – would give a better approximation of the national HICP.
- Our results indicate that measures of price changing activity are quite sensitive to the price concept and to the weights chosen for aggregation. Any cross-country differences therefore have to be interpreted with proper caution if the measurement procedures were not fully harmonised. As the choice of the price concept and the weights is often dictated by data availability, there are limits for the harmonisation of the measurement approaches and, hence, for the comparability across countries.
- As in other countries, we find infrequent but rather sizeable price adjustments. Including housing and slowly adjusting energy components as gas and electricity, prices last on average about two years, but change by 10%. Excluding housing rents, gas, and electricity price reduces the average length of price spells to 15 to 20 months. This figure is close to the estimates for other euro area countries.
- There is no unambiguous relation between the (product-specific) rate of inflation and the overall frequency of price adjustments across products. The frequency of price adjustments is, however, closely related to the product-specific volatility of inflation. Moreover, the rate of inflation is related positively to the incidence of price increases and negatively to the incidence of price reductions.
- Psychological threshold prices, convenient prices and regulation seem to reduce flexibility in price setting (but see further below). Sales and promotions seem to add significantly to the prevalence of price changes.
- The simultaneity of price increases and price reductions across items even for narrowly defined products, which probably is related partly to short-run bouncing of prices, also indicates that the motives behind price setting are much more complex than

acknowledged in macro models. Golosov/Lucas (2003): “Observations on aggregates must be interpreted as averages over a more complex microeconomic reality.”

- From a macro perspective, there is a substantial amount of noise in price setting. It is difficult to infer from CPI micro data alone how often prices are fundamentally reviewed with respect to macro variables – in contrast to price changes related to the product life cycle and marketing strategies (on intertemporal price setting theory for differentiated products see, for example, Lazear, 1986) and to product- and outlet-specific changes in demand and supply, summarised by Golosov/Lucas (2003) under the heading “idiosyncratic shocks”. As the latter point out, idiosyncratic adjustments may, however, be coupled with more fundamental revisions of prices
- The pronounced heterogeneity across products can also be interpreted as an indication of complex motives behind price setting.
- The outstanding rigidity of housing rents, which is also observed in US data (Genesove, 2003), is probably related to the peculiarities of long-term contracting, asymmetric information and transaction costs resulting in tenancy discounts and regulation (on the German rental market and for empirical evidence on the importance of tenancy discounts, see Hoffmann/Kurz, 2002).
- The changeover to euro cash does not seem to have resulted in additional nominal rigidities in Germany. The reduction of the number of distinct pricing points approximately by half (the conversion rate was 1.95583 D-Mark per euro) resulted in a declining importance of attractive prices. Hence, attractive prices *per se* do not seem to bring about price rigidity.
- We find evidence in favour of both time-dependent and state-dependent elements in price setting in Germany.
- The peaks in the distributions of price durations at 12 and 24 months, the low level of synchronisation of price changes and the seasonality in pricing (which is, however, not very pronounced and might also be related to seasonality in marginal costs or in demand) hint at time-dependent elements.
- The bunching of price changes, which often can be related to marginal cost shocks or to special events as VAT changes or the cash changeover, suggest state-

dependent behaviour. As Dias *et al* (2004c) point out, also the trend and the autocorrelation in the time series of the frequency of price adjustments can be interpreted as indicating time-dependent price setting practices.

- There is no persistence in price developments at the item level. Pricing typically is discontinuous (with the exception of the short-term bouncing of price related to promotions). There is, however, some evidence of persistence of price changing activities at the product level. Probably some outlets behave as price leaders and some as price followers.



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## **Annex**

**Table A.1: Descriptions of products in the common and in the national sample**

Common sample	Matched product	COICOP	
Steak	Rinderlende (1 kg)	Fillet of beef; 1kg	0112130100
1 fresh fish	Seefisch, Kabeljau (Dorsch) im Anschnitt (kein Filet), frisch (1 kg)	Saltwater fish, cod, slice (no fillet), fresh; 1kg	0113111100
Lettuce	Kopfsalat (1 kg)	Lettuce; 1kg	0117110100
Banana	Bananen (1 kg)	Banana; 1kg	0116200100
Frozen spinach	Rahmspinat, in Packungen zu etwa 450 g (Tiefkühlkost) (450 g)	Spinach, frozen, in packages of approx. 450g; 450g	0117610100
Milk	H-Milch, in standfesten Packungen, 3,5% Fettgehalt (1 Liter)	UHT milk, in stable packages, 3.5% fat content; 1 litre	0114150100
Sugar	Zucker, fein (EG-Kategorie i), in Packungen zu 1 kg (1 Kg)	Sugar, fine (EU category i), in 1kg packages; 1kg	0118110100
Mineral water	Mineralwasser, 1 Kasten mit 12 X 0,7 l Flaschen (ohne Pfand) (1 Kasten)	Mineral water, 1 crate containing 12 x 0.7l bottles (excluding deposit); 1 crate	0122100100
Coffee	Bohnenkaffee, gemahlen, in Packungen zu 500 g, mittlere Qualität (500 G)	Coffee, ground, in 500g packages, medium quality; 500g	0121111100
Whisky	Scotch Whisky, in 0,7 l Flaschen, gute Importware (0,7 Liter)	Scotch whisky, in 0.7l bottles; imported product of good quality; 0.7l	0211090100
Beer in a shop	Flaschenbier, gängige Sorte, 11-14% Stammwürzegehalt, in 0,33 oder 0,5 Liter Flaschen (ohne Flaschenpfand) (0,5 Liter)	Bottled beer, popular brand, 11-14% original gravity (OG), in 0.33l or 0.5l bottles (excluding deposit); 0.5l	0213010100
Fuel type 1	Normalbenzin, bleifrei, Markenware, Selbstbedienung (10 Liter)	Regular fuel, unleaded, branded, self-service; 10l	0722011100
Fuel type 2	Superbenzin, bleifrei, Markenware, Selbstbedienung (10 Liter)	Premium grade fuel, unleaded, branded, self service; 10l	0722013100
Gasoline (heating)	Extra leichtes Heizöl, bei Abnahme von 3000 l (Tankware) (1hl)	Fuel oil, extra-light, purchase of 3000l, by tank	0453010100
	Gas, mit Grund- (Verrechnungs-) und Arbeitspreis, für eine Wohnung mit Küche, günstiger Tarif, bei einer Abnahmemenge von 1600 kWh (monatlich)	Gas, for a dwelling with kitchen, favourable tariff, consumption of 1600 kWh; monthly	0452130200
	Elektrischer Strom, Haushaltsbedarf, Arbeits-, Leistungs- und Verrechnungspreis bei einem Monatsverbrauch von 325 kWh (monatlich)	Electricity, for households, transfer price with a monthly consumption of approx. 325kWh; monthly	0451015300
Shirt (men)	Herren-Oberhemd, reine Baumwolle, pflegeleicht, gute Qualität, Größe 40 (1 Stück)	Men's shirt, pure cotton, easy care, good quality, size 40; 1 piece	0312191100
Jeans	Jeanshose für Damen, Baumwolle, etwa Inchgröße 30/30 oder deutsche Größe 40 (1 Stück)	Pair of jeans for women, cotton, inch size of about 30/30 or German size 40; 1 pair	0312226100
Socks	Herren-Socken, Wolle bzw. Baumwolle mit synthetischer Faser, Gr. 43-46 (1 Paar)	Men's socks, wool or cotton with manmade fibre, size 43-46; 1 pair	0312196100
Sport shoes	Tennis-/Trainings- oder Joggingschuhe, Größe 42 (1 Paar)	Tennis-, track- or running shoes, size 42; 1 pair	0321250100
Acrylic paint	Acrylfarbe, weiß, für Innen- und Außenanstrich, in Dosen zu etwa 750 ml (1 Dose)	Acrylic paint, white, for interior and exterior use, in boxes of approx. 750ml; 1 box	0431030200
Cement	Spachtelmasse	Filler	0431070100
Toaster	Toaster für zwei Scheiben, mit Röstgradwähler und selbsttätigem Ausstoß, etwa 1000 Watt (1 Stück)	Toaster, 2-slice, with variable browning control and automatic pop-up, approx. 1000 Watt; 1 piece	0532010100
Electric bulb	Glühlampe, Matt, 60 Watt (1 Stück)	Electric bulb, opal, 60 Watt, 1 piece	0552032200
1 type of furniture	Polstergarnitur, 3-teilig, Federkern, Bezugsstoff aus synthetischer Faser (1 Stück)	Suite, three-piece, innerspring, cover material of manmade fibre; 1 piece	0511039100
Towel	Frottierhandtuch, Baumwolle, mittlere Qualität, etwa 50x100 cm (1 Stück)	Towel, cotton, average quality, approx. 50x100 cm; 1 piece	0520061100
Car tyre	Pkw-Stahlgürtelreifen, schlauchlos, 175/70 R 13 (1 Stück)	Steel-belted radial tyre for cars, tubeless, 175/70 R 13; 1 piece	0721011200
Fax machine	HiFi-Midianlage mit CD-Player, Tuner, Doppelkassetendeck, Verstärker mit etwa 2 X 100 Watt Musikleistung (1 Stück)	Midi Hi-fi component system, including CD player, tuner, double cassette recorder, amplifier with power output of 2x100 Watt	0911121100
Television set	Farbfernsehgerät, Stereo, Fernbedienung, Tischgerät, 100 Hz, Standardausführung, Videotext, etwa 70 cm (1 Stück)	Colour television set, stereo, remote control, table model, 100Hz, standard design, videotext; 1 piece	0911210100

Common sample	Matched product	COICOP
Dog food	Hundefutter, in Dosen zu etwa 400g (400g)	Dog food, can of approx. 400g; 400g 0934053100
Tennis ball	Fussball, Vollrindleder, gute Qualität, Größe 5 (1 Stück)	Football, leather, good quality, size 5; 1 piece 0932011100
Construction game (Lego)	Kunststoffbaukasten, für Kinder ab 8 Jahre (1 Packung)	Construction game, for children from 8 years on; 1 set 0931014100
Toothpaste	Zahncreme (keine medizinische) zu etwa 75ml (75ml)	Toothpaste (non-medicinal) approx. 75 ml; 75ml 1213051100
Suitcase	Koffer oder Schalenkoffer, etwa 65 cm lang (1 Stück)	Suitcase or shell suitcase, length approx. 65cm; 1 piece 1232154300
Dry cleaning	chemische Reinigung (Vollreinigung) nebst Bügeln eines Sakkos oder Blazers (1 Mal)	Dry-cleaning (full clean) with ironing of a two-piece men's suit; single 0314210100
Hourly rate of an electrician	Abschleifen und Versiegeln von Parkettfußboden (1 qm)	Sanding and sealing of parquet flooring; 1sqm 0513050100
Hourly rate of a plumber	Waschmaschinenreparatur, Auswechseln der Heizstäbe, ohne Materialkosten und ohne Wegegeld (1 Stunde)	Repair of washing machine, change of the heating coil, excluding cost of materials and travelling expenses; 1 hour 0533070100
Domestic services	Zentrale Erhebung.	Centrally recorded.
Hourly rate in a garage	Große Inspektion laut Herstellervorschrift, incl. Material (Paketpreis) bei einem Pkw mit 900 bis 2000 qcm (1 Mal)	Main service according to manufacturers' instructions, including material (package price), for a car with 900 to 2000 cm3 0723015100
Car wash	Pkw-Oberwäsche, in der Waschstrasse (1 Mal)	Car wash, machine wash; single 0723018100
Balancing of wheels	Bremsklötze vorne ersetzen, incl. Material, bei einem Pkw mit 900 bis 2000 cm3 (1 Mal)	Exchange of front brake pads, including material, for a car of 900 to 2000cm3; single 0723017200
Taxi	Taxifahrt, Entfernung 3 km, von einer Taxihaltestelle aus, mit Wartezeiten (von insgesamt 3 Minuten) (1 Fahrt)	Taxi journey, distance 3km, starting at a taxi rank, including waiting period (of overall 3 minutes); 1 journey 0732031100
Movie	Kinoeintrittskarte, Platz in der mittleren Reihe, Abendvorstellung, samstags (1 Karte)	Cinema ticket, seat in mid row, evening showing, Saturday; one ticket 0942150100
Videotape hiring	Leihgebühr eines Videofilmes für ca.1-2 Tage (1 Mal)	Videotape hiring for approx. 1-2 days; once 0942370100
Photo development	Fotoarbeiten, Entwicklung eines Kleinbildfarbfilmes, 36 Aufnahmen (1 Film)	Photo processing, development of 35mm colour film, 36 photos;1 film 0942430100
Hotel room	Übernachtung mit Frühstück in Mittelklassehotel	Overnight accommodation with breakfast in mid-range hotel 1120012200
Glass of beer in a café	Verzehr von Bier (auch alkoholfreies Bier) in Restaurants	Consumption of beer (including alcohol-free beer) in restaurants 1111056130
1 meal in a restaurant	Verzehr von Fleischgerichten in Restaurants	Consumption of meat dishes in restaurants 1111011230
Hot-dog	Verfügbar erst ab 2000.	Available from 2000 on only.
Cola based lemonade in a café	Verzehr von anderen alkoholfreien Getränken (ohne alkoholfreies Bier) in Restaurants	Consumption of non-alcoholic beverages (excluding alcohol-free beer) in restaurants 1111054130
Haircut (men)	Friseurleistungen für Herren, Haarschneiden einschl. Waschen und Föhnen (1 Mal)	Hairdressing services for men, haircut including wash and blow dry; single 1211011100
Hairdressing (ladies)	Friseurleistungen für Damen, Waschen, Föhnen, ohne Festiger und ohne Haarspray (1 Mal)	Hairdressing services for women, wash, blow dry, excluding setting lotion and hairspray; single 1211015100
	Neubauwohnungen ab dem 20.06.1948, Wohnung mit 2 und mehr Zimmern mit Küche, Bad und Sammelheizung, mehr als 70 m <sup>2</sup> Wohnfläche freifinanziert (Monatsmiete)	Privately financed apartment, 2 and more rooms, with kitchen and bathroom, central heating, more than 70m2, built after 20 June 1948; monthly rent 0411022400
	Neubauwohnungen ab dem 20.06.1948, Wohnung mit bis zu 3 Zimmern mit Küche, Bad u. Sammelheizung, bis 70 m <sup>2</sup> Wohnfläche, öffentlich gefördert (Monatsmiete)	Subsidised apartment, up to 3 rooms, with kitchen and bathroom, central heating, up to 70m2, built after 20 June 1948; monthly rent 0411022200

Sources: Dhyne *et al* (2004), German Federal Statistical Office, translated by the Deutsche Bundesbank.

**Table A.2: The variable “reason of change”**

Code	Clear text	Description
1	Price missing temporarily	
2	Price missing permanently	
A	True change in price	Change in price without change in quality.
B	Change in packaging	
C	Replacement of product	Price difference between old and new product variant mainly explained by true price difference.
D	Replacement of product	Price difference between old and new product variants explained by true price difference and by a change in quality.
E	Replacement or product	Price difference between old and new product variant mainly explained by a substantial change in quality.
F	Special case	Description of change in clear text.
G	Corrected price	
H	New reporting unit	New outlet number.
L	Replacement of reporting unit	New reporting unit without change in the outlet number.
M	Replacement of product	Old product variant vanished from the market. For durable high-quality products and clothing only.
P	Purposive product replacement	Linking prices of old and new products in overlapping periods.
S	Promotion	Code is attached to price reductions starting the promotion and price increases ending the promotion.
W	Change in range of goods	Product variant vanishes from the shelf of the sampled outlet, but is still in the product mix of a different outlet. Linking price of old and new products by taking out the price difference found in other outlets.
Y	Neither change in price nor in quality	

Sources: German Federal Statistical Office, translated by the Deutsche Bundesbank.



**Table A.4: The incidence of replacements**

Product	Item replacements	Outlet replacements	Total replacements	Replacement per month
Filet of beef	22	8	29	0.4
Cod	50	0	50	0.7
Lettuce	48	5	54	0.7
Banana	7	6	13	0.2
Spinach, frozen	140	4	143	2.0
Milk	32	4	36	0.5
Sugar	18	6	25	0.3
Mineral water	79	7	86	1.2
Coffee	26	4	30	0.4
Whisky	64	7	71	1.0
Bottled beer	40	7	47	0.7
Regular fuel	7	1	8	0.1
Premium grade fuel	7	1	8	0.1
Heating oil	24	2	25	0.3
Gas	11	0	11	0.2
Electricity	17	0	17	0.2
Shirt	169	2	171	2.4
Jeans	214	2	216	3.0
Socks	111	1	112	1.6
Sport shoes	185	1	186	2.6
Acrylic paint	64	3	67	0.9
Filler	68	3	71	1.0
Toaster	196	1	197	2.7
Electric bulb	65	3	67	0.9
Suite	194	4	198	2.8
Towel	101	1	102	1.4
Steel radial tyre	57	2	59	0.8
Hi-fi system	392	1	393	5.5
Television set	426	0	426	5.9
Dog food	59	1	59	0.8
Football	156	0	156	2.2
Construction game	193	1	194	2.7
Toothpaste	94	5	99	1.4
Suitcase	168	2	169	2.4
Dry-cleaning	14	2	16	0.2
Sanding and sealing of parquet flooring	3	1	4	0.1
Repair of washing machine	20	1	21	0.3
Car main service	39	2	41	0.6
Car wash	15	0	15	0.2
Brake service	40	2	42	0.6
Taxi journey	3	0	3	0.0
Cinema admission	8	3	11	0.2
Video hiring	18	3	21	0.3
Photo processing	28	2	30	0.4
Overnight accommodation	23	4	27	0.4
Glass of beer	32	4	37	0.5
Meat dish	49	4	52	0.7
Glass of non-alcoholic beverages	24	4	27	0.4
Hairdressing services for men	8	4	13	0.2
Hairdressing services for women	31	4	35	0.5
Rent for privately financed apartment	26	15	41	0.6
Rent for subsidised apartment	67	10	76	1.1

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004, four-digit weights rescaled with original main-components weights. Item replacements excluding comparable replacements. Figures as percentage of total observations. Effects of redesign product and outlet sample in February 2000 taken out. Some double counting of replacements as combinations of variants of item and outlet changes occur.



**Table A.5: The implied duration of prices**

Product	R1	R2	Q
Filet of beef	11.0	11.3	11.4
Cod	3.0	3.0	3.0
Lettuce	1.2	1.2	1.2
Banana	1.9	1.9	1.9
Spinach, frozen	8.3	8.7	8.8
Milk	9.8	9.8	9.8
Sugar	15.2	15.3	15.2
Mineral water	11.0	11.7	11.7
Coffee	4.5	4.5	4.5
Whisky	10.3	10.7	10.6
Bottled beer	12.0	12.2	12.1
Regular fuel	1.1	1.1	1.1
Premium grade fuel	1.1	1.1	1.1
Heating oil	1.1	1.1	1.1
Gas	7.0	7.2	7.2
Electricity	8.9	9.3	9.3
Shirt	12.3	13.4	13.4
Jeans	12.8	14.6	14.7
Socks	14.6	15.5	15.4
Sport shoes	14.0	16.2	16.2
Acrylic paint	12.9	13.2	13.2
Filler	18.9	19.6	20.1
Toaster	15.7	18.3	18.3
Electric bulb	20.2	21.3	21.3
Suite	12.7	14.6	14.4
Towel	15.3	16.2	16.2
Steel radial tyre	9.5	10.0	10.0
Hi-fi system	10.3	12.1	12.1
Television set	8.2	9.5	9.6
Dog food	14.6	14.9	15.0
Football	17.4	20.6	20.6
Construction game	12.4	14.8	15.1
Toothpaste	9.6	10.0	10.0
Suitcase	13.2	15.3	15.3
Dry-cleaning	22.4	23.7	24.1
Sanding and sealing of parquet flooring	22.0	24.2	23.7
Repair of washing machine	22.4	25.2	25.2
Car main service	14.6	15.4	15.3
Car wash	26.6	27.9	28.3
Brake service	15.0	15.8	15.9
Taxi journey	22.9	24.6	24.6
Cinema admission	25.6	26.8	26.8
Video hiring	35.3	36.2	36.8
Photo processing	26.6	27.3	27.3
Overnight accommodation	17.5	18.7	19.0
Glass of beer	23.6	24.4	24.7
Meat dish	19.7	20.8	20.5
Glass of non-alcoholic beverages	30.5	31.9	30.7
Hairdressing services for men	22.2	23.0	22.8
Hairdressing services for women	19.4	21.7	21.7
Rent for privately financed apartment	46.7	56.6	56.9
Rent for subsidised apartment	34.4	42.0	42.4

Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, February 1998 to Jan 2004. Average duration in months computed from the average incidence of price changes by using the formula  $T=1/F$ . R1: Including item replacements, actual prices. R2: Including item replacements, quality-adjusted prices. Q: Including all replacements, quality adjusted prices. Effects of redesign of sample in February 2000 taken out.

**Table A.6: The incidence of price attractive prices and of promotions and sales**

Product	Attractive prices			Promotions and sales		
	Convenient prices	Threshold prices	Total	Promotions	Sales	Total
Filet of beef	20.4	23.9	44.4	0.5	0.2	0.8
Cod	12.4	23.2	35.6	2.0	2.1	4.1
Lettuce	19.5	19.3	38.8	1.2	9.5	10.7
Banana	11.0	45.7	56.7	4.7	3.7	8.4
Spinach, frozen	12.8	23.9	36.7	0.7	0.3	1.0
Milk	19.2	53.0	72.1	0.6	0.1	0.7
Sugar	2.2	86.5	88.8	0.6	0.1	0.6
Mineral water	14.1	36.8	50.9	0.8	0.2	1.0
Coffee	9.7	48.9	58.6	2.6	0.7	3.2
Whisky	16.3	15.6	31.9	0.8	0.2	1.0
Bottled beer	37.0	23.4	60.4	0.5	0.1	0.6
Regular fuel	18.7	10.6	29.4	2.6	10.9	13.4
Premium grade fuel	19.5	10.7	30.2	2.6	10.9	13.6
Heating oil	20.2	8.2	28.3	0.8	11.0	11.8
Gas	22.2	8.5	30.7	0.0	0.0	0.0
Electricity	21.5	8.8	30.3	0.0	0.0	0.0
Shirt	14.6	68.1	82.7	0.5	0.3	0.8
Jeans	11.7	72.1	83.8	0.3	0.3	0.5
Socks	50.1	34.7	84.8	0.2	0.1	0.3
Sport shoes	18.3	68.8	87.1	0.2	0.2	0.4
Acrylic paint	17.4	16.6	34.0	0.2	0.1	0.2
Filler	18.8	33.8	52.6	0.0	0.0	0.1
Toaster	12.9	61.9	74.8	0.1	0.1	0.2
Electric bulb	50.4	31.9	82.3	0.1	0.0	0.1
Suite	19.9	37.2	57.1	0.1	0.1	0.2
Towel	24.2	62.6	86.8	0.3	0.1	0.4
Steel radial tyre	20.9	17.9	38.8	0.0	0.1	0.1
Hi-fi system	11.6	63.2	74.8	0.2	0.2	0.4
Television set	6.8	70.6	77.4	0.3	0.2	0.6
Dog food	26.3	52.2	78.5	0.6	0.0	0.7
Football	27.7	60.1	87.8	0.1	0.1	0.1
Construction game	11.5	51.3	62.8	0.1	0.2	0.3
Toothpaste	13.2	28.1	41.3	0.8	0.1	1.0
Suitcase	11.5	75.8	87.3	0.2	0.1	0.3
Dry-cleaning	37.8	18.0	55.8	0.0	0.0	0.0
Sanding and sealing of parquet flooring	24.9	14.2	39.1	0.0	0.1	0.1
Repair of washing machine	29.4	12.4	41.8	0.0	0.0	0.0
Car main service	24.5	9.7	34.2	0.0	0.0	0.0
Car wash	35.8	43.5	79.4	0.1	0.0	0.1
Brake service	19.4	10.5	29.9	0.0	0.0	0.0
Taxi journey	44.1	6.4	50.5	0.0	0.0	0.0
Cinema admission	92.0	0.6	92.6	0.1	0.0	0.1
Video hiring	80.8	1.3	82.1	0.0	0.0	0.0
Photo processing	26.1	55.9	82.0	0.0	0.0	0.1
Overnight accommodation	70.0	4.8	74.7	0.1	0.1	0.1
Glass of beer	32.3	8.8	41.1	0.0	0.0	0.0
Meat dish	53.3	17.6	70.9	0.0	0.0	0.0
Glass of non-alcoholic beverages	38.6	6.1	44.8	0.0	0.0	0.0
Hairdressing services for men	23.4	8.7	32.1	0.0	0.0	0.0
Hairdressing services for women	24.0	10.6	34.6	0.0	0.0	0.0
Rent for privately financed apartment	24.3	9.4	33.8	0.0	0.0	0.0
Rent for subsidised apartment	20.0	11.2	31.2	0.0	0.0	0.0

Sources: German Federal Statistical Office and authors' calculations.

Notes: February 1998 to Jan 2004. Item replacements excluding comparable replacements. Figures as percentage of total observations. Effects of redesign product and outlet sample in February 2000 taken out. Some double counting of replacements as combinations of variants of item and outlet changes occur.

**Table A.7: The size of price changes**

Product	Price adjustments				Price increases				Price decreases			
	M	R1	R2	Q	M	R1	R2	Q	M	R1	R2	Q
Filet of beef	12.8	12.0		10.7	11.9	11.2		10.0	13.8	13.1		11.6
Cod	13.2	12.0		11.7	13.2	12.0		11.5	13.2	12.1		11.9
Lettuce	43.3	37.5		36.9	42.9	37.6		36.7	43.7	37.3		37.0
Banana	23.7	20.1		20.0	22.9	19.2		19.2	24.5	20.9		20.9
Spinach, frozen	16.9	20.1		15.1	16.1	18.4		14.4	17.3	19.9		15.9
Milk	10.7	9.9		9.4	12.1	11.1		10.6	9.2	8.7		8.2
Sugar	9.5	8.4		7.8	9.9	8.7		8.0	9.0	8.2		7.5
Mineral water	13.7	14.2		11.5	13.1	13.2		11.0	14.4	15.3		12.1
Coffee	13.9	12.4		12.2	14.2	12.7		12.6	13.6	12.1		11.9
Whisky	9.4	9.1		7.9	8.7	8.5		7.4	10.3	9.8		8.6
Bottled beer	10.1	9.6		8.3	9.9	9.2		8.2	10.3	10.2		8.4
Regular fuel	3.6	3.1		3.1	3.8	3.3		3.4	3.3	2.9		2.9
Premium grade fuel	3.5	3.0		3.1	3.7	3.2		3.3	3.2	2.8		2.8
Heating oil	7.6	6.4		6.4	7.6	6.5		6.6	7.5	6.3		6.3
Gas	7.2	7.1		6.8	8.0	7.7		7.5	5.5	5.9		5.2
Electricity	5.1	4.9		4.8	4.4	4.4		4.1	7.3	6.8		7.2
Shirt	19.1	21.9		17.0	17.1	21.9		16.4	20.7	21.6		17.8
Jeans	16.0	19.0		14.1	14.0	18.3		12.9	18.1	19.9		15.6
Socks	15.6	18.2		12.9	13.8	17.0		11.7	18.0	19.8		14.6
Sport shoes	14.0	18.5		12.1	9.6	18.1		9.7	19.0	18.9		15.3
Acrylic paint	7.3	9.1		7.2	6.9	8.7		6.8	8.3	10.3		8.3
Filler	9.8	13.7		9.3	8.7	11.7		8.1	12.9	18.8		12.1
Toaster	9.6	15.2		9.3	7.6	14.1		8.2	11.5	15.9		10.3
Electric bulb	14.1	19.0		12.8	12.9	17.8		11.2	16.3	20.9		15.3
Suite	5.6	11.6		5.7	4.5	9.4		4.6	8.8	16.2		8.9
Towel	17.3	19.2		14.7	14.8	18.4		13.0	20.0	20.1		16.8
Steel radial tyre	6.8	7.3		6.2	5.3	5.4		4.9	8.9	9.6		8.0
Hi-fi system	12.6	17.7		11.6	9.9	17.9		11.6	13.4	17.4		11.6
Television set	11.8	15.6		9.4	10.7	18.8		8.5	12.2	13.5		10.0
Dog food	14.1	15.9		12.2	13.2	15.4		11.3	14.9	16.5		13.3
Football	13.9	22.6		12.3	12.5	22.8		10.7	15.0	22.6		13.9
Construction game	11.9	18.1		10.2	10.4	17.8		8.5	13.8	18.2		12.6
Toothpaste	17.7	18.2		15.1	17.0	18.6		14.5	18.4	17.7		15.8
Suitcase	12.1	16.6		10.9	9.7	15.6		9.5	14.7	17.6		12.5
Dry-cleaning	7.1	10.3		6.5	6.5	6.7		6.0	9.3	20.3		8.6
Sanding and sealing of parquet flooring	5.6	5.6		4.8	5.3	5.1		4.4	6.1	6.5		5.8
Repair of washing machine	6.7	10.8		6.7	6.7	10.0		6.2	6.6	15.7		11.3
Car main service	5.8	7.4		5.6	5.1	5.9		4.7	9.6	12.9		9.6
Car wash	11.2	12.1		10.0	10.9	10.8		9.6	12.3	15.9		11.1
Brake service	7.9	9.7		7.3	6.1	7.4		5.8	14.7	17.2		12.3
Taxi journey	8.7	8.4		8.3	9.8	9.4		9.5	3.7	4.7		3.4
Cinema admission	11.0	11.4		9.8	10.9	10.4		9.7	11.0	13.8		10.0
Video hiring	15.1	17.0		12.7	16.3	16.2		12.8	14.3	17.9		12.5
Photo processing	13.1	14.9		11.8	13.4	15.4		12.0	12.6	14.0		11.5
Overnight accommodation	12.1	14.4		10.8	10.8	12.8		9.5	15.4	16.7		13.8
Glass of beer	7.2	10.5		6.7	7.3	8.1		6.7	6.6	11.8		6.9
Meat dish	7.2	8.9		6.6	6.7	7.9		6.2	8.2	11.1		7.5
Glass of non-alcoholic beverages	9.0	10.1		8.4	8.5	8.5		7.8	11.3	15.8		11.0
Hairdressing services for men	7.2	7.1		6.0	7.0	6.5		5.7	8.7	9.5		7.7
Hairdressing services for women	8.6	12.9		6.6	8.7	13.0		6.5	7.7	10.3		7.5
Rent for privately financed apartment	7.4	9.7		7.5	8.1	9.9		7.7	4.3	9.3		6.0
Rent for subsidised apartment	7.2	8.4		6.3	7.5	8.5		6.3	5.9	7.9		6.1

Sources: German Federal Statistical Office and authors' calculations.

Notes: February 1998 to Jan 2004. Item replacements excluding comparable replacements. Figures as percentage of total observations. Effects of redesign product and outlet sample in February 2000 taken out. Some double counting of replacements as combinations of variants of item and outlet changes occur.

**Table A.8: The correlation between price increases and price reductions over time and the synchronisation of price changes**

Product	Correlation		Synchronisation of price changes					
	In Jan 02	Ex Jan 02	Including January 2002			Excluding January 2002		
			AD	IN	DE	AD	IN	DE
Filet of beef	0.79	0.38	0.21	0.18	0.12	0.12	0.12	0.07
Cod	-0.26	-0.46	0.15	0.16	0.15	0.11	0.13	0.15
Lettuce	-0.97	-0.97	0.15	0.49	0.49	0.15	0.47	0.48
Banana	-0.81	-0.83	0.19	0.34	0.34	0.18	0.34	0.34
Spinach, frozen	0.04	-0.16	0.14	0.12	0.15	0.12	0.12	0.13
Milk	-0.04	-0.10	0.30	0.30	0.29	0.28	0.30	0.27
Sugar	-0.01	-0.10	0.26	0.25	0.28	0.21	0.25	0.18
Mineral water	0.53	0.15	0.12	0.10	0.09	0.08	0.08	0.06
Coffee	-0.48	-0.48	0.14	0.18	0.18	0.14	0.18	0.18
Whisky	0.17	-0.07	0.11	0.10	0.11	0.09	0.09	0.08
Bottled beer	0.63	0.47	0.13	0.12	0.08	0.11	0.11	0.06
Regular fuel	-0.98	-0.98	0.22	0.65	0.65	0.22	0.65	0.64
Premium grade fuel	-0.98	-0.98	0.22	0.65	0.65	0.21	0.65	0.64
Heating oil	-0.99	-0.99	0.20	0.67	0.68	0.20	0.68	0.68
Gas	0.00	-0.04	0.59	0.63	0.42	0.58	0.63	0.36
Electricity	-0.01	-0.03	0.72	0.78	0.40	0.70	0.76	0.40
Shirt	0.53	0.39	0.21	0.14	0.19	0.15	0.13	0.12
Jeans	0.56	0.34	0.20	0.16	0.16	0.15	0.14	0.11
Socks	0.77	0.32	0.17	0.13	0.13	0.09	0.08	0.07
Sport shoes	0.50	0.21	0.19	0.14	0.16	0.14	0.12	0.12
Acrylic paint	0.32	0.14	0.17	0.16	0.12	0.15	0.15	0.11
Filler	0.29	0.04	0.18	0.15	0.16	0.14	0.13	0.15
Toaster	0.66	0.45	0.16	0.11	0.14	0.12	0.09	0.11
Electric bulb	0.54	0.30	0.15	0.13	0.11	0.11	0.10	0.09
Suite	0.73	0.22	0.21	0.18	0.13	0.12	0.12	0.07
Towel	0.63	0.19	0.18	0.12	0.16	0.10	0.10	0.09
Steel radial tyre	0.55	0.43	0.20	0.17	0.13	0.17	0.16	0.11
Hi-fi system	0.48	0.16	0.16	0.13	0.14	0.12	0.11	0.11
Television set	0.32	0.06	0.14	0.13	0.12	0.11	0.12	0.09
Dog food	0.48	0.31	0.15	0.11	0.14	0.12	0.10	0.11
Football	0.58	0.42	0.20	0.13	0.18	0.16	0.12	0.15
Construction game	0.50	0.37	0.17	0.14	0.13	0.15	0.13	0.12
Toothpaste	0.34	0.05	0.14	0.11	0.12	0.10	0.10	0.09
Suitcase	0.43	0.23	0.17	0.16	0.13	0.13	0.11	0.12
Dry-cleaning	0.89	0.27	0.43	0.40	0.18	0.16	0.16	0.09
Sanding and sealing of parquet flooring	0.47	0.33	0.35	0.36	0.17	0.33	0.35	0.14
Repair of washing machine	0.66	0.43	0.43	0.42	0.16	0.36	0.36	0.14
Car main service	0.65	0.66	0.28	0.25	0.16	0.26	0.25	0.12
Car wash	0.89	0.41	0.34	0.29	0.19	0.13	0.12	0.10
Brake service	0.52	0.44	0.28	0.27	0.13	0.26	0.27	0.11
Taxi journey	0.69	0.07	0.52	0.36	0.54	0.28	0.28	0.17
Cinema admission	0.95	0.18	0.51	0.42	0.30	0.11	0.10	0.10
Video hiring	0.93	0.62	0.51	0.43	0.31	0.22	0.18	0.17
Photo processing	0.45	0.20	0.21	0.18	0.18	0.15	0.11	0.17
Overnight accommodation	0.75	0.21	0.41	0.37	0.22	0.18	0.17	0.16
Glass of beer	0.77	0.11	0.41	0.37	0.22	0.15	0.14	0.15
Meat dish	0.67	0.24	0.38	0.36	0.17	0.15	0.13	0.14
Glass of non-alcoholic beverages	0.78	0.29	0.45	0.41	0.21	0.17	0.15	0.16
Hairdressing services for men	0.92	0.19	0.43	0.38	0.22	0.15	0.16	0.06
Hairdressing services for women	0.92	0.25	0.41	0.35	0.26	0.15	0.15	0.07
Rent for privately financed apartment	0.57	0.32	0.07	0.06	0.06	0.06	0.05	0.05
Rent for subsidised apartment	0.45	0.12	0.15	0.11	0.16	0.10	0.08	0.14

Sources: German Federal Statistical Office and authors' calculations.

Notes: February 1998 to Jan 2004. Item replacements excluding comparable replacements. Figures as percentage of total observations. Effects of redesign product and outlet sample in February 2000 taken out. Some double counting of replacements as combinations of variants of item and outlet changes occur.

**Table A.9: Price spells and censoring**

Product	Number of price spells				
	All	Censored	Censored as percentage of all	With length of 73 months	With ... as percentage of price trajectories
Filet of beef	4954	2014	40.7	8	1.2
Cod	3007	577	19.2	0	0.0
Lettuce	40256	3037	7.5	0	0.0
Banana	27457	2338	8.5	0	0.0
Spinach, frozen	2138	1004	47.0	0	0.0
Milk	1789	546	30.5	2	0.9
Sugar	4138	1697	41.0	8	1.1
Mineral water	3854	1709	44.3	5	1.0
Coffee	3566	849	23.8	1	0.5
Whisky	4622	1960	42.4	1	0.2
Bottled beer	3547	1407	39.7	0	0.0
Regular fuel	43259	1630	3.8	0	0.0
Premium grade fuel	43386	1625	3.7	0	0.0
Heating oil	22194	816	3.7	0	0.0
Gas	1652	389	23.5	0	0.0
Electricity	1380	401	29.1	0	0.0
Shirt	1316	795	60.4	3	1.6
Jeans	1103	732	66.4	1	0.6
Socks	2878	1548	53.8	6	1.3
Sport shoes	968	651	67.3	4	2.6
Acrylic paint	909	384	42.2	0	0.0
Filler	665	383	57.6	7	5.1
Toaster	1021	713	69.8	2	1.1
Electric bulb	964	557	57.8	14	6.7
Suite	1816	1112	61.2	6	2.3
Towel	2203	1266	57.5	9	2.4
Steel radial tyre	1397	470	33.6	2	1.3
Hi-fi system	1051	775	73.7	1	0.8
Television set	1503	1007	67.0	0	0.0
Dog food	1035	510	49.3	6	3.5
Football	570	403	70.7	3	2.8
Construction game	816	526	64.5	1	0.9
Toothpaste	1904	833	43.8	5	2.3
Suitcase	804	501	62.3	0	0.0
Dry-cleaning	1848	1164	63.0	0	0.0
Sanding and sealing of parquet flooring	328	170	51.8	3	4.0
Repair of washing machine	344	200	58.1	1	1.2
Car main service	1009	418	41.4	1	0.6
Car wash	654	411	62.8	10	5.7
Brake service	982	431	43.9	2	1.2
Taxi journey	166	92	55.4	0	0.0
Cinema admission	1013	607	59.9	1	0.4
Video hiring	311	235	75.6	1	1.1
Photo processing	581	363	62.5	8	5.1
Overnight accommodation	450	257	57.1	0	0.0
Glass of beer	561	387	69.0	0	0.0
Meat dish	508	278	54.7	1	1.0
Glass of non-alcoholic beverages	388	261	67.3	1	0.9
Hairdressing services for men	3297	1769	53.7	5	0.7
Hairdressing services for women	3942	2345	59.5	0	0.0
Rent for privately financed apartment	5845	4732	81.0	500	22.4
Rent for subsidised apartment	8936	6723	75.2	381	13.3

Sources: German Federal Statistical Office and authors' calculations.

Notes: February 1998 to Jan 2004, actual prices.

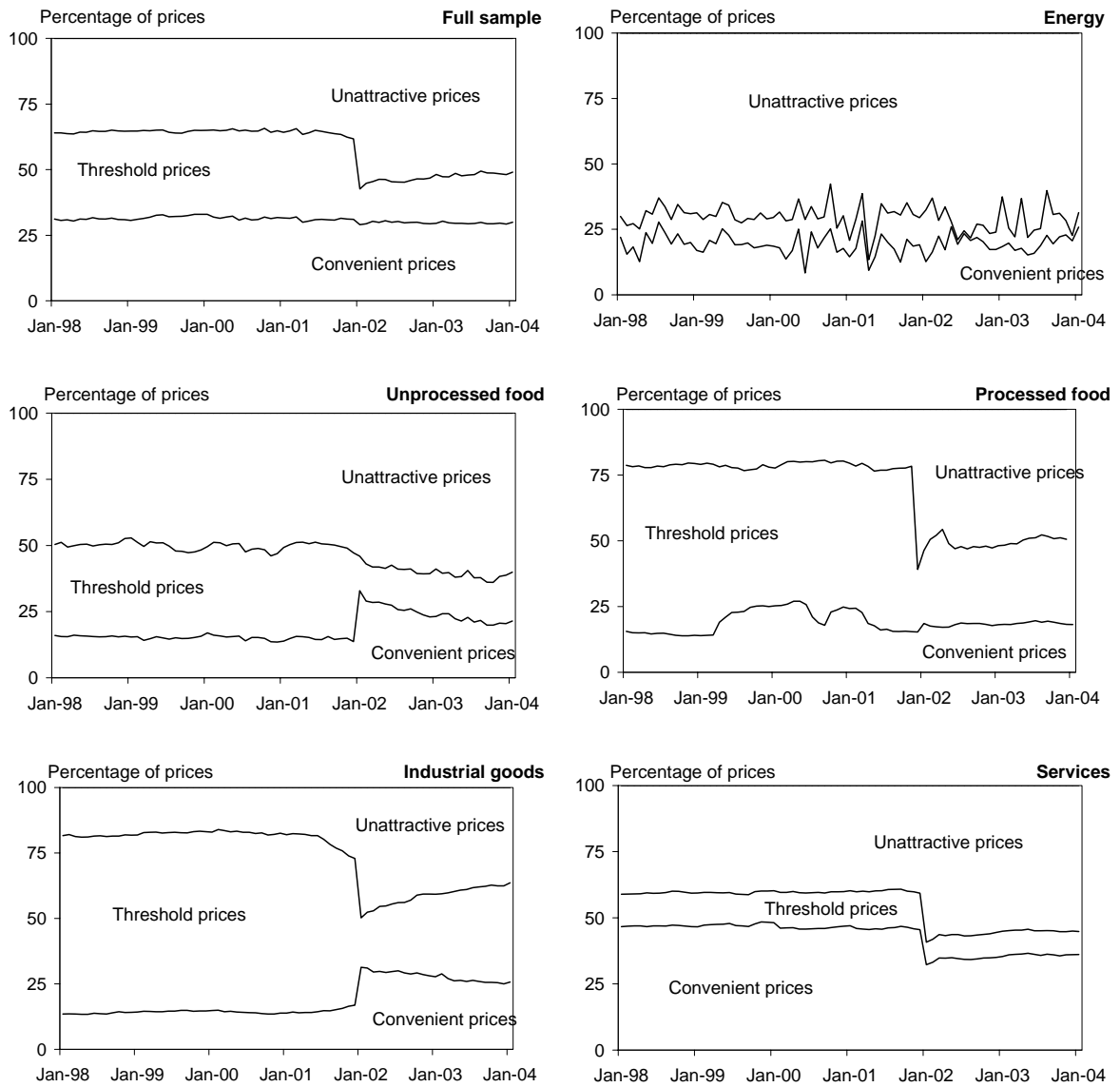
**Table A.10: The mean length of price spells**

Product	Without adjustment		Duration adjusted		Censoring adjusted
	All spells	Uncensored	All spells	Uncensored	All spells
Filet of beef	9.5	7.4	22.3	16.0	37.6
Cod	2.9	3.0	9.1	8.0	11.3
Lettuce	1.2	1.2	1.5	1.7	1.7
Banana	1.8	1.8	5.3	4.2	5.8
Spinach, frozen	6.8	7.2	13.9	14.6	26.2
Milk	8.7	6.5	17.0	12.3	24.5
Sugar	12.6	8.0	25.2	16.9	42.7
Mineral water	9.5	8.4	23.0	19.1	41.4
Coffee	4.2	4.4	11.0	10.3	14.4
Whisky	8.9	8.2	20.8	17.6	36.2
Bottled beer	10.3	8.8	24.6	19.4	40.7
Regular fuel	1.1	1.1	1.2	1.2	1.3
Premium grade fuel	1.1	1.1	1.2	1.2	1.2
Heating oil	1.1	1.1	1.2	1.2	1.2
Gas	6.5	7.0	9.1	10.0	11.9
Electricity	8.0	9.9	11.5	13.5	16.2
Shirt	10.4	10.0	25.5	20.4	64.4
Jeans	10.9	12.5	25.0	23.9	74.2
Socks	12.0	10.7	25.1	22.8	54.3
Sport shoes	11.7	10.8	25.8	19.4	78.8
Acrylic paint	10.9	10.4	21.3	17.9	36.8
Filler	14.9	13.3	28.0	21.5	66.0
Toaster	12.7	12.1	25.3	25.1	83.9
Electric bulb	15.8	13.3	31.5	23.8	74.6
Suite	10.5	11.2	20.8	18.9	53.8
Towel	12.7	11.0	27.4	22.8	64.4
Steel radial tyre	8.2	8.4	16.5	16.2	24.8
Hi-fi system	8.8	11.2	20.3	19.5	77.2
Television set	7.0	9.9	14.9	19.3	45.2
Dog food	12.1	10.2	27.8	21.9	54.7
Football	13.8	13.6	27.5	24.7	93.8
Construction game	10.3	10.7	22.2	20.0	62.5
Toothpaste	8.5	8.5	18.7	17.3	33.3
Suitcase	10.6	10.8	20.9	21.7	55.3
Dry-cleaning	14.5	15.7	20.7	25.9	55.9
Sanding and sealing of parquet flooring	16.7	15.8	32.9	27.8	68.2
Repair of washing machine	17.2	19.1	29.1	29.3	69.5
Car main service	12.0	12.0	24.3	21.3	41.4
Car wash	19.6	16.5	34.0	26.3	91.5
Brake service	12.5	12.9	26.1	22.4	46.6
Taxi journey	17.6	13.4	25.8	21.4	57.8
Cinema admission	19.0	13.8	30.1	23.0	75.0
Video hiring	22.3	16.7	32.0	26.8	130.7
Photo processing	19.6	15.5	34.4	28.2	91.7
Overnight accommodation	12.5	10.5	21.1	21.3	49.1
Glass of beer	14.6	15.4	19.8	23.1	63.8
Meat dish	15.1	12.9	25.4	21.6	56.1
Glass of non-alcoholic beverages	20.7	17.4	30.4	25.1	92.9
Hairdressing services for men	16.3	15.8	25.2	25.0	54.4
Hairdressing services for women	13.6	15.5	20.0	24.6	49.3
Rent for privately financed apartment	27.9	20.2	44.9	29.8	235.9
Rent for subsidised apartment	23.3	19.4	38.3	27.9	154.5

Sources: German Federal Statistical Office and authors' calculations.

Notes: February 1998 to Jan 2004, actual prices. Duration adjusted: correction for oversampling of long spells as described in the main text. Censoring adjusted: Average duration multiplied by the total number of spells divided through the number of uncensored spells. See Baudry et al (2004).

**Figure A.1: The changing importance of attractive prices**



Sources: German Federal Statistical Office and authors' calculations.

Notes: National sample, January 1998 to Dec 2003, four-digit weights rescaled with original main-components weights. Convenient prices: percentage of prices ending on 0 and 5, (psychological) threshold prices: percentage of prices ending on 9; attractive digits (a): up to DM2 xx.xa, up to DM20, xx.aa, up to DM200 xxa.aa, DM200 and higher, xaa.aa.