EUROPEAN CENTRAL BANK

EUROSYSTEM INFLATION PERSISTENCE NETWORK

WORKING PAPER SERIES
NO 652 / JULY 2006

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GERMANY IN A PERIOD OF LOW INFLATION

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and Jeong-Ryeol Kurz-Kim

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In 2006 all ECB publications will feature a motif taken from the €5 banknote.

1 This paper was written as a contribution to the joint Eurosystem "Inflation Persistence Network" (IPN). The authors would like to thank the German Federal Statistical Office and the statistical agencies of the German federal states for providing the individual price data. We are especially grateful to Gudrun Eckert of the German Federal Statistical Office who performed the arduous task of editing and cleaning the data. We would also like to thank the CPI staff and the price index research group at the German Federal Statistical Office in general, who helped us understand the nature of the data. Hans-Georg Wels of the Economics Department of the Deutsche Bundesbank contributed substantially to the analysis of the cash changeover effect on prices, which was a forerunner to this project. Sabine Günther and Ute Lange provided us with detailed information from the wage statistics of the Bundesbank. Furthermore, we would also like to express our gratitude to the members of the IPN, who provided suggestions and comments on this work at various stages, especially to Stephen Cecchetti, Emmanuel Dhyne, Michael Ehrmann, Philip Vermeulen and an anonymous referee. More generally, this paper has benefited immensely from presentations and discussions at IPN meetings. Finally, we would like to thank our colleagues at the Bundesbank, especially Heinz Herrmann, Ian McLoughlin, Harald Stahl and Ulf von Kalkreuth. This paper represents the authors' personal opinions and does not necessarily reflect the views of the Deutsche Bundesbank or its staff.

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The Eurosystem Inflation Persistence Network

This paper reflects research conducted within the Inflation Persistence Network (IPN), a team of Eurosystem economists undertaking joint research on inflation persistence in the euro area and in its member countries. The research of the IPN combines theoretical and empirical analyses using three data sources: individual consumer and producer prices; surveys on firms' price-setting practices; aggregated sectoral, national and area-wide price indices. Patterns, causes and policy implications of inflation persistence are addressed.

Since June 2005 the IPN is chaired by Frank Smets; Stephen Cecchetti (Brandeis University), Jordi Galí (CREI, Universitat Pompeu Fabra) and Andrew Levin (Board of Governors of the Federal Reserve System) act as external consultants and Gonzalo Camba-Méndez as Secretary.

The refereeing process is co-ordinated by a team composed of Günter Coenen (Chairman), Stephen Cecchetti, Silvia Fabiani, Jordi Galí, Andrew Levin, and Gonzalo Camba-Méndez. The paper is released in order to make the results of IPN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the Eurosystem.

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CONTENTS

Abstract: We analyse the adjustment of retail and services prices in a period of low inflation, using a set of individual price data from the German Consumer Price Index that covers the years 1998 to 2003. We strong find evidence of time- and state-dependent price adjustment. Most importantly, the differences in "unconditional" sectoral price flexibility are found to be linked to input price volatility.

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

JEL-Classification: E31, D43, L11

Non-Technical Summary

The examination of price dynamics at the level of individual items is of interest for a number of reasons. 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, it is only at the individual item level that 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 can be related to structural factors. Fourthly, evidence on 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 in the years 1998 to 2003, based on a large set of individual consumer price data assembled for the computation of the German CPI. The focus of our analysis is on the frequency and the (average) size of price changes since the period covered is relatively short and many price spells are relatively long. Evidence on price durations and the size of individual price adjustments is provided to supplement this analysis.

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, in some cases, there are marked differences in the estimates of the frequency and the size of price adjustments, overall 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 concentrate our analysis 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 more than two years – if price changes within a month are not considered – but change by nearly 10%. The longest price durations are found for housing rents, which, on average, are for more than four years. Excluding housing rents and gas and electricity prices reduces the mean duration of prices to less than two years. This is more in line with what is reported in other European country studies, which typically do not cover these items. Concerning the direction of price changes, downs are only slightly less frequent than ups, which lead 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 the level and, most importantly, to the volatility of sector-specific input price inflation. Concerning the temporal dimension, in each period we observe a certain level of price changing activity, although in some periods a bunching of price adjustments occurs, which often can be related to idiosyncratic shocks. For many narrowly defined products, price increases and prices decreases occur simultaneously, and, at the level of specific items, price decreases are sometimes followed immediately by price increases, which indicates that the pricing process is to some extent noisy. There is no evidence of persistence in changes of prices at the item level, but measures of the frequency of price changes exhibit some persistence, hinting at lagged adjustment.

The size of price changes is not uniform, neither for the full sample nor at the product level. We even find a substantial number of small price changes. While the share of small price changes is too small to be consistent with zero costs of changing prices, the prevalence of small changes might be interpreted as a (partial) refutation of the menu cost hypothesis. Many of the small price changes were, however, related to the changeover to euro banknotes and coins, which can be understood as shock on menu costs. For some products, especially small price decreases are found to be absent, which indicates that there is a certain reluctance to cut prices.

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 months, a low level of synchronisation of price changes and evidence on seasonality in pricing (which, however, is not very pronounced and is partly related to seasonality in marginal costs or in demand) suggest time-dependent elements. The bunching of price changes related to input price shocks or to special events such as VAT changes or the cash changeover hint at state-dependent elements. Moreover, the probability of observing a price change is related to product-specific retail and input price inflation. This effect is particularly strong for sequences of price changes in one direction, whereas it is rather weak for sequences of price changes in opposing directions.

The other way round, aggregate inflation seems to be mainly driven by variations in the frequency of price increases, whereas variations in the frequency of price decreases and in the absolute size of price adjustments play a less prominent role.

The changeover to euro cash does not seem to have added to nominal rigidities in Germany. Given the prominence of attractive prices in the D-Mark era, the conversion factor of DM 1.95583 per euro might have reduced the frequency and increased the size of price adjustments. However, the reduction by half in the number of potential pricing points resulted in attractive prices becoming less important.

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, as 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 (intrinsic) 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, which are collected by the German Federal Statistical Office and the statistical offices of the German federal states (*Bundesländer*) for the compilation of the national Consumer Price Index (CPI) and the national component of the Harmonised Index of Consumer Prices (HICP). The data refer to 52 mostly narrowly defined products (11 types of foodstuff, five sources of energy, 18 industrial goods and the same number of services including two types of rental housing). This restricted sample of goods and services approximates the overall CPI and its main components reasonably well if suitable weights are chosen (see Annex A1 for details).

In the period under review, inflation was exceptionally low in Germany. Consumer prices increased by no more than 7.8% over the entire period, or by 1.3% per year. This was less than in any other six-year period in post-WWII Germany. It was also (with the exception of Japan) less than in any other industrialised country during the same time. Nevertheless, 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 product-specific cost and price developments.

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 more than two years (if price changes within a month are not considered), but change by nearly 10% on average. Excluding housing rents and gas and electricity prices, as is done in studies for many other country studies, reduces the mean duration of prices to less than two years. These estimates are more consistent with observations made in other European countries (see Dhyne *et al* 2005, 2006), which do not cover housing rents. Price decreases are only slightly less frequent than price increases, which indicates that there is no general downward rigidity in prices. Absent small price decreases, however, suggest that prices are reduced only reluctantly. 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 (idiosyncratic) shocks. The probability of observing a price change is found to be affected by product-specific input price and consumer price inflation. This effect is particularly strong for sequences of price changes in one direction, whereas sequences of price changes in opposing directions are less strongly influenced by inflation. Moreover, aggregate inflation seems to be driven mainly by the frequency of prices increases, whereas variations in the incidence of price reductions and the (absolute) size of price changes play a less prominent role. For many narrowly defined products, price increases and price decreases occur simultaneously, and price decreases are sometimes followed immediately by price increases, which suggests that there is some 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 serial correlation, hinting at lagged adjustment.

While these results are typical of many products, there is an enormous heterogeneity in price variability. 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 of services seem to be much more rigid than those of fuels and food are. Unconditional information on the frequency and the size of price changes alone, however, does not allow us to classify prices as rigid or as flexible. Observationally there is equivalence between truly rigid prices and prices, which are essentially flexible – within the bounds of menu costs – 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 input prices, which are much more volatile than those for, say, services.

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 in Israel. For a review of the early literature, see Wolman (2000). 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. Bils/Klenow (2004) pioneered this research.

For Germany, Fengler/Winter (2000) explore the relationship between the average rate of price change and the degrees 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/Winter (2001) investigate the contribution of psychological prices to price rigidity. Loy/Weiss (2002) and (2004) 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 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* 2005), Belgium (Aucremanne/ Dhyne 2004, 2005), in Finland (Vilmunen/Laakkonen, 2005), in France (Baudry *et al* 2004, Fougère *et al* 2005), in the Netherlands (Jonker *et al* 2004), in Italy (Veronese *et al* 2005), in Luxemburg (Lünnemann/Mathä 2005), in Portugal (Dias *et al* 2004, Dias *et al* 2005), and in Spain (Álvarez/Hernando 2004). Dhyne *et al* (2005, 2006) summarise the results of the national studies and analyse a harmonised sample of 50 products. The selection of goods and the summary statistics in this paper are mainly those agreed on in the IPN.

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 housing rents is of considerable importance in the case of Germany, as rents have a sizeable weight in the national CPI. 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 they go into the calculation of the CPI). Further value added is provided by linking the individual price dynamics at the retail level to input prices, thus endogenising the product-specific degree of price rigidity.

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 from the D-Mark to the euro 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.[1] 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 on 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 (2005a, 2005b, 2006) analyses 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. The most important findings of these studies and of the present study are summarised in Deutsche Bundesbank (2005). Hoffmann/Hofmann (2006) review the changes in the price dynamics in Germany from a macro perspective, taking into account changes in monetary policy, measurement, taxation and regulation.

In section 2, we start the investigation with a look at the distribution of price changes. 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 and the size of individual price adjustments. Section 5 discusses the results. Four appendices consider a number of methodological and measurement topics. Here the interested reader will also find a detailed description of the data underlying this study.

[1] 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).

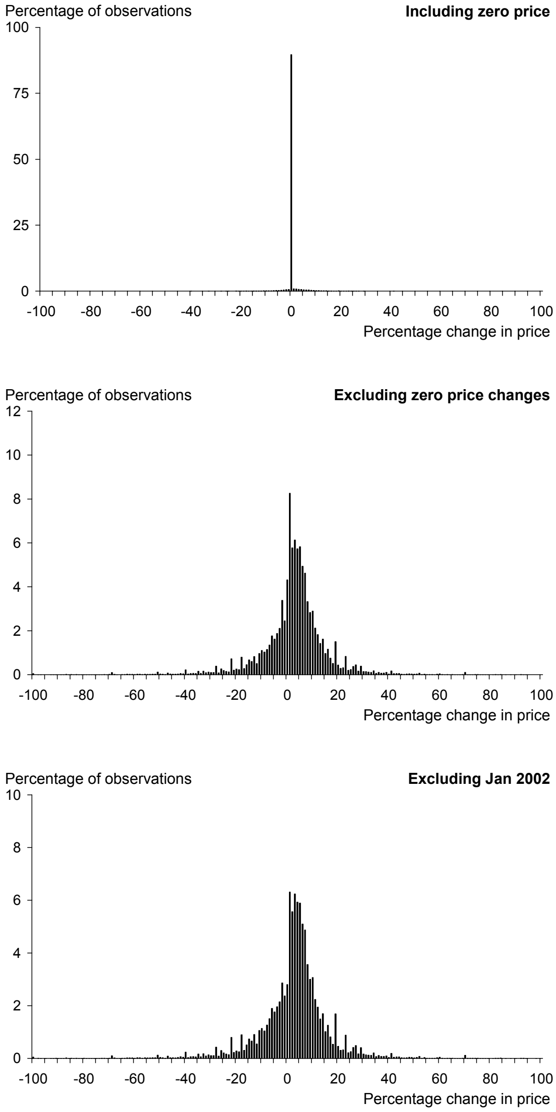
2 The distribution of price changes

We start our investigation of consumer price adjustment in Germany with a look at the (weighted) distribution of monthly price changes (Figure 1; upper panel).[2] We see that in the period February 1998 to January 2004 zero price-adjustments prevail. This is the first important finding: Prices change only infrequently. On average, just 10% of the prices are revised per month.

Excluding the zero price changes reveals an enormous diversity in price adjustments (Figure 1, middle panel). We observe price changes upwards and downwards, of less than 1% but also by more than 40%. The pronounced heterogeneity in price adjustments is the second important finding.

Removing also January 2002, the month of the changeover from D-Mark cash to euro cash, reduces the share of small price changes and makes the distribution appear smoother (Figure 1, lower panel). Overall, the histogram of price changes now broadly resembles that of a normal distribution.

Figure 1: The distribution of price changes



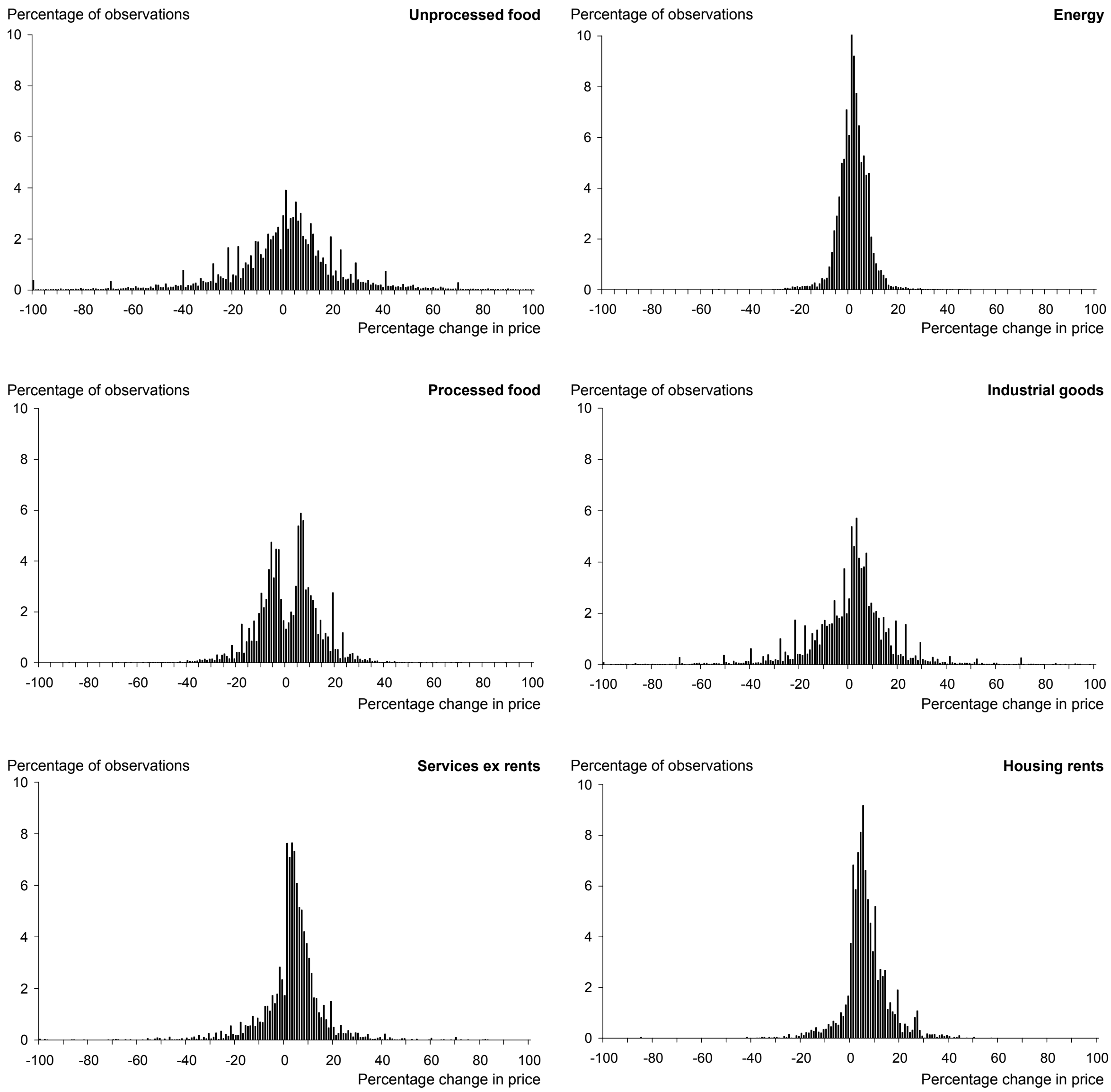
Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; February 1998 to January 2004; quality-adjusted prices; monthly price changes computed from first differences in logs; bin-width 1pp; compiled from product specific histograms with four-digit COICOP weights rescaled with original main-components weights.

There are, however, some hints at asymmetries. Firstly, even a simple visual inspection shows that there are more small and medium-sized price increases than price reductions. Secondly, even though it is not noticeable without a magnifying glass, there

[2] For a comparable investigation with Austrian data, see Baumgartner et al (2005).

Figure 2: The distribution of price changes by components



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; February 1998 to January 2004; quality-adjusted prices; monthly price changes computed from first differences in logs; bin-width 1pp; compiled from product specific histograms with four-digit COICOP weights rescaled with original main-components weights; only non-zero price changes.

are more truly big price decreases than big price increases. These findings are similar to those of Davis/Hamilton (2004) and Levy *et al* (2005), who also report evidence of small price increases occurring much more often than small price decreases.

With an overall non-zero rate of inflation, such an asymmetry does not come entirely unexpectedly, but the lack of small price reductions seems to be too pronounced to be explained by a small positive rate of change. Hence, the thinning-out of the distribution below zero may be interpreted as an indication of some downward rigidity in prices. This leads to the third important finding: while there is no evidence of a general downward price rigidity in the data, the absent small and medium-sized price reductions suggest that in the small prices are slightly more flexible upwards than downwards.

The resulting deformation of the left tail of the distribution of price changes is particularly pronounced for services and rents (see Figure 2), but there are also indications of downward price rigidity in the case of industrial goods. Whereas the distributions of price changes for unprocessed food and energy appear to be rather “normal”, mass around zero is found to be missing approximately symmetrically in the histogram for processed food. Similar patterns can also be detected for some industrial goods with small prices. These missing price adjustments are probably the consequence of menu costs, which induce a (symmetric) zone of inaction around zero.

The pronounced heterogeneity in price adjustment is clearly a challenge for economists. Firstly, with menu costs, we would not expect to find so many small price changes. Secondly, the large number of really big price changes – quite a number of price adjustments are larger than 20% – comes as a surprise. One important consequence of the diversity in price adjustments is the conclusion that there is no such thing as a typical (percentage) price change. At the level of narrowly defined products, we find more homogeneity in pricing, but the size of price adjustments is still surprisingly diverse.

For analysing the dynamics of consumer prices in Germany in more detail, we reduce the complexity of price adjustment. In the next chapter, we start from a macroeconomic perspective and decompose the (average) rate of inflation into the average incidence and the average size of price increases and price decreases. This means that the full distribution of price changes is collapsed into three bins, one located at zero, one located at the average price increase and one at the average price decrease. The approach of the following chapter is more microeconomic in character: We look at the causes of the heterogeneity in price adjustment.

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" of the inflation process (Klenow/Kryvtsov 2005) is the frequency ("incidence") of price changes, defined as the number of price revisions per 100 price observations.[3] The corresponding indicator of the average size of price changes describes the "intensive margin".[4] 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 may bias the estimate of the incidence of price changes and probably also distorts the measure 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 (the replacement item) 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.[5] This is the matched-models (M) sample. The second and the third pairs also include observations related to item replacements.[6] Hence,

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

4 If the Jevons index formula is applied for lower-level aggregation instead of the Dutot index formula (as in the German CPI) and the geometric Laspeyres formula for upper-level aggregation instead of the arithmetic Laspeyres formula (as in the German CPI), the rate of inflation can be decomposed exactly into the average frequency and the average size of price changes. See Annex A2.

5 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.

6 Excluding so-called "voluntary" item replacements and outlet replacements. In our data set, replacements are indicated by the variable "reason of change" (see Annex A1). As the variable "reason for 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.

replacements – if linked to price changes – are considered as being equivalent to price changes for continuously observed items. The corresponding measures of the size of price changes are calculated either from the unadjusted market prices (replacement sample 1, R1), thus reflecting directly the pricing decisions on the market, or from the quality-adjusted prices (replacement sample 2, R2), which feed into the compilation of the CPI, reflecting also the adjustments made to prices by the statistical agency for ensuring the intertemporal comparability of prices (see Annex A1).[7] 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 index. The comparative analysis in Dhyne *et al* (2005) and most of the country studies report measures of the incidence of price changes including (involuntary) replacements (R1),[8] but consider only matched models (M) for the measurement of the average size of price changes.

3.2 Variation across sectors and products

3.2.1 The frequency of price changes

In general, prices are adjusted only infrequently. There is, however, substantial variation across products. In the matched-models sample (M), the (average) monthly incidence of price changes varies between about 2% for rents and 93% for heating oil.[9] In the quality-adjusted sample (Q), the incidence of price changes tends to be slightly higher, the difference being related to item and outlet replacements resulting in (quality-adjusted) price changes. The estimates for the replacement sample referring to unadjusted market prices (R1) are even somewhat above those for the quality-adjusted sample. The replacement sample with quality-adjusted prices (R2) gives an estimate of price changes nearly identical to that for the sample including all replacements (Q), the small differences being brought about by outlet replacements. These results suggest that measures of price changing activity are sensitive to the definition of a price change; the differences between the various measures being, however, not very pronounced.

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7 The pre-January 2002 prices were converted into euro by rounding to the second decimal place. For the quality-adjusted item-specific price indices, no conversion was required.

8 This comes to stipulating a price change of unknown size for each item replacement.

9 The incidence of price changes was computed excluding price observations related to product and outlet replacements in the denominator if they were not also included in the nominator.

Table 1: The frequency of price changes per month

Main component	Price adjustments M	R1	R2	Q	Price increases M	R1	R2	Q	Price decreases M	R1	R2	Q
Unprocessed food	28.0	29.6	29.2	29.1	14.5	15.4	15.3	15.3	13.5	14.2	13.9	13.9
Processed food	9.7	10.3	10.2	10.2	4.8	5.1	5.1	5.1	4.9	5.2	5.1	5.1
Energy	57.6	58.2	58.1	58.0	31.9	32.1	32.1	32.1	25.8	26.1	25.9	25.9
Oil products	90.7	91.2	91.2	91.2	48.5	48.8	48.9	48.9	42.2	42.4	42.3	42.3
Electricity, gas	11.5	12.3	11.8	11.8	8.5	8.9	8.8	8.8	3.0	3.3	2.9	2.9
Industrial goods	5.8	8.0	7.1	7.1	3.2	4.5	4.1	4.1	2.5	3.5	3.0	3.0
Services	3.2	3.9	3.4	3.4	2.5	2.9	2.7	2.7	0.7	1.0	0.7	0.7
Services ex rents	4.5	5.5	4.8	4.8	3.5	4.0	3.6	3.6	1.0	1.5	1.2	1.2
Housing rents	1.6	2.2	1.8	1.8	1.3	1.7	1.5	1.5	0.3	0.5	0.2	0.2
Overall	10.1	11.3	10.8	10.8	5.9	6.5	6.3	6.3	4.3	4.8	4.5	4.5
Ex rents, electricity and gas	12.8	14.2	13.6	13.6	7.2	8.0	7.7	7.7	5.6	6.2	5.9	5.9

Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product, February 1998 to Jan 2004, monthly incidence of price changes (percentage), four-digit COICOP 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 the redesign of the item and outlet sample in February 2000 taken out.

Because of the substantial heterogeneity in price adjustment, the weights chosen for aggregation are much more important for the aggregate estimate. Properly weighted (four-digit COICOP weights rescaled with the original main components weights; see Annex A1), the average monthly incidence of price adjustments is estimated at 10% in the matched-models sample and at 11% in the quality-adjusted sample (Table 1).[10] As we cannot observe price variation within a month with our data, these estimates probably underestimate the "true" degree of unconditional price flexibility, especially for products with frequent price adjustments as heating oil and fuels and fresh fruits and vegetables.[11]

The differences in the frequency of price adjustments prevail at the level of the main components. It is true that there is also substantial heterogeneity within some

[10] Taking the ten-digit COICOP weights inflated to the full CPI would give an exaggerated estimate of the incidence of price adjustments (17% for the matched models and of 18% in the quality-adjusted universe), since the sample of price representatives is rather unbalanced (see Annex A1). The corresponding estimates for the ten-digit COICOP weights rescaled with the main components are 11% and 12% respectively.

[11] It unlikely, 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.

components,[12] but usually it tends to be less pronounced than across sectors. About 60% of the energy prices are revised each month, whereas only less than 3½% 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 significantly lower than in the energy sector.

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% per month if only continuously priced flats without any modifications are considered. In the more important privately financed market segment, the pace of price adjustment stood at just 1½% per months. Quality-adjusted rents change at rates of 2½% and 2% per month, respectively, indicating that rent adjustments are often related to renovation and reconstruction measures. Excluding housing, the average incidence of price adjustment for services comes to 4½% (matched models) and nearly 5% (quality-adjusted prices). In the energy component, the low incidence of price adjustments among gas and electricity stands out. Just 14% of the gas prices and 11% of the electricity price were changed per months, compared to more than 90% of the prices changed per months for fuels and heating oil. Both electricity prices and gas prices were regulated in the period under review. Excluding housing rents, electricity and gas raises the estimated frequency of price adjustment to 13% for the matched models and 13½% for the quality-adjusted prices. These figures correspond more closely to the estimates for other euro area countries (see Dhyne *et al*, 2005, 2006), which typically do not cover housing and household energy.[13]

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

[12] Mainly 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 differ from the previous period) and in the energy component (prices for heating oil and fuels change nearly monthly, whereas prices for electricity and gas typically were adjusted once a year in the period under review). For details, see Annex Table A1.

[13] While the results for Germany are broadly comparable to those for other European countries, they are much lower than those for the U.S. are. Excluding housing, Bils/Klenow (2004) find that more than 26% of the prices were changed each months in the period 1995 to 1997. A closer inspection reveals that the differences are most pronounced for industrial goods and services, whereas for unprocessed food and energy prices change at a broadly comparable rate. For a comparison of U.S. and euro area evidence, see Dyne *et al* (2006).

replacements take place in the industrial goods segment, 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%. Jeans, sport shoes, toasters, three-piece suites and construction games were replaced twice (or at a rate of nearly 3% per month). In the full sample, only about 1% of the items were exchanged per month, reflecting the low replacement rates in the non-industrial goods components.[14] Outlets changed even less often. In the period under review, only 4½% of the reporting units were replaced, which is less than 0.1% per month.[15]

The incidence of replacements is approximately consistent with the difference between the frequency of price adjustments for matched models and for the quality-adjusted sample including replacements. The correspondence is, however, not perfect, as replacements do not necessarily result in (quality-adjusted) price changes. In the case of industrial goods, for example, 2½% 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 1½%.[16]

Concerning the direction of price adjustments, price decreases are nearly as frequent as price increases. On average, more than 40% of the price changes are downwards and less than 60% upwards, irrespective of the price concept chosen. As with the overall incidence of price adjustments, there is substantial heterogeneity across sectors. In the processed food segment, downs are as frequent as ups, whereas services prices changes are predominately upwards and only to a small extent downwards. Most interestingly, even for housing rents we find evidence of reductions.

Across products, there is a relatively strong positive correlation between the incidence of price increases and the incidence of price decreases. At first glance, this

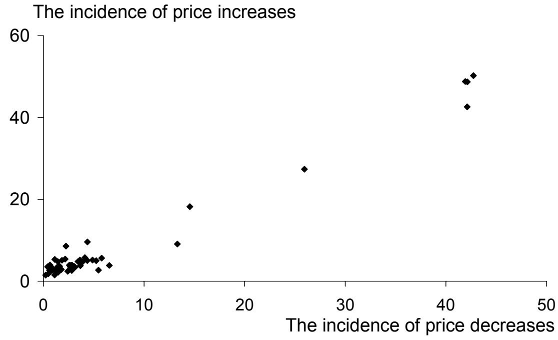
[14] Bils/Klenow (2004) find in the US CPI data a much higher share of price quotes associated with item substitutions (3.4%), a finding which may partly explain the differences in the frequency of price adjustments. However, 54% of the item substitutions were considered to be comparable, which were excluded from our calculations.

[15] However, as many disruptions in the price trajectories were caused by outlets disappearing from the market, the cleaning of the data set (see Annex A1) distorts the estimate of the rate of outlet replacements downwards.

[16] Therefore, the practice of stipulating that a price change occurs when an item is (involuntarily) replaced most likely results in an overestimation of the incidence of price changes.

finding does not seem to be remarkable, as pricing might be more flexible, say, for unprocessed food than for services. 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 adjustment. Hence, without some 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 (Figure 3), a phenomenon which is also observed by Baudry *et al* (2004). Even removing the "outliers" (defined here as products with an incidence of price increases and price decreases above 10%) leaves the coefficient of correlation above 0.5.

Figure 3: The incidence of price increases and decreases across products



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; February 1998 to January 2004; quality-adjusted prices; average incidence price increases and decreases as percentage of monthly observations.

The bouncing of prices indicated by the pronounced correlation of the incidence of price increases and decreases across products might be related either to the volatility of important cost (or demand) factors – as in the case of energy or unprocessed food – or to deliberate pricing strategies at the retail level. For example, it may pay 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). Prices might simply fluctuate between regular and sales prices, which are themselves rigid. Hence, such price adjustments do not seem to "reflect any true price flexibility" (Taylor 1999). 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.

The German consumer price statistics record temporary price reductions related to promotions, sales and end-of-season sales. However, prices are generally surveyed in the middle of the month only. As end-of-season sales traditionally started in the second half of the affected months, most of the price-reducing effects were not captured. This biases the estimates of the frequency of price adjustments downwards for Germany. In our sample, the variable "reason for change" is also supposed to indicate promotions. There are, however, strong indications that even promotions are often not properly flagged. Hence, we try to identify sales and promotions indirectly.[17] We term a sequence of prices with $P_{t+1} < P_t$ and $P_{t+2} = P_t$ "promotion" and a sequence with $P_{t+1} < P_t$ and $P_{t+2} > P_t$ "sale".

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 stages in the value-added chain. In the processed food component, "promotions" reduce the monthly incidence of price changes from about 10% to 8% and in the industrial goods segment from slightly more than 7% to less than 6½%. Assuming that true sales and promotions occur only in the processed food and industrial goods sectors, taking out these special sales lowers the estimate of the average frequency of price changes for the full CPI by nearly ½ percentage point.[18] With respect to the direction of price changes, excluding temporary price reductions shifts the balance slightly more strongly in favour of price increases. The bulk of price reductions cannot, however, be rationalised by sales.

3.2.2 The average size of price changes

On average, the individual price adjustments tend to be quite pronounced at the retail level in Germany. In our sample, for matched models the average price change amounted to 9% (Table 2), which is quite high compared with the average monthly rate of inflation of just 0.1% and in comparison with the average annual rate of price change

[17] For a similar approach, see Baumgartner *et al* (2004) and Klenow/Kryvtsov (2005), who, however, consider only temporary promotions. For a slightly different approach, see Lünnemann/Mathä (2005).

[18] In the US, price changes related to promotional activities seem to occur more often. Klenow/Kryvtsov (2004) report that in the US CPI 11% (15% in the food, 8% in the non-food segment) of the price quotes relate to sales, of which ⅔ follow the u-shaped pattern which we use for the indirect identification of promotions.

Table 2: The average percentage size of price changes

	Price adjustments				Price increases				Price decreases			
Main component	M	R1	R2	Q	M	R1	R2	Q	M	R1	R2	Q
Unprocessed food	25.5	25.9	25.0	25.1	24.6	24.8	24.1	24.1	26.6	26.5	26.1	26.2
Processed food	10.0	10.9	9.8	9.9	10.2	11.0	10.2	10.1	9.8	10.8	9.5	9.7
Energy	3.8	3.9	3.8	3.9	4.0	4.0	4.0	4.0	3.6	3.7	3.6	3.6
Oil products	3.7	3.7	3.7	3.7	3.8	3.8	3.9	3.9	3.5	3.5	3.6	3.5
Electricity, gas	5.5	5.8	5.4	5.6	5.3	5.9	5.4	5.4	5.5	6.7	5.6	6.2
Industrial goods	11.6	16.6	10.8	11.5	9.5	15.4	10.1	10.0	14.1	18.0	12.7	13.7
Services	7.3	13.0	8.0	7.5	6.9	9.5	6.8	7.1	8.6	12.9	10.9	9.2
Services ex rents	7.4	14.3	8.5	7.6	6.8	9.4	6.7	6.8	9.7	16.4	11.8	9.8
Housing rents	6.8	14.0	6.3	7.4	7.4	9.8	7.0	7.7	4.1	9.2	6.0	6.0
Overall	9.0	11.3	9.0	9.1	8.3	10.2	8.5	8.5	9.8	11.4	9.8	9.9
Ex rents, electricity and gas	8.8	11.6	9.3	9.3	8.2	10.5	8.8	8.7	9.6	11.6	10.0	10.1

Sources: German Federal Statistical Office and authors' calculations.

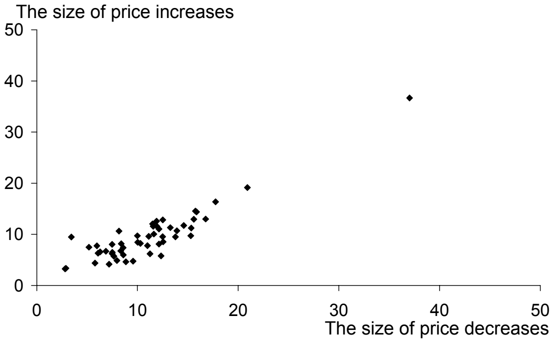
Notes: 52-product sample; February 1998 to Jan 2004; percentage change in prices computed from first difference in logs; four-digit COICOP weights rescaled with original main-components weights. M: Matched models, actual prices. R1: Including item replacements, actual prices. R2: Including item replacements, quality-adjusted prices. Q: Including all replacements, quality adjusted prices. Effects of redesign of sample in February 2000 neutralised.

of 1.3%.[19] 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 – increases the average size of price changes to more than 11%. After correcting for changes in quality, the estimate of the average size of price adjustments is reduced again to 9%. This pattern, which is also visible at the level of the individual products, suggests that measures of the size of price changes based on quality-adjusted prices tend to give estimates which are close to those derived from matched models, but lower than those including unadjusted replacements are.

As with the incidence of price changes, there are substantial differences in the average size of price changes across and within sectors (Table 2 and Annex Table A1). The most sizeable adjustments are to be found among unprocessed food, with lettuce displaying the biggest variations. Price changes of industrial goods also tend to be sizeable, whereas in the services and – even more so – in the energy component, price adjustments are smaller on average.

[19] The full-period average size of price changes was calculated by weighting the time-varying average size of price changes by the time-varying incidence of price changes. Simply averaging monthly mean price changes would not result in a measure that corresponds to the mean frequency (see Annex A2).

Figure 4: The size of price increases and price reductions across products



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; February 1998 to January 2004; quality-adjusted prices; average size of price increases and decreases as percentages (computed from first differences in logs).

Among the energy products, price changes for fuels are less intense than those for gas or electricity are (which are adjusted less often).

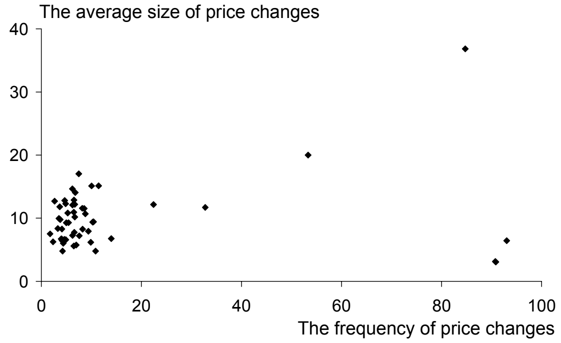
On average, price increases are of the same order of magnitude as price reductions. For the full sample, we observe that upward adjustments are somewhat less sizeable than downward corrections, thereby counteracting the higher incidence of the former to some extent. The surplus size of the price reductions is mainly the consequence of the absent small price decreases (see Section 2). The median size of price reductions – which might be considered to represent the typical size of price reductions, as it is more robust with respect to outliers and measurement errors – is nearly identical to that of price increases. At the sectoral level, we observe the phenomenon of more pronounced (average) price reductions particularly in the industrial products and services (excluding rents) components, whereas in other sectors the size of price changes is more balanced.

As with the frequency of price changes, across products the average size of price increases is closely correlated to the average size of price reductions (Figure 4). 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 decreases is rather puzzling, at least at first glance, the strong correlation between the size of positive and negative price adjustments suggests approximately symmetric product-specific menu costs.

3.2.3 Explaining the differences in the frequency and the size of price changes

The analysis of the previous sections did not address the reasons behind the pronounced disparities in "unconditional" price flexibility across products. Taking nothing else into account, the empirical evidence presented here could lead to the conclusion that, for some products, price setting is intrinsically less flexible than for other products. Such an inference, however, would be premature, as less frequent price adjustments may simply reflect more steady demand and supply conditions. Hence, the crucial question is whether pricing for some products is really more rigid or whether prices simply have less reason to change. In this section, we will try to give an answer to this question by linking the frequency and the size of price adjustments to conditions prevailing in the respective markets.

Figure 5: The size and the frequency of price changes across products



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; February 1998 to January 2004; quality-adjusted prices; average size of price increases and decreases as percentages (computed from first differences in logs).

From a theoretical point of view, the (product-specific) rates of cost inflation and their volatility, the (product-specific) demand developments and structural factors characterising the organisation of markets are the usual suspects for differences in the incidence of price changes across products.

Firstly, if the size of prices increases and price reductions is uniform and identical across sectors, if product-specific cost developments are steady and if there is no idiosyncratic volatility in individual prices, then there is an exact correspondence between the absolute value of the average rate of price change and the frequency of price adjustments across products: the incidence of price increases (decreases) rises with the rate of product-specific inflation (deflation). Volatility in product-specific cost developments, caused by short-term changes in important input prices, raises the frequency of both price increases and price decreases (if the short run variation in costs is pronounced compared to the trend in costs). Pronounced volatility in demand also adds to the frequency of price adjustments.

Secondly, if the size of price changes is variable, the frequency of price adjustments is expected to vary inversely with the degree of (endogenous) nominal rigidities, which may be summarised under the heading "menu costs".[20] A number of

[20] In our sample, however, the frequency and the size of price changes do not seem to be strongly correlated (Figure 5), a phenomenon which has also been observed with French and Dutch data (Baudry *et al* 2004, Jonker *et al* 2004). At first glance, this finding seems to refute the menu-cost conjecture. If, however, overall price developments are not uniform across products, there is no reason to expect a strong negative correlation between the intensive and the extensive margin of price adjustment. And, indeed, if we regress the frequency of price revisions on the average absolute change

factors may influence the relative size of price changes. If the costs of changing prices are independent of the level of prices, the frequency of price adjustments may increase and the relative size of price adjustments decrease with the product-specific (average) price level. Outlets operating in a rapidly changing environment may try to keep menu costs low, which would tend to reduce the average size of price adjustments, but increase its incidence. On the other hand, as Hansen (1999) has demonstrated, the Dixit (1991) model of lumpy adjustment implies that volatility will, to some extent, widen the range of inactivity, but pronounced volatility may still increase the number of price changes. If it pays to have attractive prices (convenient or threshold prices), price changes tend to be larger; hence, the incidence of price adjustments will be lower. According to our data, attractive prices are quite common in Germany (see Figure 11, page 36), with psychological threshold prices having a substantial importance for processed food and industrial goods, whereas convenient prices are often found among services.[21]

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. Modern outlets, here defined as department stores, cash and carry markets, supermarkets, discount shops, gas stations and energy utilities, sell most of the processed food and energy in Germany. Generally, firms operating in a more competitive environment can be expected to adjust prices more rapidly (Rotemberg/Saloner, 1987; Martin, 1993). Among unprocessed food and industrial goods, traditional outlets have a greater importance. In the services sector decentralised structures dominate. The prevalence of short-turn price fluctuations related to sales and promotions, which may occur more often in modern outlets, will also add to the incidence of price adjustments.[22] And finally, regulation is supposed to reduce price flexibility and probably increase the size of price changes (Dexter *et al* 2002).

in the corresponding price index and on the average size of price adjustments, both explanatory variables turn out to be highly significant with the expected signs.

21 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. For a rationalisation of this practice, see Basu (2004).

22 Beware, however, that some modern outlets follow an every-day-low-price strategy instead of the high-low pricing strategies of promotion-oriented outlets. The latter typically demand, on average, higher prices. On these two distinct pricing strategies, see Hoch/Dreze/Purk (1994).

Table 3: Summary statistics of the regression variables

	Full sample		Clean sample		Excluding energy and unprocessed food	
Variable	Mean	Std dev	Mean	Std dev	Mean	Std dev
Frequency of price changes	15.0	23.7	20.3	28.0	6.5	3.3
Frequency of price increases	8.4	12.4	11.2	14.6	3.9	1.3
Frequency of price reductions	6.6	11.4	9.1	13.5	2.7	2.3
Size of price changes	10.1	5.2	9.7	6.1	9.7	3.0
Size of price increases	9.6	5.2	9.3	6.1	9.1	2.9
Size of price reductions	11.2	5.4	10.8	6.1	11.0	3.2
Average cumulated absolute change in input prices	0.9	2.1	1.3	2.5	0.3	0.2
Input price inflation	0.1	0.2	0.1	0.2	0.1	0.1
Input price inflation variability	1.2	2.7	1.7	3.2	0.4	0.4

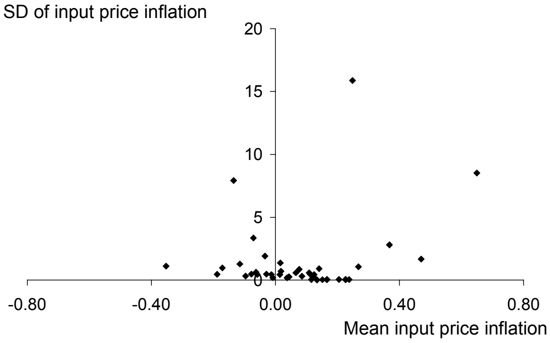
Sources: German Federal Statistical Office and authors' calculations.

Notes: Quality-adjusted price sample. Average absolute cost change $\left(\sum \left| \ln inputprice_t - \ln inputprice_{t-1} \right|\right)/72$. Cost inflation (cost variability): mean (standard deviation) of monthly quality-adjusted product-specific inflation rates. Full sample (excluding housing rents): 50 products. Clean sample: 32 products with exactly or closely matching input price indices. Sample excluding energy and unprocessed food: 40 products.

For exploring the determinants of the "intensive" and the "extensive" margins of the inflation process empirically, we regress the average frequency and size of price adjustments on measures of cost inflation and its volatility.[23] We match the food and energy products and the industrial goods in our sample with the corresponding subindices of the German Producer Price Index and the German Import Price Index (for details see Annex A3). For 21 products we achieved an exact or close match, for 13 products an approximate match (see Annex Table A6). In the case of services, we approximate the development of costs with wage figures taken from the Index of Negotiated Wages as compiled by the Deutsche Bundesbank. For 11 services, the match can be considered close, for three services approximate. Housing rents are not considered in this exercise as not even a poor proxy for the input price inflation is available. The cost variable enters the regression either with the average absolute monthly change in the corresponding input price index or with the average rate of change and its standard deviation. For the summary statistics of the left-hand and right-hand variables, see Table 3.

[23] Alternatively, we might regress the frequency and the size of price adjustments on product-specific rates of inflation and its variability as is done in Dhyne *et al* (2005).

Figure 6: The mean and the standard deviation of input price inflation



Sources: German Federal Statistical Office and authors' calculations.

Notes: 50-product sample; February 1998 to January 2004; for input prices see Annex Table A.4; rates of change computed from first differences in logs.

We employ two different set-ups for the analysis of the relationship between the size and the frequency of price adjustments and the explanatory factors. In the first one explaining the differences in the unconditional degree of price flexibility in general, we look at the determinants of the frequency and the absolute size of price changes, without differentiating between upward and downward adjustments. As there is no reason to expect an unambiguous relationship between (cost) inflation and the frequency of price adjustments in general – higher overall inflation may simply reduce the incidence of price decreases and increase the incidence of price increases without changing the overall incidence of price adjustments – the average absolute monthly change in the input price indices serves as an explanatory variable. This variable captures the long-term trend as well as the short-term fluctuations in input prices.

In the second set-up, we distinguish price increases and price decreases. As we would normally expect inflation to increase the probability of upward price adjustments and decrease the probability of downward priced revisions, we take the mean input price inflation and its volatility as explanatory variables. Since the mean and the standard deviations of the change in input prices are not correlated across the 50 products in our sample (Figure 6), we hope to be able to separate the contribution of these two factors in the second set-up.

Overall, we have six equations, three explaining the frequency and three the average size of price adjustments. As we have observations for only 50 cross sections, we have to keep the empirical specification rather parsimonious. The true relations between the explanatory variables are probably non-linear,[24] with the explanatory

[24] Linear models are not fully appropriate as frequencies are bounded between 0 and 100 (and the size variable is bounded at zero). Alternatively, we might transform them into a log-odds ratio, as it is done by Dhyne *et al* (2005). This transformation is itself not without problems, and there is no

Table 4: Explaining the differences in price setting across products

	Total price flexibility		Downward and upward price flexibility			
	Incidence of price adjustments		Incidence of price increases		Incidence of price decreases	
Constant	6.89	(1.78) ***	2.40	(0.82) ***	1.62	(0.83) *
Average absolute change in input prices	8.77	(1.86) ***				
Input price inflation			21.11	(9.14) **	11.47	(8.80)
Variability of input price inflation			3.20	(0.69) ***	3.18	(0.57) ***
Adj R-squared	0.58		0.64		0.64	
Number of cross sections	50		50		50	
	Size of price adjustments		Size of price increases		Size of price decreases	
Constant	8.68	(0.59) ***	9.02	(0.59) ***	10.95	(0.69) ***
Average absolute change in input prices	1.57	(0.60) **				
Input price inflation			-11.64	(3.37) ***	-13.34	(3.93) ***
Variability of input price inflation			1.40	(0.38) ***	1.29	(0.42) ***
Adj R-squared	0.59		0.55		0.47	
Number of cross sections	50		50		50	

Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample excluding housing rents. OLS. White heteroscedasticity-consistent standard errors in parenthesis. *** significant 1% level, ** significant 5% level. Quality-adjusted price sample. Average absolute change in input prices (Annex Table A.4) $(\sum \left| \ln inputprice_t - \ln inputprice_{t-1} \right|)/72$. Input price inflation (variability of input price inflation): mean (standard deviation) of monthly quality-adjusted product-specific input price inflation rates.

variables interacting which each other. We stay with a simple linear specification without any interaction terms, start with a set-up without any "structural" variables.

By and large, the empirical model performs rather well, and the results seem to be quite robust. As the estimates for the matched models and the quality-adjusted prices are nearly identical qualitatively, we present only the results for the quality-adjusted prices (Table 4). Moreover, qualitatively the estimates do not differ much between the full sample and a "clean" sample restricted to the 32 products with an exact or close match to input price indices. Hence, we may conclude that, at least qualitatively, the

straightforward interpretation of the coefficients. As we are mainly interested in the qualitative results, we stay in this paper with the untransformed left-hand variables and perform simple OLS regressions. The alternative approach would - qualitatively - lead to the same results in most cases, with one major exception (which will be reported later on).

results of our estimations do not seem to depend on products for which the match to input prices is more dubious.

The results of the estimations mostly confirm our expectations. Input price inflation and its variability are highly significant in explaining differences in the frequency and size of price changes across products, and a substantial part of the variation in the frequency and the size of price adjustments across sectors can be explained. The average absolute monthly change in input prices is found to increase the frequency of price adjustments, a result, which is very much in favour of state-dependent pricing models. The same is true of the variability in input price inflation with respect to price increases and price decreases, a finding that is supportive of the Dixit-Hansen conjecture. Mean input price inflation is found to increase the incidence of price increases.[25] It does not, however, make a significant contribution to the explaining of the incidence of price reductions. Hence, price reductions seem to be mostly related to (short-term) volatility in prices, whereas variations in the incidence of price increases are, to a greater extent, related to underlying price trends.

With respect to the size of price revisions, the average absolute change in input price indices enlarges the size of price changes. Input price inflation tends to reduce the size of both price increases and decreases, whereas the variability of input prices makes price changes more sizeable, which is in line with the Dixit-Hansen conjecture.[26]

If the "structural factors" as the product-specific share of modern outlets or the importance of attractive pricing are included in the estimation, the results are less clear-cut. Most of the estimated coefficients are statistically not different from zero. This does not come as a big surprise, as there is some collinearity among these variables. Therefore, choosing the adequate subset of explanatory variables is not straightforward, and the remaining variables may capture the effects of other factors. Hence, at this

[25] The coefficient of the input price inflation (but not of its variability) becomes insignificant, however, when the left-hand variable is transformed into a log-odds ratio.

[26] This result is, however, probably a statistical artefact brought about by the monthly frequency of price recording. For products with volatile input prices, prices are reviewed more often than once a month. Hence, the "true" frequency of price changes might be much higher, and – if there are at least short-run trends in input prices – the "true" size of price changes is probably smaller. Especially for fruits and vegetables, the seasonal movement in input prices generates such short-term trends. Therefore, with our data we cannot give a definite answer to the question of whether volatility increases the size of price adjustments.

place, we leave the analysis of the influence of the "structural" factors to the micro econometric analysis in section 4.2.

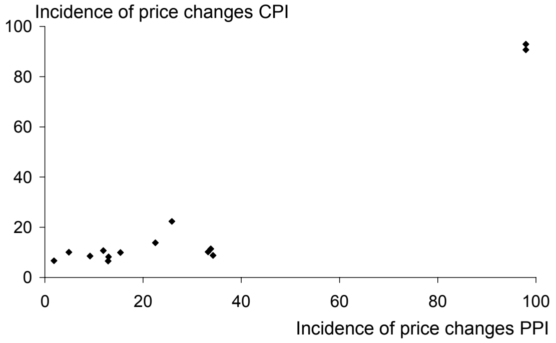
If we add dummy variables for the five main components to the econometric set-up, they prove be highly statistically significant. Obviously, the products in the five categories share some characteristics, which are not adequately captured by the other explanatory variables. Moreover, in the equation explaining the incidence of price increases the inclusion of dummies representing the main components renders the product-specific average input price inflation irrelevant. The coefficient of the average absolute change in input prices and the coefficient of the variability of input price inflation, however, are still statistically significant.

If unprocessed food and energy products are excluded from the sample, the influence of input price variability on the average frequency and size of price adjustments becomes very small or even vanishes. This finding might be interpreted as indicating that the central message of the previous estimation – the significant contribution of input price inflation variability to the explanation of differences in the degree of "unconditional" priced flexibility – is not really robust. In the sample restricted to processed food, industrial goods and services, there is, however, not much variation either in the frequency of price adjustments nor in input price developments (Table 3). Moreover, the proportion of rather ill-fitting input price indices is rather large in this sub-sample. Hence, while we have to concede that input price inflation and its variability cannot explain small differences in price setting, we can confirm that they can explain large differences.

A more direct approach for assessing the degree of intrinsic consumer price rigidity is to compare the frequency of price adjustments at the retail level to that at earlier stages of production. For 14 products – beef, processed vegetables, milk, dog food, sugar, coffee, beer, mineral water, toothpaste, tyres, electricity, gas, fuel and heating oil – it was possible to match individual price data of the Producer Price Index (PPI) to such of the CPI. We find the incidence of price changes in the CPI to be highly correlated to that in the PPI (Figure 7). Prices, which often change at the factory gate, often change at the retail level as well.[27] However, this result is driven to a large extent

[27] For a thorough analysis of the full individual PPI data set, see Stahl (2006).

Figure 7: Price adjustments in the PPI and in the CPI



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period October 1997 to September 2003 (PPI); February 1998 to January 2004 (CPI). Average incidence of price changes as percentage of monthly observations. Quality-adjusted prices.

by fuels and heating oil. If these products are excluded, the coefficient of correlation remains positive but shrinks from 0.95 to 0.39. Once again, it appears that, by linking consumer prices to input prices, we can explain differences in price setting at the retail level at a general level, but not in specific instances.

Furthermore, we see that for seven out of 12 remaining products the frequency of price adjustments at the retail level is significantly lower than at the factory gate. The opposite is true of only two products. This evidence seems to indicate that while there is a certain correspondence between the frequency of price changes at the producer and at the retail level, consumer prices are revised less often than producer prices, which hints at some additional rigidity in price setting at the retail level.

In the case of services, wages are probably the most important single cost factors. Negotiated wages are typically changed once a year in Germany. Hence, we might expect an average monthly incidence of price adjustments of about 8%. The actual frequency of price changes in the services ex housing rents sample amounts to less than 5%. The difference between the frequency of wage and price adjustments seems to lead to the conclusion that there is some additional rigidity in the price setting for services beyond the rigidity in wage setting. In some services sectors, however, no wage increases have taken place in recent years, or the enterprises simply have stopped applying the union pay rates. Hence, wages actually changed less often than once a year. For example, according to the Bundesbank's statistic of negotiated wages, in hairdressing an average of 5% of the wages were adjusted per month in the period under review. The corresponding frequency of price adjustment, at 4.5%, was however even somewhat lower.

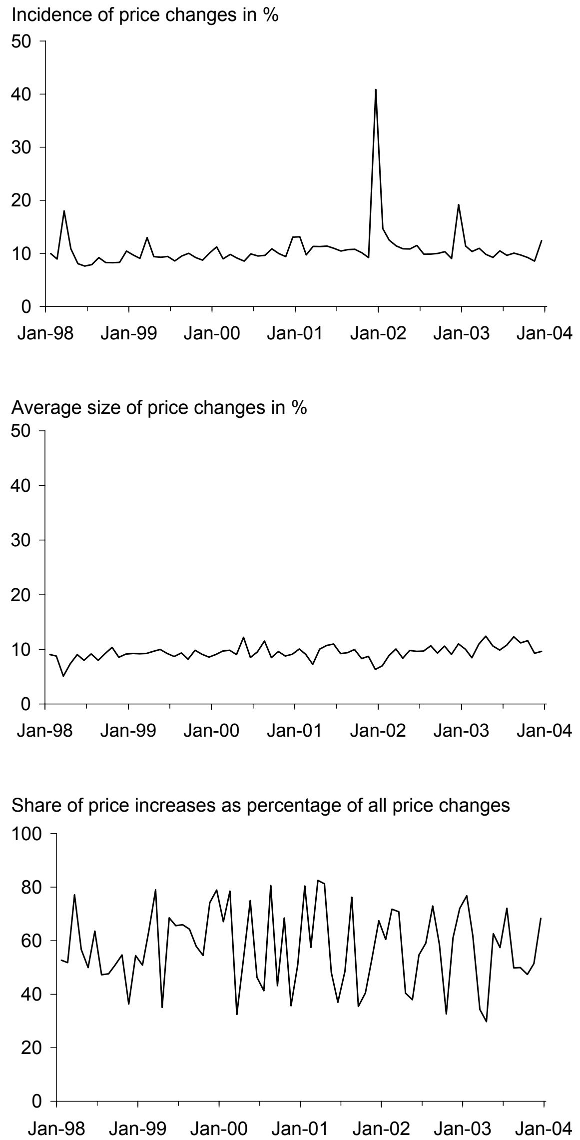
3.3 Variation over time

3.3.1. A visual inspection

Following the exploration of the cross-sectional differences in price setting, we turn now to the temporal dimension. Significant temporal variation in the incidence of price adjustments would hint at important state-dependent elements in pricing, whereas a steady level of price-changing activity might be interpreted as indicating the prevalence of time-dependent pricing rules. Concerning the intensity of price adjustments, substantial temporal variation in the size of price adjustments would seem to favour time-dependent rules, whereas a more-or-less invariant size of price changes indicates state-dependent price setting.

A preliminary visual inspection of the aggregate time series of the incidence of quality-adjusted price changes (Figure 8, upper panel) – those for matched models do not differ significantly – suggests a rather steady level of price changing activity. There are, however, some remarkable peaks, related to the VAT increase in April 1998 and to the cash changeover in January 2002, which hints at state-dependent elements. The pronounced peak in January 2003 cannot be explained by any exogenous factor (it probably simply mirrors the bunching of price changes in January 2002). There is even less variation in the average (absolute) size of price adjustments (Figure 8, middle

Figure 8: Temporal variation in the incidence and the size of price changes



Sources: German Federal Statistical Office and authors' calculations.
Notes: 52-product sample, quality-adjusted prices, four-digit COICOP weights rescaled to the original main-components weights, monthly incidence of price changes (percentage), percentage change in prices computed from the first difference in logs.

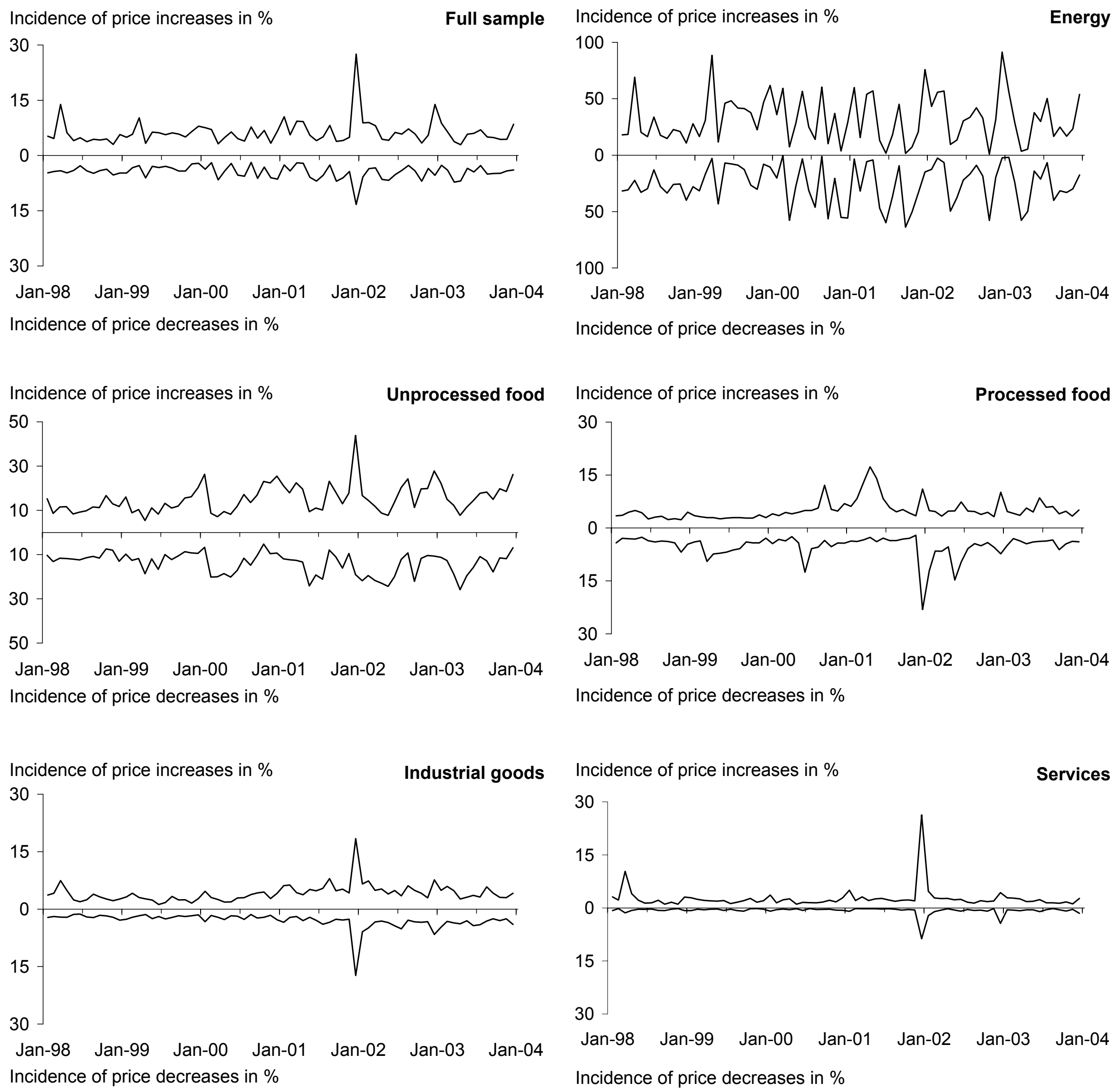
panel). Price changes appear to be slightly below average in the months of the VAT increase and the cash changeover (April 1998 and in January 2002), but, in other periods, prices were adjusted on average by a roughly invariant percentage. In contrast to the frequency and the (absolute) size of price adjustments, the composition of price changes in terms of price increases and price decreases displays substantial variation over time (Figure 8, lower panel). In the period under review, it fluctuates wildly between 30% and 80%.

These fluctuations in the direction of price changes are strongly correlated (0.71) with variations in the exactly corresponding monthly rate of inflation (see Annex A2), whereas the correspondence between the frequency of price adjustments and the inflation rate is much less pronounced (0.54). Excluding the cash changeover reduces the correlation coefficient to 0.30. The correlation between the average absolute size of price changes and the overall rate of monthly inflation is close to zero (-0.16).

Whereas the largely time-invariant frequency of price adjustments is supportive of time-dependent pricing strategies, the rather weak correlation between the variations in the (absolute) size of price adjustments and the rate of inflation seems to undermine this case. The strong correspondence between the composition of price changes in terms of increases and reductions points to the importance of this distinction for the dynamics of inflation.

Instead of comparing the dynamics of the average absolute size of price adjustments and that of the composition of price changes to the rate of inflation, Klenow/Kryvtsov (2005) choose a measure that averages upwards and downward price changes. This measure turns out to be almost perfectly correlated with inflation (0.98). With the German data, this measure is also strongly correlated (0.92) with the overall rate of price change (and with the composition of price changes in terms of upward and downward movements). By mixing positive and negative price adjustments this measure does, however, give the rather misleading impression of smooth adjustment of the size of price changes. It is true that there are also small price changes, but price adjustments are typically large and do not vary systematically over time. It is the composition of price changes in terms of increases and decreases that matters, not the absolute size of adjustments.

Figure 9: The varying incidence of price adjustments



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample, quality-adjusted prices, monthly incidence of price changes (percentage), four-digit COICOP weights rescaled to the original main-components weights.

Looking at price increases and decreases separately reveals that it is only the incidence of price increases that is strongly positively correlated with inflation (0.75), while there is a negative, but weak correlation between the incidence of price reductions and the overall rate of change in prices. Hence, we may tentatively conclude that it is mainly the frequency of price increases, which drive inflation.

This result is primarily brought about by the industrial goods and the services components, whereas for food and energy the frequency of price reductions is as strongly correlated with inflation as that of price increases. A strong correlation of the size of price increases and price reductions with sector-specific price developments can be only observed only for unprocessed food and industrial goods.

While the share of price increases in overall price changes fluctuates strongly, it never approaches 0% or 100%, implying that there is some simultaneity of upward and downward price revisions. At the aggregate level (Figure 9), we do not find a single period without either price increases or price decreases. The lowest rate of price reductions was observed in September 2000, but even then, 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 the level of the 52 products that we find months devoid of any price reductions or increases. Frequent periods without downward price adjustments are observed mostly among products with a low intensity of price revisions in general, as is the case for many services and some industrial products.

The simultaneity of price decreases and increases observed for the main components cannot be explained by the heterogeneity of product-specific price developments. Even for relatively homogeneous products, it is quite common that in periods with frequent upward (downward) price revisions, some outlets reduce (increase) prices. For example, the share of outlets cutting prices for bananas does not drop below 5% in any single month. In April 2001, the month with the lowest incidence of price reductions, no less than 42% of the outlets increased prices, while 5.3% reduced prices. In other periods, we find 25% of the outlets adjusting prices upwards and 25% downwards. Similar phenomena can be observed for other products.[28]

Despite the (partial) coincidence of price increases and price decreases, at the aggregate level we find a relatively strong negative correlation of -0.5 between the frequency of price increases and decreases if January 2002 is excluded. This result is, however, driven solely by the strong negative correlation for unprocessed food and energy products (-0.45 and -0.86, respectively). For the other main components, the

[28] To a certain extent, the simultaneity of upward and downward price adjustments may stem from differing dates of price observation. In the German consumer price statistics, prices are recorded up to the middle of the month. Volatile prices are to be recorded exactly in the middle of the month, but it is likely that prices are not always collected on precisely the same dates throughout Germany.

temporal correlation between price increases and price reductions is either weak (processed food) or positive (industrial goods and services), which means that in those periods with a relatively large number of price increases a relatively large number of prices reductions also occur. At the level of the individual products, only five items display a strong negative correlation between price increases and price decreases. The weighted average of the product-specific correlation coefficients is positive but close to zero.

The relatively steady intensity of price adjustments observed for many products already hints at a low level of synchronisation across outlets. It is only in a few periods that a bunching of price changes occurs, most notably in January 2002. The synchronisation measure proposed by Fisher/Konieczny (2000), which relates the actual standard deviation of the frequency of price changes to a hypothetical one with 100% synchronised price adjustments, also indicates low synchronisation. Among the main components, only energy stands out with a relatively high synchronisation coefficient. Synchronisation tends to be more pronounced when price increases and price decreases are considered separately. At the level of the individual products, there is a relatively high degree of synchronisation for some unprocessed food and services, even when January 2002 is excluded.[29]

There are further episodes before the cash changeover in which price adjustments were synchronised to a higher degree than usual. The spike in spring 1998 can be explained by the increase in VAT that took place at this time. Among processed food, the downward peak in mid-2000 is probably 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 spring 2001 were caused by the decision of the German competition authority to outlaw prices below costs, which effectively ended the retail price war, and to several livestock health crises, which pushed food prices upwards.

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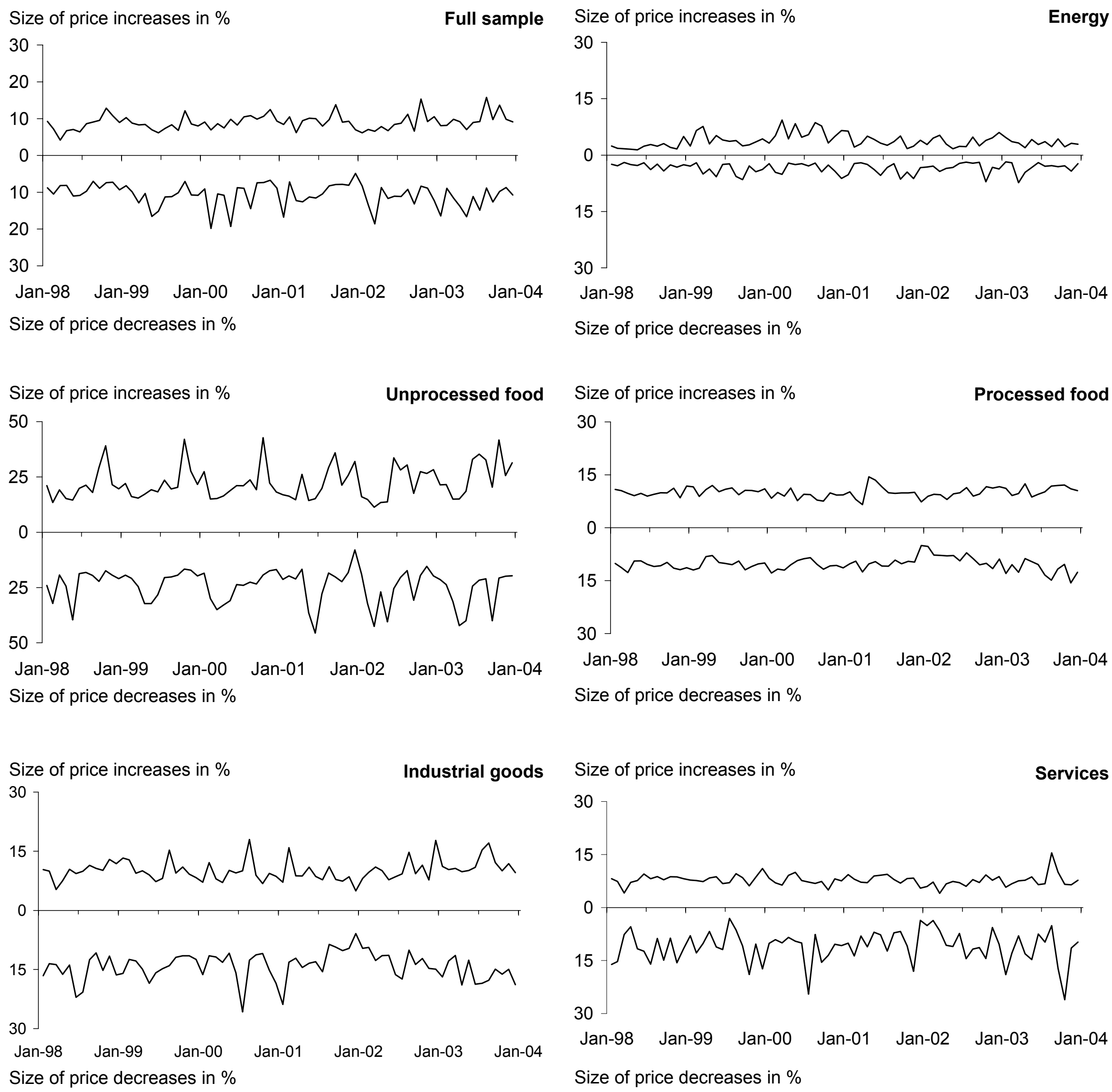
[29] Loy/Weiss (2004) also report a relatively high degree of synchronisation for unprocessed food in Germany. They analyse weekly price data provided by the ZMP for ten fresh food products in 108 grocery stores – which belong to six different retail chains – using a fixed-effects probit approach. Loy/Weiss find strong evidence of synchronisation within retail chains, weaker evidence of 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* (2005) observe a high degree of synchronisation at the local level, especially among services.

Figure 10: 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 the first difference in logs, four-digit COICOP weights rescaled with original main-components weights.

At the beginning of this section, we noted that the average absolute size of price changes was did not vary strongly over time. Disaggregating along the direction of price changes and across products tends to increase the temporal size-variability (Figure 10). At the level of the main components, the size of price changes for processed food and – to a lesser extent – for energy seems to be rather steady, as is the case with price increases for services. For other product categories, however, we find an even stronger variation in the average size of price adjustments. Especially in the unprocessed food and industrial goods components, the variation in the intensity of price revisions is quite pronounced.[30]

3.3.2 Some econometric explorations

For a preliminary investigation of the temporal variation in price adjustment, we regress – at the level of the full sample and of the main components – the overall incidence of price changes, and, separately, the incidence of price increases and price decreases on several explanatory variables.[31] The list of our 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 (ET; in April 1999, January 2000, January 2001, January 2002, January 2003).[32] There are three dummy variables related to the changeover to prices denominated in euro in January 2002. The first one (EURO1) captures the price effects exactly in January 2002. The second one (EURO12) is introduced for testing whether in a period six months preceding and five months following the cash changeover (excluding January 2002) the incidence of price adjustments was different from the remainder of the period under review. The POSTDM dummy tests whether price adjustments in the euro period were as frequent as in the D-Mark period, and, in combination with the trend variable, whether trends have changed after the euro cash changeover.

The dummy WAL (July 2000=1) captures the effect of the price war among grocery chains initiated by the market entrance of Wal-Mart in 1999, which culminated in a synchronised reduction of prices for some foodstuff at the end of June 2000. In September of the same year, the German competition authority (*Bundeskartellamt*) prohibited several retail chains from selling a number of grocery products below their respective cost prices. For capturing the effect of prices returning to normal levels, we add a POSTWAL dummy for October 2000.[33] Furthermore, seasonal dummies are

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[30] This variation can be partly explained by the aggregation procedure, which weights the product-specific size of price adjustments with the product-specific frequency of price changes (see Annex A2), thus giving, in some periods, greater weight to products with above-average or below-average product-specific size of price changes.

[31] This approach 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.

[32] For a similar set-up, see also Veronese *et al* (2004).

[33] We introduce Wal-Mart dummies only for these two periods for which we have reliable information from the proceedings of the competition authority. It is most likely that the market entrance of Wal-

included, which, if statistically different from zero, might either indicate time-dependent pricing behaviour or seasonal variations in supply and demand.

When estimating this set-up, we find, as Àlvarez/Hernando (2004) do, frequent serial correlation in the residuals. We model the serial dependence by adding to the list of regressors the lagged incidence of price changes (AD) or the lagged incidence of price increases (IN) and price reductions (DE), respectively. These terms are supposed to capture lagged adjustment and bouncing of prices. We proceed from a very general to a component-specific specification by successively dropping variables statistically insignificant at the 5% level, and end up with relatively parsimonious specifications, which seems to be appropriate given the relatively small number of observations. The results for the matched-models sample are close to those for quality-adjusted prices; hence, we report only the latter (Table 5).

As the purpose of this exercise is to characterise the time-series properties of the frequency of price reviews, not to give a full explanation of the price dynamics, the overall fit of the equations is not the only relevant criterion for assessing the results of these estimations. Still, it is surprising that even this rudimentary specification, which leaves out important state-dependent elements (with the exception of the dummies relating to special events and the trend and the lagged endogenous variable and, probably, the seasonal dummies), results in a satisfactory fit for the full sample and for some of the main components.[34] These findings may be interpreted as indicating that the contribution of state-dependent factors – at least at the aggregate level – is rather limited.

For the full sample, the overall fit is quite good for price adjustments in general and for price increases. For price decreases, the explanatory power turns out to be much weaker. Similar patterns are also observed for energy and unprocessed food. For the remaining main components, the explanatory power of the equations relating to direction of price changes is more balanced.

Mart also influenced price developments before July 2000 as did the decision of the competition authority after October 2000. See the press notice released by the German competition authority "Bundeskartellamt prohibits sales below cost price for first time" of 8 September 2000.

34 Concerning the size of price adjustments, the explanatory power of a comparable set-up is much less satisfactory.

Table 5: Explaining the temporal variation in the frequency of price changes

	Full sample			Energy			Unprocessed food		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
Constant	7.58	4.67	4.21	43.89			15.78	9.83	12.63
VAT	9.06	8.46		37.78					
ET	X	X	X	X					
EURO1	28.36	22.08	8.03				28.44	21.90	10.47
EURO12			1.07				-2.13	-4.54	
POSTDM				-6.56			19.23		3.27
AD(-1)	0.10			0.10			0.24		
IN(-1)/DE(-1)				0.03					
IN(-1)		0.16							
TREND	0.05			0.27			0.24	0.21	-0.08
TREND POSTDM	-0.10			-0.27			-0.38	-0.37	
SEASON	X			X			X	X	X
Adj R squared	0.97	0.76	0.38	0.86			0.93	0.71	0.42
DW statistic	1.94	1.91	2.12	1.79			1.64	1.73	1.65
Incl observations	71	71	72	71			71	72	72
Mean dependent var	10.77	6.31	4.46	58.12			29.19	15.27	13.86
SD dependent var	4.11	3.40	1.79	10.64			6.05	6.38	4.88

	Processed food			Industrial goods			Services		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
Constant	5.17	1.14	2.59	1.61	1.42	1.62	2.85	1.71	0.39
VAT				6.22	5.49	0.84	8.68	8.05	1.10
EURO1	26.58	6.89	19.65	26.29	12.47	13.65	30.50	23.04	7.12
EURO12		-2.31							
POSTDM				2.85		1.61		2.11	
WAL	8.52		8.18						
POSTWAL	5.59	7.55	-1.36						
AD(-1)	0.44								
IN(-1)		0.53			0.45			0.17	
DE(-1)		-0.11	0.42		-0.37			-0.40	
IN(-1)/DE(-1)				-1.35					
TREND		0.08		0.08	0.06	-0.03		0.01	0.01
TREND POSTDM		-0.19		-0.21	-0.09	0.08		-0.03	
SEASON				X		X	X	X	X
Adj R squared	0.66	0.58	0.71	0.91	0.85	0.92	0.95	0.96	0.80
DW statistic	1.54	1.82	1.85	1.85	2.31	1.86	1.99	2.10	2.21
No of periods	71	71	71	71	71	72	72	71	71
Mean dependent var	10.21	5.10	5.11	7.14	4.15	2.97	3.39	2.64	0.73
SD dependent var	4.46	2.85	3.18	4.14	2.30	2.02	4.10	3.11	1.11

Sources: German Federal Statistical Office and authors' calculations.
Notes: OLS. Quality-adjusted prices. AD: price adjustments. IN: price increases. DE: 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. WAL=1 in July 2000; POSTWAL=1 in October 2000. SEASON=X: seasonal dummies jointly significant at a 5% level. ET=X: energy taxes statistically significant at the 5% level. Only coefficients reported which are statistically significant at 5% level, using Newey-West HAC standard errors.

Turning to the results in more detail, we find a highly significant impact of changes in indirect taxes on the frequency of price adjustments. Both the increase in VAT in April 1998 and the various changes in the energy taxes induce additional price increases. The impact of the 1998 VAT increase on the frequency of the affected components (food was excluded) was, however, rather muted. In the industrial goods component, the frequency of upward price adjustments increased by only 5.5pp, in the services component by 8.7pp. Only in the energy component was the impact stronger.

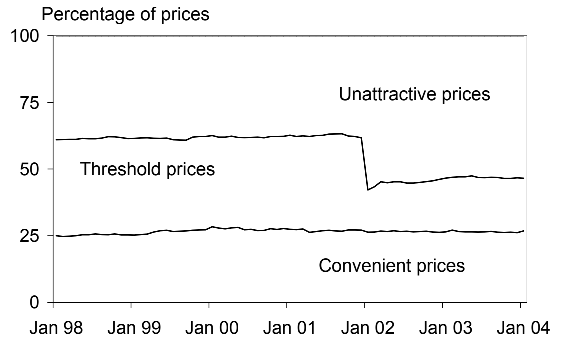
The changeover to the euro led to a significant increase in the incidence of price changes in January 2002. This is exactly what models with non-zero costs of price adjustments would predict, as the changeover from D-Mark cash to euro cash went hand in hand with a changeover from D-Mark prices to price denominated in euro (Hobijn *et al* 2006). We do not, however, find any evidence that the period six months before and after the changeover – that is the EURO12 variable – was characterised by a below-average intensity of price adjustments. Therefore, the pure menu-costs explanation of the clustering of price changes in January 2002 cannot be the full story. However, as prices are revised only very infrequently for quite a number of goods and services, we probably would expect the changeover to affect the incidence of price adjustments over a more extended period. On the other hand, it is remarkable that not all prices were changed on January 2002. Excluding changes less than 0.1pp[35] – which is less than 0.1% for most products – only 40% of the prices were revised, whereas the normal share of prices adjusted in January is 11%.

The "euro effect" was particularly pronounced – compared with the normal level of price changing activity – in the industrial goods and services sector, less so in the processed food component. In the energy sector, euro effects cannot be identified because a major increase in energy taxes took place in the same month, and unprocessed food was affected by weather-related specific price developments for fruit and vegetables. Whereas the majority of the additional price adjustments were upwards in the services component, they were predominately downwards in the processed food component. For industrial goods, the effect is nearly balanced.

[35] The quality-adjusted item price indices are rounded to the first position after the decimal point. Alternatively, we might have excluded from the calculation small price changes, say, of less than 0.5%. We were, however, reluctant to do so, as we observe (an admittedly small number of) very small price changes in other periods, too.

Over the full period, we observe a slight upward trend in the frequency of price adjustments (TREND), on which a negative trend is superimposed in the post D-Mark period (TREND POSTDM). There is, however, no indication that the inclination to change prices is generally lower in the post D-Mark. The POSTDM dummy, which was intended to capture this effect, did not prove to be statistically significant or showed a positive sign.

Figure 11: The prevalence of "attractive" prices



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52 product 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 D-Mark 2 xx.xa, up to D-Mark 20, xx.aa, up to D-Mark 200 xxa.aa, D-Mark 200 and higher, xaa.aa.

Hence, there is no persuasive evidence that the conversion rate of DM 1.95583/euro, which reduced the number of pricing points by half in Germany, increased nominal rigidities. And indeed, when looking at the patterns of price setting, we observe that the share of psychological threshold prices dropped with the changeover (Figure 11; see also Brambach 2002 and Deutsche Bundesbank 2002). It did, however, recover afterwards, albeit only slowly. This finding seems to correspond to the slowly declining rate of price revisions in the post D-Mark era.

In the components where attractive prices play a prominent role – that is the processed food and industrial goods component, and with some qualifications the services sector – we find either no indication of an increasing reluctance to revise prices, or – in the industrial goods component – a higher inclination to change prices in the post D-Mark period, which is, however, declining.

The Wal-Mart effect is not statistically significant at the aggregate level, but the price war and the ruling of the competition authority impacts forcefully on the frequency of price revisions for processed food, adding to the downward adjustments in July 2000 and to the upward adjustments in October 2000.

Most interestingly, there is some persistence in the frequency of price adjustments. At the aggregate level, the coefficient of the lagged frequency of price adjustments is small (0.10), but statistically significant at the 5% level. Among the main components, the persistence in price adjustments is particularly strong in the processed food segment. Regarding the direction of price changes, persistence in the frequency of price increases prevails in the processed food, industrial goods and services components. For services and industrial goods, there is also an impact of the incidence of price reductions of the previous period: it reduces the frequency of price increases. Concerning price reductions, positive temporal dependence is observed for processed food.

There is substantial seasonality in price adjustment (Table 6). The seasonal effects are particularly pronounced for unprocessed food, industrial goods and services, less so for energy. It was only among processed food that no significant seasonality could be found. Regarding energy, we find a bunching of price adjustments in January and in April, even after controlling for tax increases. The seasonality vanishes if upward and downward adjustments are analysed separately, which hints at time-dependent pricing strategies. At the level of individual products, such time-dependent strategies are observed for gas, and most importantly, for electricity. For industrial goods and services, the seasonal pattern of upward price adjustments resembles that of downward revisions: there are many more price adjustments at the beginning of the year than at the end of the year. In the unprocessed food component, we observe an above-average inclination to change price in January. Seasonality is much more pronounced with respect to the direction of price changes: price increases occur much more often in November, December, January and February, less often in the months March to July. For price decreases, the opposite applies. This pattern hints at strong seasonal effects in the driving forces, not so much in pricing itself.

Since the econometric exploration uncovers fewer regularities with respect to the size of price changes, we do not report the details. However, three important aspects of the temporal pattern of the intensity of price changes are worth mentioning. Firstly, there are statistically significant seasonal effects in the size of price changes, most importantly for unprocessed food, but also in some other categories. In the former segment, the seasonal variations in size tend to reinforce those in the frequency of price adjustments. Secondly, price changes related to the increase in VAT were on average significantly smaller than in other periods. This effect was particularly pronounced in

Table 6: Seasonality in price adjustment

	Full sample			Energy			Unprocessed food		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
January	1.84			12.17			3.43	6.77	-4.09
February	0.99			-2.21			1.56	5.12	-1.78
March	-0.16			-2.53			-1.37	-2.29	1.33
April	0.39			4.20			0.72	-2.06	2.32
May	0.03			-0.61			0.62	-4.31	4.78
June	-0.45			-2.01			-0.44	-5.45	4.96
July	0.02			-1.58			-0.19	-3.50	3.10
August	-0.70			-2.76			-1.01	-0.30	-0.84
September	-0.14			-1.52			-0.31	1.87	-2.42
October	-0.10			2.35			-0.85	-1.11	0.20
November	-0.56			-2.89			-0.83	2.69	-3.61
December	-1.17			-2.61			-1.33	2.59	-3.97
	Processed food			Industrial goods			Services		
	AD	IN	DE	AD	IN	DE	AD	IN	DE
January				1.75	0.88	0.81	1.68	0.85	0.88
February				2.19	0.92	0.92	1.87	1.54	0.44
March				1.39	1.35	-0.10	-0.07	0.02	-0.11
April				-1.39	-0.76	-0.44	0.22	0.26	-0.12
May				-1.00	-0.65	-0.07	0.10	0.06	-0.18
June				-1.01	-0.51	-0.40	-0.49	-0.33	-0.24
July				-0.50	-0.41	0.01	-0.08	-0.17	0.08
August				0.33	-0.36	0.64	-0.93	-0.57	-0.29
September				1.75	1.81	-0.23	-0.65	-0.54	-0.09
October				-1.11	-0.62	-0.41	-0.47	-0.41	0.01
November				-0.77	-0.46	-0.26	-0.28	-0.08	-0.10
December				-1.61	0.88	-0.47	-0.89	-0.62	-0.27

Sources: German Federal Statistical Office and authors' calculations.
Notes: Additive seasonal factors for the regression results of Table 15. Quality-adjusted prices. AD: price adjustments. IN: price increases. DE: price decreases.

the services segment. And thirdly, the price changes related to the cash changeover were significantly smaller than in other periods, especially in the processed food and the industrial goods segment, where upward and downward adjustments were affected in a similar way. For services, price increases were much less strong, whereas the size of price decreases was not outstanding. The below-average size of price adjustments observed with the cash changeover might be interpreted as evidence supporting the menu-cost explanation of the bunching of price revisions (Gaiotti/Lippi 2004). However, it is likely that some of the small-sized prices changes simply resulted from rounding to a convenient price (Buchwald *et al* 2002).

Summing up, at the level of the main components we find some evidence of state-dependent elements in pricing, even without directly taking account of price and demand developments in the relevant markets. The increase in VAT and the cash changeover increased the frequency of price adjustments significantly. The lagged endogenous variable, which turns out to be highly significant for some components, hints at lagged adjustment. At least in unprocessed food, the seasonal pattern can be interpreted as response to changing market conditions. In the industrial goods and services sector, however, the seasonality, which is approximately identical for upward and downward adjustments, probably results from seasonal regularities in pricing.

3.3.3 Case studies

The empirical model for the analysis of the time-series properties of the frequency and the size of price adjustments at the level of the main components presented above abstracted from time-variant cost and demand conditions. In this section, we will take into account product-specific cost developments, approximated by the input price indices introduced in section 3.2.3 (see also Annex A3).[36] Otherwise, the set-up is identical to that in the previous section. The input price variable enters the regression with the contemporaneous monthly change and with several lags. As before, explanatory variables not significant at the 5%-level are dropped.[37]

The limitations of this approach should be obvious. For a characterisation of the differences in input price behaviour in a cross-section analysis as in section 3.2.3, which implies averaging over time, the input price indices should work reasonably well. For a time-series analysis, the demands on the data are more stringent. We can hope to find a significant relationship between the frequency (and the size) of price changes at the item level only for those goods and services with closely corresponding specifications in the import and producer price indices and the CPI, which should be the case for rather homogenous products. Furthermore, the prices observed in the import and producer price indices have to correspond to the actual input prices for the provision of the

[36] For other studies linking individual price adjustment to input prices, see Slade (1998), Levy *et al* (2002) and Davis/Hamilton (2004).

[37] As in the cross-section analysis, an alternative approach would transform the left-hand variable into a log-odds ratio. As we are more interested in the qualitative results and less so in the numerical parameter estimates, we stay with the more simplistic linear approach.

consumer goods. This should be the case for goods, which are traded on well-organised markets such as energy or some foodstuffs.

This is indeed the case. For energy and unprocessed food, some processed food and one industrial product, we find a significant short-term responsiveness of the frequency of price adjustments to changes in the respective input price indices. Starting with energy (Table 7), we can establish that producer prices have a strong contemporaneous effect on the incidence (and on the size - but these results are not reported here) of price adjustments for fuel. Input price inflation increases the frequency and the size of price increases and reduces the frequency and the size of price reductions. The nearly identical results for heating oil are not reported here. The evidence on gas (and electricity) is similar with respect to the frequency of upward price revisions, but there are some indications of asymmetries as consumer prices seem to be less responsive to producer prices downwards.

Among unprocessed food, producer prices also have a strong contemporaneous effect on the frequency (and on the size) of upward and downward price adjustments for lettuce. There is some residual seasonality both in the time series of the frequency and the size of price revisions. For bananas, the evidence is quite similar with respect to the incidence of price revisions, but without indications of residual seasonality, and the link between input prices and the size of price adjustments does not seem to be very strong. Concerning other unprocessed food, the link to the input price series is rather weak. Instead, we observe some persistence in the frequency measures.

For most processed food, the input price measures do not affect the frequency of price adjustments very strongly. Moreover, little of the temporal variation in the size of price adjustments can be explained. It is only in the case of milk that the results resemble those for unprocessed food. There is a strong contemporaneous effect on the incidence of upward and downward price adjustments, and there are some indications of lagged adjustment. The producer price of milk is also found to affect the size of price increases in the same period, but the size of price reductions cannot be explained satisfactorily. Much more typical of processed food is mineral water. The not very pronounced variation in the frequency of price increases and reductions can be explained to a large extent by the cash changeover and seasonal variation.

Table 7: Temporal variation in price adjustment: case studies

	Fuel1		Gas		Electricity		Bananas		Lettuce	
	IN	DE	IN	DE	IN	DE	IN	DE	IN	DE
Constant	44.73	45.85	5.38	7.09	4.35	1.69	14.24	7.60	42.18	
Input price	10.51	-10.11	6.60	-2.41	10.17	-2.05	0.90	-0.86	0.69	-0.80
Input price (-1)							1.30	-1.46	0.45	-0.55
Input price (-2)								-0.36		-0.21
Trend				-0.05						
VAT			73.32	32.37	77.59					
EURO1					23.74			26.97		25.75
EURO12										
POSTDM										
IN(-1)							0.52	0.63		0.59
DE(-1)						0.47				0.41
WAL										
POSTWAL										
SEASON			X	X	X	X			X	X
Adj R squared	0.84	0.81	0.83	0.80	0.82	0.38	0.68	0.65	0.77	0.84
DW statistic	2.15	2.01	1.82	1.88	2.03	1.97	1.84	2.03	2.36	2.26
No of periods	72	72	72	72	72	71	71	71	71	71
Mean dependent var	48.59	42.13	9.49	4.34	8.48	2.24	27.36	25.95	42.35	42.12
SD dependent var	32.30	31.66	18.36	8.54	21.62	5.88	14.99	14.70	23.97	24.10

	Milk		Water		Beer		Tyre	
	IN	DE	IN	DE	IN	DE	IN	DE
Constant	2.29	3.05	2.33	3.35	2.42	2.00	4.94	3.93
Input price	3.90	-3.64	1.12				1.54	
Input price (-1)		-3.13	0.47		1.43			
Input price (-2)		-2.11	1.04		2.66			
Input price (-3)			0.44					
Input price (-4)			0.55					-0.33
Input price (-5)			0.98					
Input price (-6)			0.30					
Trend			0.03					
VAT					1.11		22.44	10.69
EURO1		25.74	9.13	12.08	11.65		20.28	12.35
EURO12								
POSTDM				1.06	1.86			
IN(-1)	0.53	0.40			0.22			
DE(-1)								
WAL								
POSTWAL								
SEASON			X			X		X
Adj R squared	0.61	0.46	0.74	0.67	0.71	0.71	0.67	0.77
DW statistic	1.70	1.60	1.86	2.00	1.58	1.67	1.92	2.00
No of periods	71	71	71	72	71	72	72	72
Mean dependent var	5.02	5.26	4.70	3.87	4.81	3.46	5.75	4.20
SD dependent var	6.56	6.55	2.15	1.78	2.55	1.44	4.03	2.60

Sources: German Federal Statistical Office and authors' calculations.

Notes: OLS. Quality-adjusted prices. IN: price increases. DE: price decreases. Input price: changes in the respective input price indices. 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. WAL=1 in July 2000; POSTWAL=1 in October 2000. SEASON=X: seasonal dummies jointly significant at a 5% level. Only coefficients reported which are statistically significant at 5% level, using Newey-West HAC standard errors.

In the industrial goods component, it is only for a few products that the quality of the match between consumer prices and input prices is sufficient for a time series analysis of price adjustment. In the case of steel radial tyres, for which an approximately exact match was possible, the input price variable is found to affect the frequency of price revisions upwards contemporaneously. The changeover dummy and the VAT dummy are highly significant. For other industrial products, the link to the input price indices is rather weak, but the cash changeover effect is always highly significant.

For services, seasonality and the changeover effect explain most of the variation in the frequency of price adjustments. The link to the input price indices is rather weak in the time series dimension. For some services, as for hairdressing, we find a small positive trend in the incidence of price increases. In a few cases, the lagged endogenous variable is found to be statistically significant.

Summing up, for some products – such as fuels or fresh fruit – which are traded on well-organised, centralised markets, we observe a strong link between input prices and the frequency and the size of price adjustments of retail prices. This can be interpreted as a strong evidence of state-dependent pricing. For other products, we find such a strong link only exceptionally. This missing link should, however, not come as a surprise as it is not feasible with our data to link retail prices at the item level to the exactly corresponding producer prices. With well-organised markets, input price developments are uniform for all outlets, which explains the high explanatory power of input prices for the price adjustment of products such as milk or heating oil. However, even for some other products we observe an influence of input prices on price adjustment.

3.3.4 The changing distribution of prices

The adjustment of individual prices normally changes the location and the shape of the price distribution. It is only in special cases that the original distribution is maintained. If, for example, prices bounce alternatively and symmetrically, the price distribution remains invariant. If the adjustment of prices is fully synchronised and uniform in size, the location of the distribution may change, but not its shape. The same is true if prices move – when adjusted – from the bottom of the price range to the top, which can be expected for homogeneous products with perfectly staggered price setting.

More typically, if short-term adjustment is diverse, shocks will affect the distribution of prices, and it will take some time until a new equilibrium distribution is established.

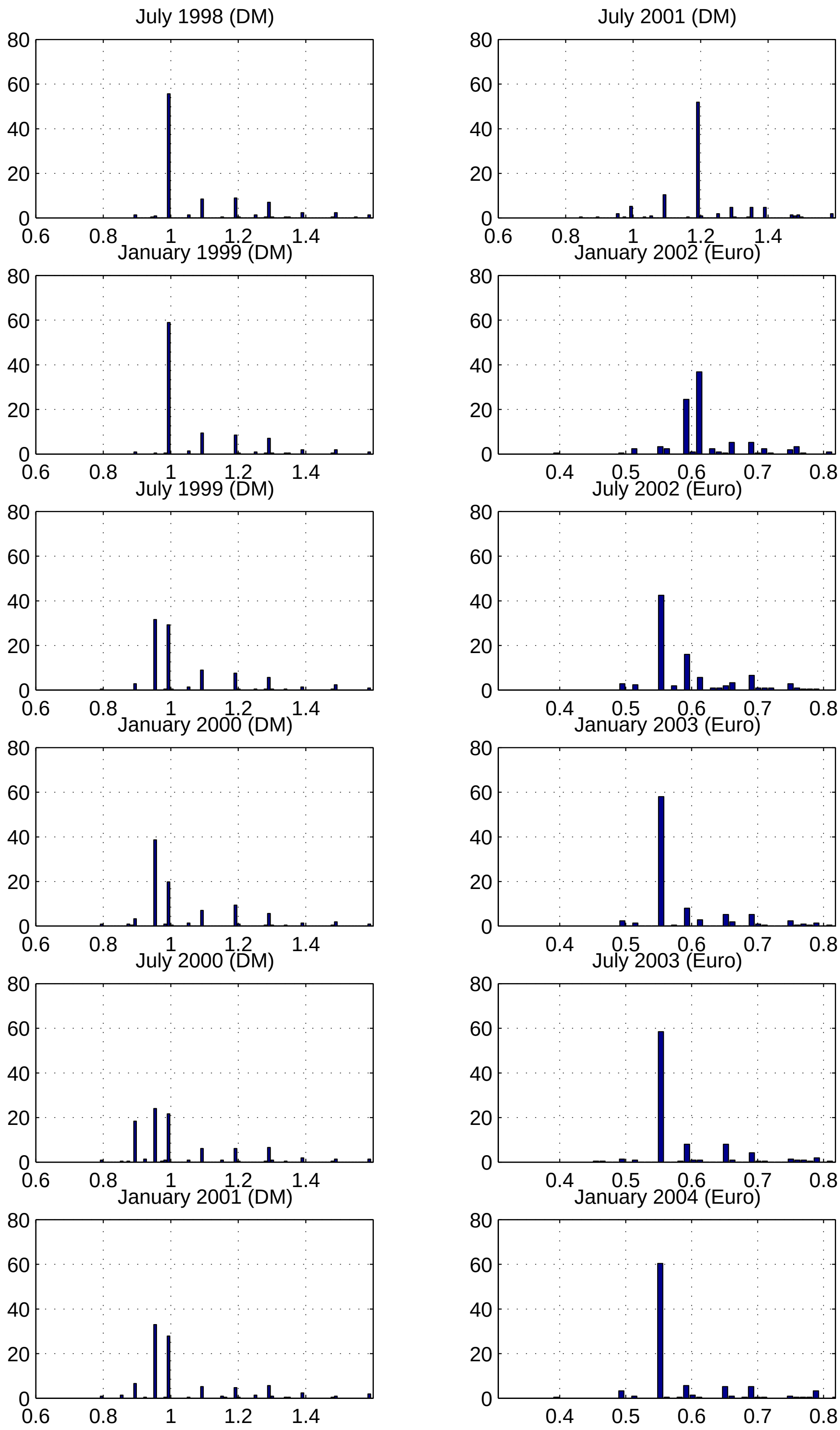
An analysis of the dynamics of price distributions is of interest in the context of the present investigation as it can shed some additional light on the degree of consumer price rigidity prevailing in the German economy. Attractive pricing implies that the full range of potential pricing points is not fully utilised for price setting. Especially at low prices, small percentage changes in prices are prevented by strict adherence to attractive pricing. The cash changeover, which called for a changeover from prices denominated in D-Mark to prices denominated in euro, by means of the conversion rate of DM 1.95583/euro cut the number of potential pricing points approximately by half. Hence, we might have expected the cash changeover to induce additional price rigidity in Germany.

In the 52-product sample, we can distinguish relatively homogeneous products, such as bananas or sugar, and products with much more differentiation in quality as, for example, television sets. Among the more homogenous products, we often find a small number of different prices accounting for a large percentage of price observations. This should not come as a surprise as for truly homogenous products with perfect competition and instantaneous adjustment the price distribution would collapse into a single mass point. Figures 12 and 13 provide evidence on the price distributions of two of the more homogenous products, milk and admission to cinema.

We see that the equilibrium distribution of milk prices (Figure 12) is characterised by a single peak, which accounts for about 60% of the observations, whereas in periods of turmoil there are up to three pikes. There are numerous other pricing points, which are actually used, but most of them are without much importance. Typically three of them account for about 10% of the observations each, whereas the other pricing points share the remaining 10% to 20% of the price observations. At the beginning of the period under review, the dominant pricing point was located at DM0.99. At the end of the period, it was at €0.55.

The distribution of cinema prices (Figure 13) is much flatter, indicating greater heterogeneity in product characteristics. The most important pricing point accounts for only up to 25% of the price observations, but normally there are two or three pricing

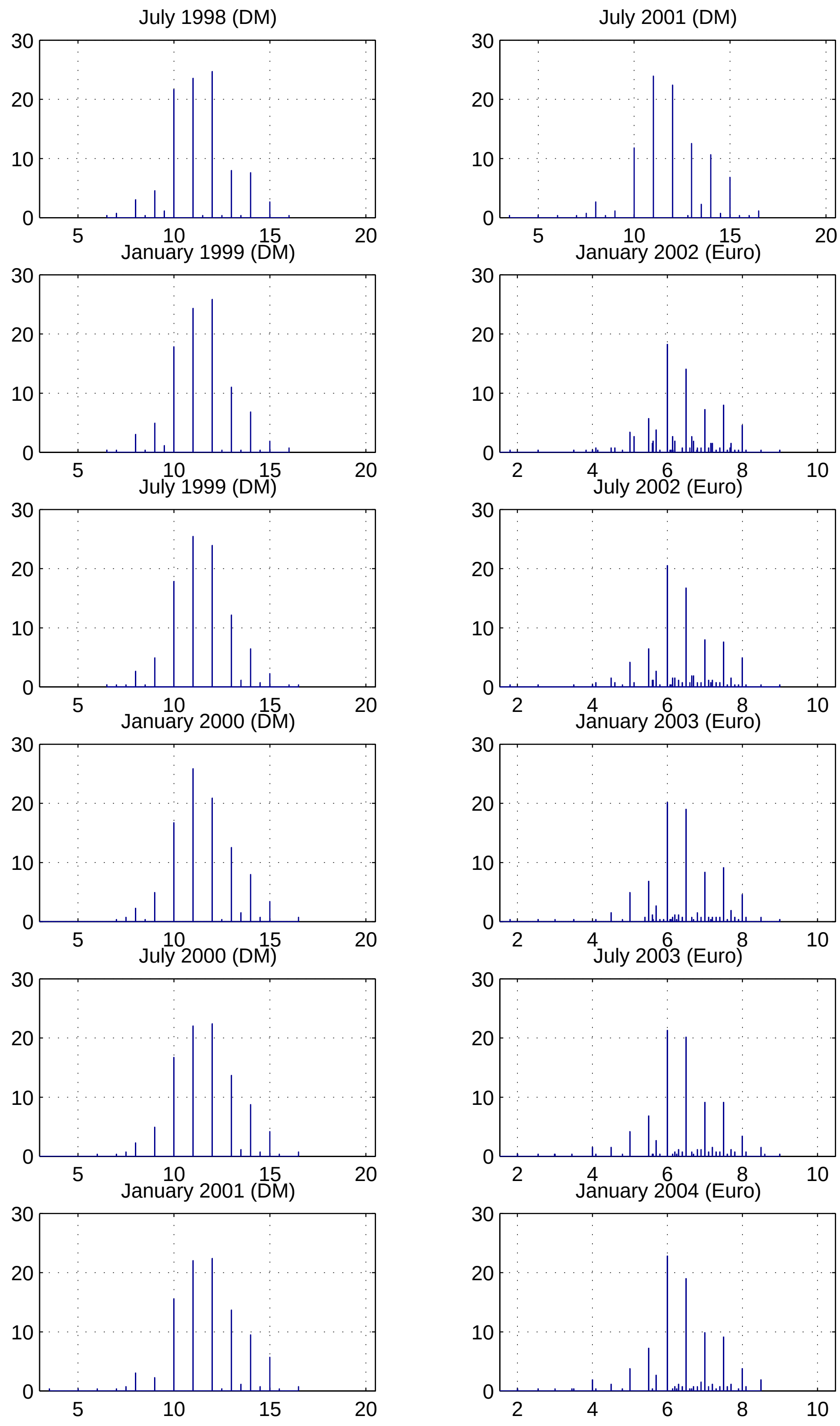
Figure 12: The changing distribution of milk prices



Sources: German Federal Statistical Office and authors' calculations.

Notes: Percentage of price observations.

Figure 13: The changing distribution of prices for cinema admission



Sources: German Federal Statistical Office and authors' calculations.

Notes: Percentage of price observations.

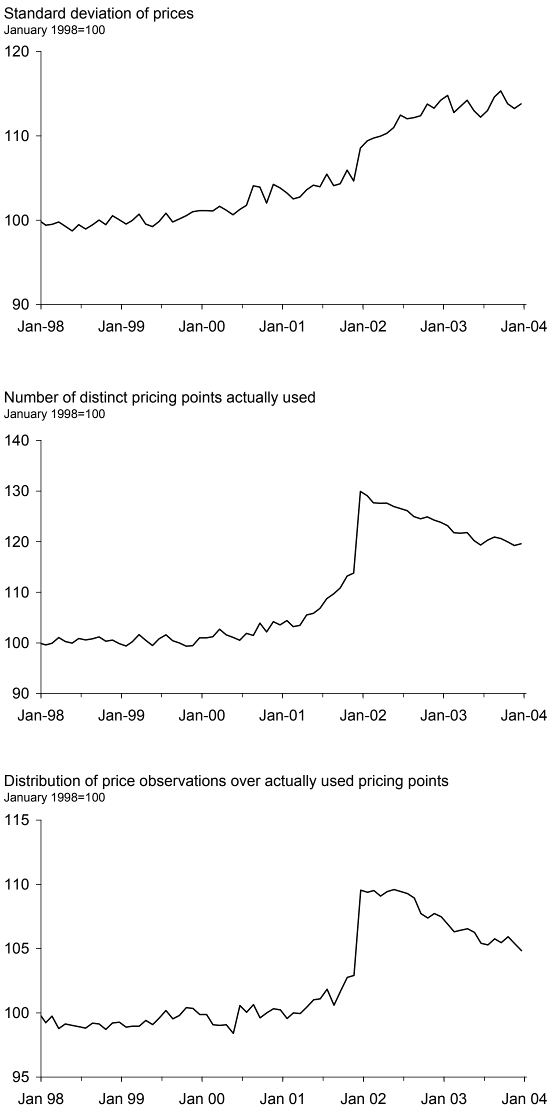
points on which more than 20% of the price records are concentrated. The cash changeover brought an increase in price diversity. The number of different pricing points actually used was stepped up sharply, but most of these new prices never gained much importance. In July 1998, DM12 was the most important price; in January 2004, it was at €6 slightly lower. However, whereas at the beginning of the period under review most of the observations were located left of the most prominent price, at the end of the period most of the mass was right of the mode. As a consequence, prices in January 2004 were, on average 9½% higher than in July 1998.

For most of the products, the price distributions are even flatter than for cinema tickets, hinting at substantial heterogeneity in product quality. We therefore use three different measures for characterising variation in price diversity. The first one is the traditional standard deviation, which is often applied for assessing price diversity. The standard deviation would be a fully satisfactory measure if the price records referred to strictly homogenous products and if distribution of prices were continuous and symmetric. The actual price distributions, which belong to differentiated products, can be characterised as degenerate continuous distributions collapsed into discrete contributions with several mass points. We therefore propose using the number of different pricing points with non-zero price observations and the Gini coefficient, which measures the evenness of the distribution of prices quotes over the actually used pricing points. As we are interested in price diversity, we choose 1-Gini as a measure, with the value 0 indicating a distribution collapsed into the mode and 1 an even distribution of the price observations over the actually used pricing points.

Products with a small number of actually used pricing points are typically quite homogenous, whereas, for heterogeneous products the number of distinct pricing points can be quite huge. A demand or supply shock affecting a specific market may either increase the number of different pricing points, or may reallocate the prices among the different pricing points, probably by reducing the mass of the predominant prices.

For milk, for example, we have 240 price observations per period, which share 27 pricing points on average. The inverse Gini coefficient averages 0.13, indicating a high degree concentration of the price observations. Concerning admission to cinemas, 263 observations per period share on average 26 pricing points, with the number of actually

Figure 14: The changing price diversity



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; February 1998 to January 2004; four-digit weights rescaled with original main-components weights; actual prices.

used distinct prices increasing from 17 in the D-Mark period to 43 in the euro period. The inverse Gini coefficient averages 0.17, without much difference between the D-Mark and the euro period. For other products such as mineral water, for example, we find a significant increase in the number of distinct prices and in the inverse Gini coefficient, indicating more diverse price setting in both dimensions.

For summarising the development of price diversity in the 52-product sample, we compute weighted averages of product-specific indices of the three diversity measures, normalised to 100 in January 1998. All three measures indicate that price diversity has increases in recent years (Figure 14). The standard deviation displays a rather steady increase, starting in 2000, which accelerated after the cash changeover. The number of distinct pricing points actually used increased sharply with the cash changeover, and went down only slowly afterwards. In January 2004, the number of distinct price was on average 20% higher than six years earlier. This means that reduction in the number of potential pricing points due to the cash changeover actually led to an increase in the number of distinct prices. This was brought about by a change in price setting, which means that the retail outlets made more use of non-attractive prices. The cash-changeover also made the distribution of prices over the actually pricing points more even. Prominent prices, at least temporarily, became less important. In the wake of the cash changeover, the importance of prominent prices increased slowly, without fully regaining its previous level.

Summing up, the analysis of the changes in the distribution of prices gives no indication that the changeover from the D-Markt to the euro increased nominal rigidities in Germany. On the contrary, the number of pricing points actually used increased substantially. The greater number of actually utilised distinct prices and the more even distribution of prices, which prevailed even two years after the changeover, however, indicate that the changeover was a major shock to price setting from which the price structure recovered only slowly.

4 Determinants of the length of price spells

4.1 Some descriptive statistics

By averaging across outlets, the frequency approach does not make full use of the panel structure of the individual price data. Furthermore, at the level of the individual price spells, the heterogeneity of the price durations within products and the dependence of price adjustments on the duration of prices can be analysed in more detail. And finally, the question of whether state- or time-dependent pricing prevails can be addressed more thoroughly.

Before proceeding to a deeper analysis of the determinants of price durations, we start with some summary statistics. After adjusting for the overrepresentation of short spells (see Appendix A4) and after applying the four-digit COICOP weights rescaled with the original main-components weights results in an estimate of the average duration of prices of nearly 29 months (Table 8). Disregarding all censored spells – spells either not beginning or not ending with a true price change (see Appendix A4) – tends to give smaller estimates of the average duration of prices (20 months). These estimates are broadly in line with the durations implied by the product-specific

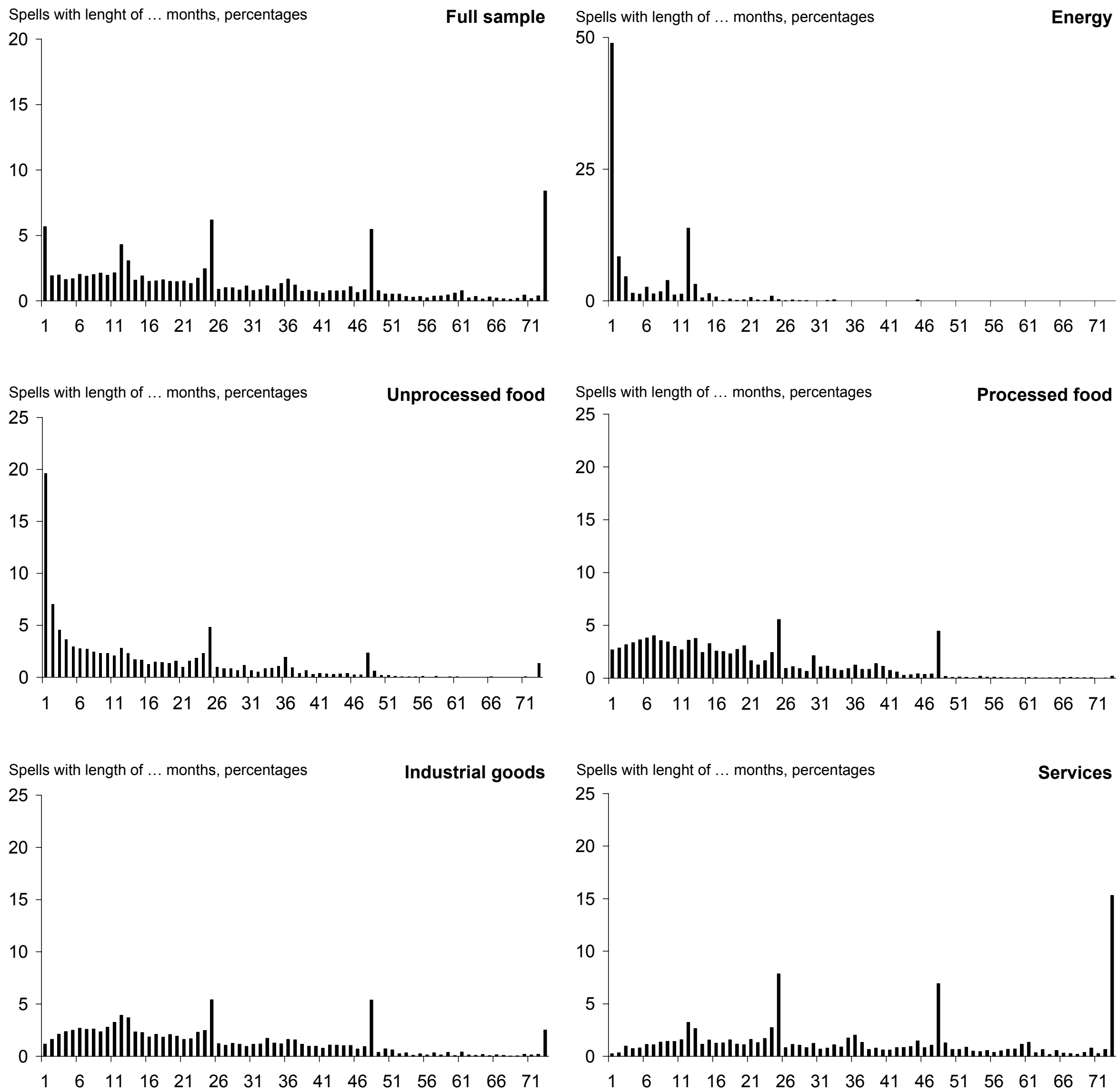
Table 8: The average length of price spells

Main component	All spells	Uncensored spells
Unprocessed food	15.4	10.6
Processed food	19.0	13.9
Energy	5.3	5.4
Oil products	1.2	1.2
Electricity, gas	10.9	11.1
Industrial goods	24.8	18.2
Services	37.7	25.6
Ex rents	27.7	22.0
Housing rents	49.2	29.7
Overall	28.6	20.0
Ex rents, electricity and gas	23.3	17.7

Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample, January 1998 to January 2004, mean duration in prices calculated from monthly quality-adjusted prices, product weights: four-digit COICOP weights rescaled with original main-components weights; duration weights.

Figure 15: The distribution of price durations – all observations



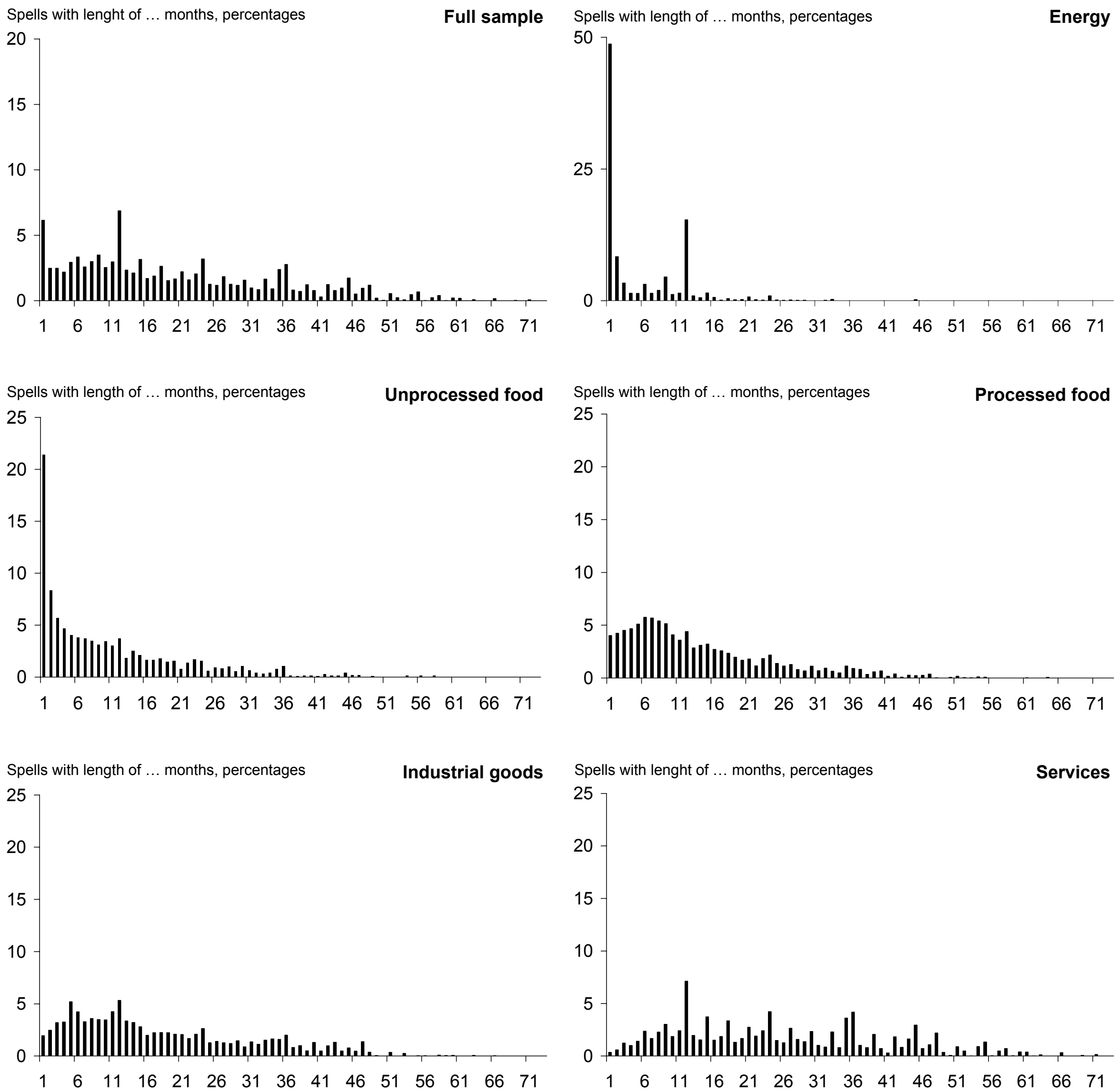
Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; January 98 to January 04; quality-adjusted prices; product weights: four-digit COICOP weights rescaled with original main-components weights; duration weights: adjustment for oversampling of short spells as described in Appendix A4.

frequencies of price adjustment changes presented in section 3.2.1.[38] Excluding housing rents, gas and electricity as in other euro-area country studies reduces the estimated average duration of price spells to 23 months.

[38] Indirect estimates of the mean duration of prices may be derived from the frequency of price changes by inverting the respective figures. Such an approach is sometimes considered more appropriate than the direct approach as it is more robust with respect to censoring. However, with heterogeneity in durations, the outcome depends heavily on the ordering of inverting and averaging (see, for example, Dhyne *et al* 2005). Inverting the weighted average of product-specific average frequencies of price

Figure 16: The distribution of price durations – uncensored spells



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample; January 98 to January 04; actual prices; product weights: four-digit COICOP weights rescaled with original main-components weights; duration weights: adjustment for oversampling of short spells as described in Appendix A4.

On the one hand, these estimates may still underestimate true average duration of prices, as there is a substantial number of spells, which are strictly double-censored. Most importantly, more than 30% of the (quality-adjusted) rents in the private sector of the German housing market did not change at any time during the six-year period under

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change would result for Germany in an estimate of the mean duration of prices of about nine months. Averaging product-specific durations gives a much higher estimate (25 months), which is close to our estimates.

review.[39] In addition, for several services and for 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 are biased upwards for products with volatile prices. Moreover, our adjustment mechanism for the correcting oversampling of short spells is biased upwards if there is a pronounced heterogeneity in product- and outlet-specific price durations.

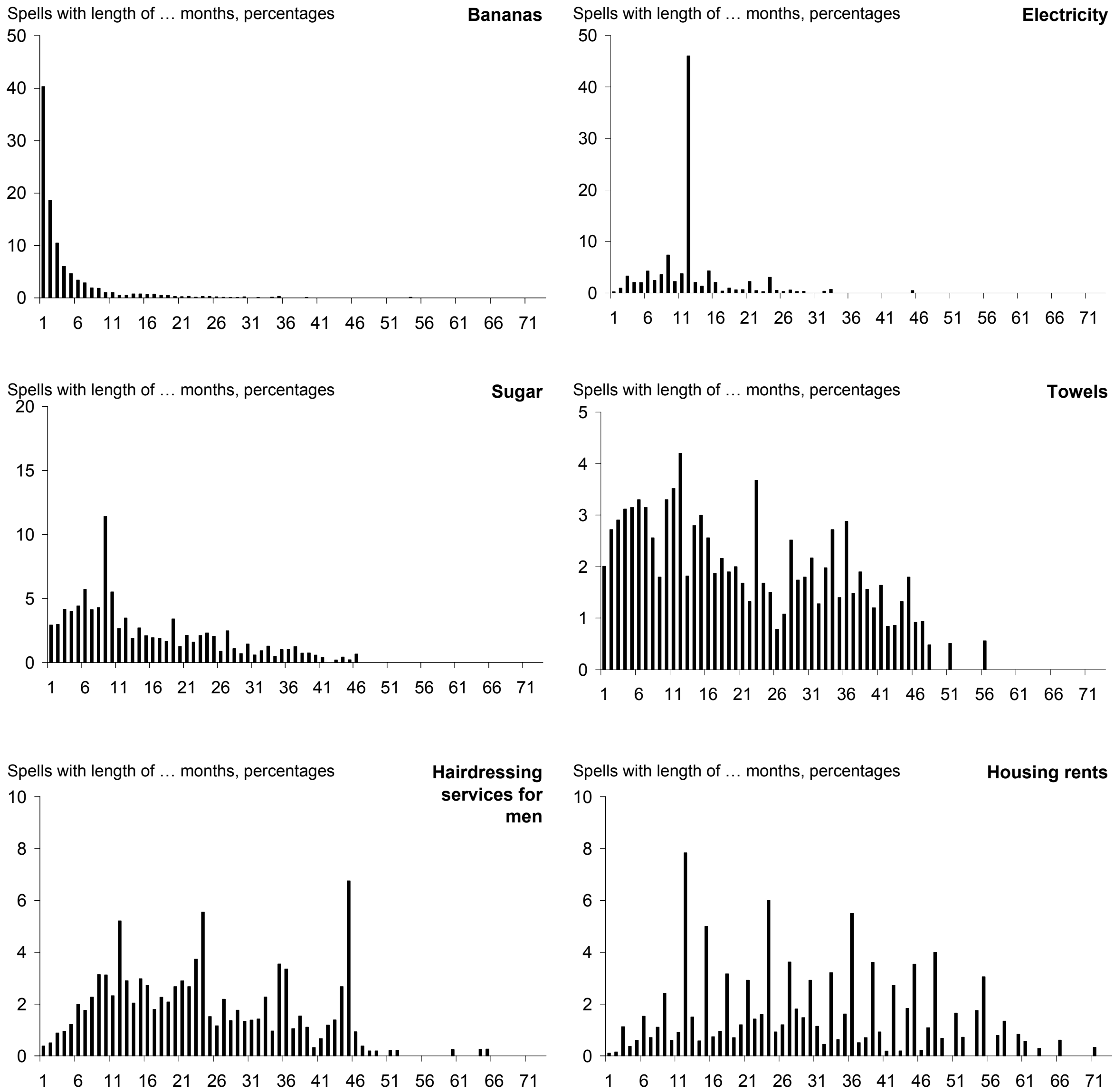
Looking at the distributions of price spells in more detail, we see that the patterns of durations are broadly similar for the full set of observations and for the uncensored spells (see Figure 15 for the full set of price spells and Figure 16 for the uncensored price spells). There are, however, three noticeable differences. Firstly, in the full sample there is a spike at 25 months, which is not apparent in the uncensored sample. This peak is related to the redesign of the product and outlet sample in February 2000, which resulted in numerous purposive product replacements.[40] The second difference is the peak at 48 months, which stems from spells which are left-censored in January 1998 and end in December 2001 with the cash changeover. Furthermore, there are a number of double-censored spells which last 73 months.

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 uncensored sample, there are 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, which are typically adjusted once a year (see Figure 17) –, 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. The distribution of price spells for unprocessed food is extremely skewed with a concentration on short durations. The distribution for processed food is much flatter with its main mass lying between one and

[39] In the matched-models sample, the share of rents never adjusted in the period under review shrinks to slightly more than 20%. About 10% of the housing rents were adjusted once, but the change in price was neutralised for the measurement of inflation as it was related to a reconditioning measure.

[40] If the statistical agencies of the German Federal States had consistently applied the overlap-method for the chain-linking of the individual price series, we would not see an above-average share of quality-adjusted price spells ending after 25 months.

Figure 17: The distribution of price durations for some selected goods and services



Sources: German Federal Statistical Office and authors' calculations.

Notes: January 98 to January 04; quality-adjusted prices; uncensored spells only; adjusted for oversampling of short spells as described in Appendix A4.

main mass lying between six and 48 months. Afterwards it flattens out. In the distribution of services price spells, 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. The changeover to the euro cash took place 45 months later. 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.

The heterogeneity of price durations does not disappear with further disaggregation (Figure 17). For example, most of the prices for bananas last only one or two months. However, a small number of outlets offered bananas at constant prices for more than three years. In the case of sugar, the high percentage of spells lasting nine months stands out. These spells mostly started with the cash changeover and ended in September 2002, when a synchronised increase in prices took place. Otherwise, prices typically last up to one year; however, a substantial number of price durations of more than two years is also observed.[41] For towels, the pattern of price durations is highly diverse: some prices lasting only one month, other prices more than four years. The distribution of price durations for hairdressing services is characterised by peak at 12, 24 and 45 months. There is a multitude of price durations for housing rents, from less than one year to more than six years, if the (double) censored spells are taken into account. The spikes at multiples of three months stem from the quarterly frequency of the rent survey.

4.2 Disentangling the heterogeneity in price durations

For analysing the consumer price adjustment in Germany at the level of the individual price spells, we estimate an empirical model explaining the probability of a price being changed.[42] A change in price is here defined as a change in the product- and outlet-specific item price index. This implies that – as in the measured rate of CPI inflation – product replacements are treated equivalently to true price changes if there is a change in the quality-adjusted item price index. We take into account all price spells, with the exception of the strictly left-censored spells, which means that only the first spell of each trajectory is considered as being left-censored and excluded.

As explanatory variables, which are detailed in Table 9, we consider duration- and state-related factors. Concerning the duration of price spells, we follow Dias *et al* (2005) and estimate a fully saturated discrete-time set-up.[43] A set of seasonal monthly dummy variables – with December chosen as the base – may also capture time-

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[41] Herrmann/Möser (2002) also report diverse price durations even for homogenous products in German groceries.

[42] For similar exercises, see, among others, Aucremanne/Dhyne (2005), Baumgartner *et al* (2005), Dias *et al* (2005) and Fougère *et al* (2005).

[43] Outliers – spells with duration of more than 36 months – are right-censored.

dependent price setting behaviour as well as state-dependent effects. Other state-dependent factors taken into consideration are the increase in VAT in April 1998 and the euro cash changeover in January 2002. An additional dummy variable (EURO12) tests whether in the months immediately before and after the cash changeover the probability of observing price changes was higher or lower, and the dummy variable postDM is expected to capture any differences in price setting behaviour in the euro era compared with the DM era. Furthermore, we allow for (cumulative) product-specific retail-price and input-price inflation as introduced in section 3.2.3.

For reducing the problem of heterogeneity, we control for the main product categories, outlet types, the regulation of markets and attractive pricing.[44] Moreover, as Dias *et al* (2005) and Stahl (2005a) have stressed, saturating the hazard function (instead of a parametric approach) should minimise the problem of unobserved heterogeneity. With respect to weighting, we also follow Dias *et al* (2005) and adjust for the oversampling of short price spells by weighting the individual price spells with the inverse of the number of non-left censored price spells of the item-specific price trajectory. Furthermore, as the number of price trajectories per product is rather unbalanced and the relative importance of the various products in the CPI is not uniform, we also apply the rescaled 4-digit-COICOP weights.

With respect to the direction of price changes, firstly it seems to be sensible to distinguish price increases and price decreases. As Aucremanne/Dhyne (2005), Fougère *et al* (2005) and Lünnemann/Mathä (2005) suggest, the effects of the covariates on the probability of a price adjustment will differ with respect to direction of the adjustment, most importantly in the case of cumulative inflation. Secondly, there are reasons to expect that the motives for a sequence of price adjustments in one direction are different from those, which lie behind a series of price changes in opposing directions. Therefore, we consider, as Stahl (2005a) did, four different transitions separately: a price increase followed by a price increase, a price increase followed by a price decrease, a price decrease followed by a price increase, and a price decrease followed by a price

[44] Alternatively, one might apply a fixed-effects panel estimator, as proposed by Baumgartner *et al* (2005). This, however, has the consequence that the effects of the time-invariant covariates are no longer visible.

Table 9: Explanatory variables

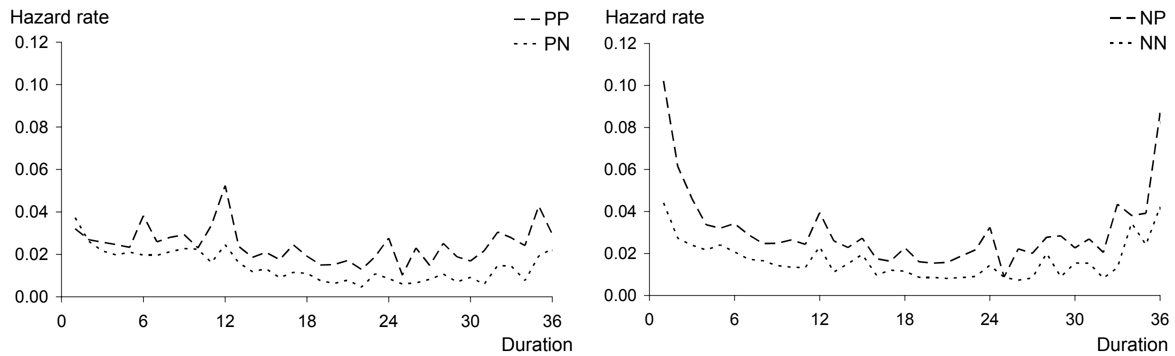
Code	Clear text	Default
absvgstart	absolute size of the previous price change	0
repstart=1	previous price change connected to product replacement	0
cuminf	cumulative product-specific inflation	0
cuminp	cumulative product-specific input price inflation	0
dcuminf	average cumulative product-specific inflation (dcuminf/dur)	0
dcuminp	average cumulative product-specific input price inflation (dcuminp/dur)	0
vat	April 1998 = 1	0
euro	January 2002 = 1	0
euro12	July 2001 to June 2002 = 1	0
postDM	from February 2002 on = 1	0
January		0
February		0
March		0
April		0
May		0
June		0
July		0
August		0
September		0
October		0
November		0
December		1
att	Attractive prices	
reg	Regulated prices	
out1	Department store	0
out2	Supercenter	0
out3	Supermarket	0
out4	Discount store	0
out5	Speciality store	0
out6	Other retail trade	0
out7	Service provider	1
unp	Unprocessed food	0
pro	Processed food	0
en	Energy	0
ind	Industrial goods	0
ser	Services	1
ldur	Duration (log)	

decrease. Following Stahl (2005a), we group these four transitions into two multinomial logit models.[45]

The estimation of unconditional (i.e. without covariates) multinomial logit models reveals significant differences in the transition-specific hazard functions. Whereas the hazard for a price increase following a price increase is approximately flat (with some

[45] The independence of the irrelevant alternatives (IIA) assumption underlying the multinomial logit model is often considered as being very demanding. In the present context, it is, however, not clear, why the IIA assumption should not hold, with the exception of price changes close to zero. Still, the test proposed by Hausman/Mc Fadden (1984) rejects IIA for our data. This means that the parameter estimates are inconsistent and should be interpreted with caution. The multinomial probit estimator, which is often proposed as alternative, as it does not rely on the IIA assumption, is, however, computationally infeasible.

Figure 18: Estimated unconditional hazard functions



Sources: German Federal Statistical Office and authors' calculations.

Notes: multinomial logit estimates; 52-product sample excluding housing rents, January 98 to January 04; quality-adjusted prices; excluding left-censored spells; weights: inverse of number of spells per item-specific price trajectory times four-digit weights rescaled with original main-components weights. PP: price increase following a price increase, PN: price decrease following a price decrease, NP: price increase following a price decrease, NN: price decrease following a price decrease.

peaks at six, 12 and 24 months), the hazard for a price increase following a price decrease is strictly decreasing up to a duration of six months (Figure 18). This indicates that the direction of the preceding price change matters and that just controlling for the direction of the previous price change by introducing a dummy variable will only capture some of the differences.

The results of the estimations including the covariates are detailed in Table 10. We report the estimated coefficients and the respective significance levels. The odds ratio (or relative risk ratio), which is computed by raising the natural log e to an exponent equal to the logit, can be understood as a measure of association. An odds ratio of one indicates that there is no statistical relationship between the covariate and the dependent variable. An odds ratio above one implies that an increase in the independent variable increases the risk of observing a price change relative to observing no price change.

Most of the results for the full sample seem to be quite robust and meaningful. Separate estimations for products groups or even specific products (which are not reported here) often gave qualitatively similar results. Sometimes, however, the results for sub-samples were less well behaved.

Overall, state- and time related as well as structural factors seem to play a role. Even after controlling for product-specific inflation and product-specific input price developments, prices tend to be changed more often at the beginning of the year than at

Table 10: Determinants of the probability of price changes

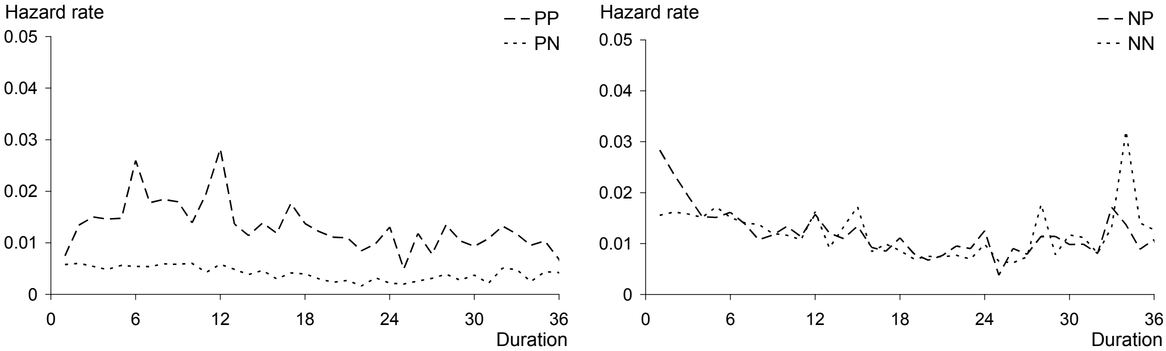
	Price increase followed by				Price decrease followed by			
	price increase		price decrease		price increase		Price decrease	
Variable	Coeff.	OddsR	Coeff.	OddsR	Coeff.	OddsR	Coeff.	OddsR
absvgstart	-0.002	0.998	0.025 ***	1.025	0.021 ***	1.022	0.006 ***	1.006
repstart	-0.005	0.995	0.123 *	1.131	-0.038	0.963	-0.031	0.969
cuminf	0.055 ***	1.057	-0.002	0.998	0.002	1.002	-0.072 ***	0.931
cuminp	0.049 ***	1.050	-0.118 ***	0.889	0.015 ***	1.015	-0.109 ***	0.897
vat	1.762 ***	5.824	0.516 ***	1.675	0.361	1.435	0.056	1.057
euro	2.635 ***	13.94	2.490 ***	12.066	2.192 ***	8.953	2.725 ***	15.26
euro12	-0.002	0.999	0.068	1.070	-0.119 **	0.888	0.279 ***	1.321
postDM	-0.376 ***	0.686	-0.125 ***	0.882	-0.272 ***	0.762	-0.126 ***	0.882
January	0.909 ***	2.481	1.123 ***	3.075	0.780 ***	2.182	0.714 ***	2.042
February	0.845 ***	2.327	0.542 ***	1.719	0.422 ***	1.525	0.333 ***	1.395
March	0.663 ***	1.940	0.261 ***	1.299	0.370 ***	1.448	0.109	1.116
April	0.602 ***	1.825	0.216 **	1.242	0.299 ***	1.349	0.114	1.120
May	0.447 ***	1.563	0.183 **	1.201	0.152 *	1.164	0.142	1.152
June	0.272 ***	1.312	0.141	1.151	0.113	1.120	0.244 ***	1.276
July	0.413 ***	1.511	0.316 ***	1.371	0.236 ***	1.266	0.524 ***	1.689
August	0.108	1.114	0.128	1.136	0.118	1.125	0.222 ***	1.249
September	0.278 ***	1.321	0.210 **	1.234	0.556 ***	1.743	0.034	1.034
October	0.250 ***	1.283	0.292 ***	1.339	0.375 ***	1.456	0.117	1.124
November	0.209 **	1.232	0.223 ***	1.250	0.136	1.146	0.024	1.024
att	-0.141 ***	0.869	0.053	1.055	-0.148 ***	0.863	-0.144 ***	0.866
reg	-5.691 ***	0.003	-5.847 ***	0.003	-4.383 ***	0.012	-5.106 ***	0.006
out1	-0.303 *	0.739	0.153	1.166	-0.162	0.850	-0.684 ***	0.505
out2	-0.294 *	0.745	0.178	1.195	0.106	1.111	-0.642 ***	0.526
out3	-0.478 ***	0.620	-0.044	0.957	-0.091	0.913	-0.678 ***	0.507
out4	-0.126	0.881	0.213	1.238	0.369	1.446	-0.780 ***	0.458
out5	-0.350 **	0.704	0.042	1.043	-0.101	0.904	-0.710 ***	0.492
out6	-0.417	0.659	0.501	1.650	-0.215	0.807	-1.024 ***	0.359
unp	0.948 ***	2.580	1.263 ***	3.536	1.268 ***	3.553	1.198 ***	3.313
pro	0.937 ***	2.552	1.567 ***	4.792	0.991 ***	2.694	1.171 ***	3.226
en	6.056 ***	426.7	6.141 ***	465.7	5.048 ***	155.7	5.746 ***	312.9
ind	0.512 ***	1.669	0.769 ***	2.159	0.465 ***	1.593	0.683 ***	1.979
Pseudo R2	0.17				0.16			
Observations	474,396				302,778			

Sources: German Federal Statistical Office and authors' calculations.

Notes: multinomial logit estimates explaining the occurrence of price changes; 52-product sample excluding housing rents; January 1998 to January 2004; quality-adjusted prices; excluding strictly left-censored spells; explanatory variables as detailed in Table 9; four-digit COICOP rescaled with original main-components weights and duration weights; *** significant at the 1% level, ** significant at the 5% level, *** significant at the 10% level; significance level derived from robust standard errors. OddsR: odds ratio = e^coefficient. The estimated coefficients of the 35 dummy variables capturing the duration are reported in Figure 19. PP: price increase following a price increase, PN: price decrease following a price decrease, NP: price increase following a price decrease, NN: price decrease following a price decrease.

the end. Regulation of price setting and attractive pricing is associated with less frequent price changes. For energy, the odds ratio is significantly higher than for the other product groups, and higher for non-energy goods than for services. However,

Figure 19: Conditional hazard functions



Sources: German Federal Statistical Office and authors' calculations.

Notes: Notes: multinomial logit estimates; covariates set to default values as in Table 9; 52-product sample excluding housing rents, January 98 to January 04; quality-adjusted prices; excluding left-censored spells; weights: inverse of number of spells per item-specific price trajectory times four-digit COICOP weights rescaled with original main-components weights. PP: price increase following a price increase, PN: price decrease following a price decrease, NP: price increase following a price decrease, NN: price decrease following a price decrease.

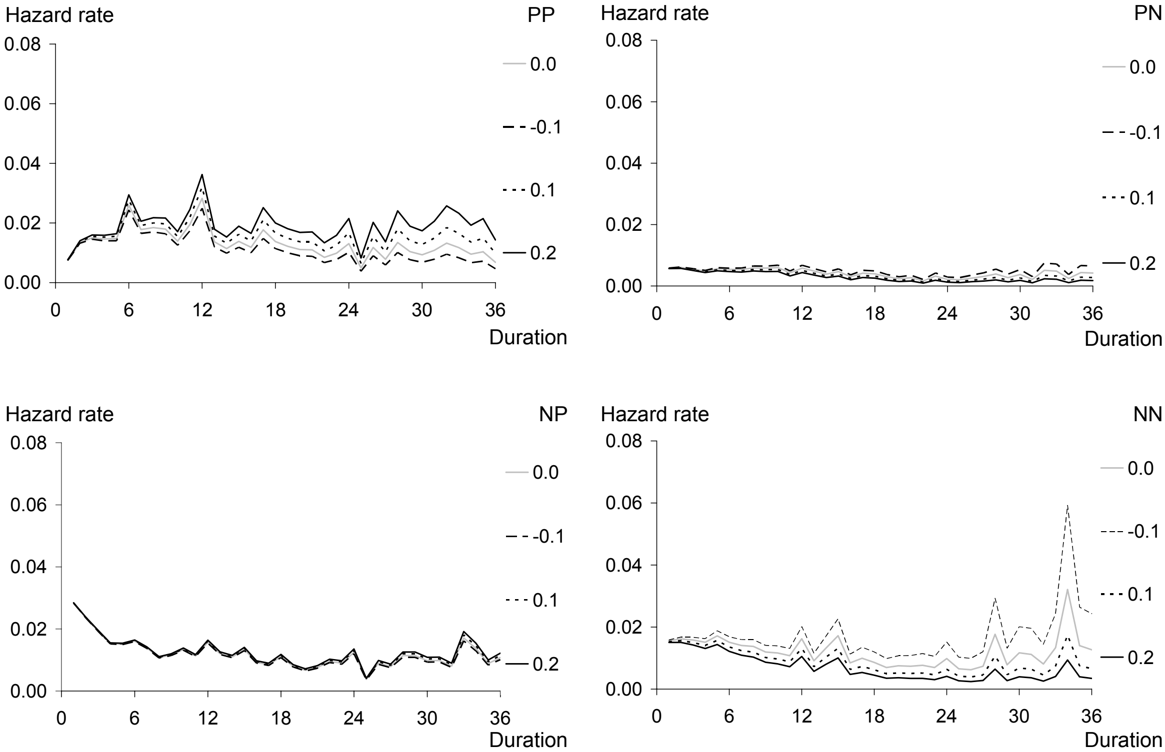
within the non-energy goods, after controlling for all the other factors, the odds ratios for processed food are approximately as high as for unprocessed food. The relative risk of industrial goods prices being changed is much lower. We do not find any systematic outlet effects.[46]

Turning to state-dependent effects, we see that the VAT increase of April 1998, and, more importantly, the changeover to euro cash of January 2002, were strongly associated with price changes. The VAT increase affected the probability of observing a price increase following a price increase positively (but also the probability of observing a price decrease following a price increase). The changeover increased the odds of price adjustments strongly, irrespective of the direction of the previous or the present price change. In the six months preceding and following the changeover the probability of observing a sequence of price decreases (and of a price increase following a price decrease) was higher. For the other transitions, the odds ratio is not significantly different from one. In the full post DM era, after controlling for the other factors, price changes occurred less often. The risk of price increases, in particular, shrinks.

Concerning the start conditions, the size of the previous price change turns out to be highly significant for all transitions with the exception of a sequence of price increases. A larger price increase at the beginning of a spell lengthens the duration of a

[46] The low odds ratio observed for several outlet types for a sequence of two consecutive price reductions is a rather strange result und asks for further considerations.

Figure 20: The impact of inflation on the hazard functions



Sources: German Federal Statistical Office and authors' calculations.

Notes: multinomial logit estimates; covariates set to default values as in Table 9 with the exception of product specific input and retail price inflation (monthly rates of change -0.1, 0.0, 0.1, 0.2; --, –, ¨, –); January 98 to January 04; quality-adjusted prices; excluding left-censored spells; weights: inverse of number of spells per item-specific price trajectory times four-digit COICOP weights rescaled with original main-components weights. PP: price increase following a price increase, PN: price decrease following a price decrease, NP: price increase following a price decrease, NN: price decrease following a price decrease.

spell ending in a price increase, but shortens a spell ending in a price reduction. The size of a price reduction shortens price durations for both upward and downward adjustments. It does not seem to matter at all, however, whether the price change at the beginning of a price spell was related to an item replacement. The REPSTART dummy, which takes the value one if the previous price change was related to a replacement, is not significant different from zero at a 5% level for any transition. This lends some credence to our approach of treating replacements as equivalents to true price changes.

Most importantly, the cumulative product-specific input price and retail price inflation since the last price change increases the likelihood of a price being increased and reduces the likelihood of a price being reduced. In general, this effect tends to be stronger for sequences of price changes in one direction than for ones in different directions.

The conditional hazard functions computed for the default values of the explanatory variables (see Table 9) – meaning, for example, that the product-specific input inflation rates are set to zero – are depicted in Figure 19. The hazard function for sequences of price increases is approximately flat. There are, however, some highly significant peaks at six and 12 months, hinting at time-dependent price adjustment. For price reductions following a price increase, the hazard function is also approximately flat. For price increases following price reductions, the hazard function is strictly declining for short durations. This pattern is probably related to promotions and special sales. Sequences of price reductions result in a partially declining hazard function.

The effects of non-zero rates of input and retail price inflation on the hazard rates are illustrated in Figure 20. Whereas for sequences of price increases, the effect of inflation on the hazard rates is quite pronounced, this is less so for price reductions following a price increase. A similar pattern can be found for price spells starting with a price decrease. A marked impact of inflation on the risk of price decreases contrasts with a rather muted impact on increases. Hence, while inflation seems to be relevant for price changes in one direction, this is less so for price changes in opposing directions.

Summing up, the econometric analysis of the determinants of the length of price spells reveals that state-dependent factors are relevant for price adjustment. This effect is particularly strong for sequences of price adjustments in one direction, whereas it is rather weak for price adjustments in opposing directions. This finding emphasises the importance of this distinction underlying our analysis.

4.3 Explaining the diversity in the size of price adjustments

The (multinomial) logit approach would provide an encompassing description of the factors governing retail price adjustment if the (relative) price changes were uniform in size. This is, unfortunately, not the case. Price adjustments are diverse. We observe small price changes of 1% or 2%, and we observe big price changes of 20% or 40%. The question, therefore, is whether there is any regularity in price setting with respect to the size of price adjustments.

For analysing this issue, we regress the size of non-zero price changes on the structural variables as, for example, those describing the product group and the outlet category, and state-dependent variables, for example, cumulative inflation. The explanatory variables are mostly the same as in the multinomial logit approach explaining the occurrence of price changes, albeit with two important exceptions. The first is that we employ a parametric approach to duration. The second is that – for capturing the effect of the time elapsed since the last price spell fully with the duration variable – we divide cumulated input and retail price inflation by the duration of the price spell. Hence, instead of cumulative inflation in the equation explaining the occurrence of price changes, it is here average cumulative inflation, which is to explain the size of price changes. Therefore, the coefficient of duration is expected to be positive, as firms delaying a price adjustment are expected to change prices more strongly than do firms with a policy of changing prices frequently. The variable to be explained is the size of absolute size of price adjustments, which is analysed separately for the four transitions. All the estimates are weighted, using the weights described in the previous section.

According to these estimates, which are detailed in Table 11, the size of price changes varies with input and retail price inflation. Overall increasing prices enlarge upward price adjustments and reduce downward ones, and *vice versa*. The duration of price changes, however, is not statistically significant at a 5%-level.

The increase in the VAT in April 1998 reduced the size of price increases. The changeover to euro cash of January 2002 reduced the size of price adjustments in both directions, with the moderation being more pronounced for price increases. In the period immediately before and after the changeover price changes turned out to be smaller. And finally, in the post-DM era the size of price adjustments changes for sequences of changes in the same direction was as large as in the DM era, which indicates that price rigidity did not increase systematically in the wake of the changeover. For the structural variables, mostly a statistically significant influence cannot be found.

Summing up, it is not only the probability of price adjustments but also the size of price changes, which is affected by product-specific, input price and retail price inflation. The same is true with respect to attractive pricing and regulation. However, whereas price increases have occurred less often in the euro era, the size of price increases has not changed significantly (at the 5% level), indicating that price rigidity has not become more intense.

Table 11: Determinants of the size of price changes

	Price increase followed by		Price decrease followed by	
	price increase	price decrease	price increase	price decrease
Variable	Coeff.	Coeff.	Coeff.	Coeff.
absvgstart	0.129 ***	0.329 ***	0.526 ***	0.134 ***
repstart	-0.208	1.440 *	-1.333 **	-0.514
dcuminf	0.426 ***	-0.384 ***	0.459 ***	-0.540 ***
dcuminp	0.704 ***	-0.718 ***	0.686 ***	-0.633 ***
vat	-3.400 ***	0.700	-1.964 ***	-2.536 *
euro	-5.269 ***	-2.536	-9.717 ***	-3.732
euro12	-0.399	-2.022 ***	-0.927 ***	-3.960 ***
postDM	-0.457	5.000 *	-1.826	3.167
January	-0.451	-0.604	0.574 ***	0.401
February	-0.059	-0.955 *	0.463 ***	-1.197 *
March	0.051	-0.850	-1.401	0.437
April	0.524	-5.749 **	1.144	-3.538
May	0.895	-4.020	2.303	-2.923
June	1.379 ***	-0.166	1.302 **	-0.992
July	-0.735 *	0.022	0.327 **	1.511 *
August	-0.121	-1.673	-0.405	1.172
September	-0.114	-1.048	-1.485	-0.034
October	0.149	0.554	-1.184	0.325
November	1.291 ***	0.495	-0.887	0.648
att	0.180	0.869	-0.411	1.047
reg	0.005	1.938 *	-0.247	1.630 *
out1	1.464 ***	-0.547	0.900	0.109
out2	1.287 ***	0.126	-1.310	-0.669
out3	1.365 **	-0.204	-0.270	0.700
out4	1.070 ***	1.048 ***	1.259 ***	0.781 *
out5	4.590 ***	4.700 ***	1.701 ***	6.429 ***
out6	0.630	-1.901	-0.901	-0.242
unp	0.696	-0.761	-1.439	0.742
pro	0.639	-1.138	-1.248	-0.661
en	-0.487	-0.875	-0.557	-0.129
ind	0.310	-1.140	-1.422	-0.422
lduration	2.481 *	-0.947	-1.467	-0.625
_cons	2.280 ***	2.913 ***	2.405 ***	2.807 ***
R-squared	0.19	0.25	0.41	0.15
No of observations	55,796	60,381	67,259	45,154

Sources: German Federal Statistical Office and authors' calculations.

Notes: OLS explaining the (absolute) size of (non-zero) price changes; 52-product sample excluding housing rents; January 1998 to January 2004; quality-adjusted prices; excluding strictly left-censored spells; explanatory variables as detailed in Table 9; four-digit COICOP weights rescaled with original main-components weights and duration weights; *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level; significance level derived from robust standard errors. PP: price increase following a price increase, PN: price decrease following a price decrease, NP: price increase following a price decrease, NN: price decrease following a price decrease.

The separate analysis of the determinants of the occurrence and the size of price adjustments is clearly not satisfying. Applying the Heckman selection model is however, not convincing either, as the zero price changes are observed outcomes of the optimisation process and are not equivalent to missing observations. Our approach resembles that of the two-part (or hurdle) model familiar in health economics, which is also problematic (Mullahy, 1998). More appropriate, but also more demanding, would be the estimation of a friction model, which is, however, beyond the scope of this paper.

5 Discussion of some important findings

Price adjustment in Germany is lumpy. Prices typically do not respond immediately to marginal changes in cost or demand. On the contrary (estimated from monthly price observations and adjusted for oversampling short spells) prices last on average about two years. Each month, only 10% of the prices are changed.

Focusing on average price durations and on the average proportion of prices being changed per month masks, however, the very pronounced differences in (unconditional) price flexibility. Firstly, there are sectoral differences. For fuels, a different price is recorded nearly every month, whereas prices of grocery products persist on average for several months. Secondly, there are marked differences even within sectors. Whereas prices of some foodstuffs, as lettuce or bananas, are typically adjusted very frequently, this is not the case for other food.

A closer inspection reveals that retail prices of grocery products with volatile producer prices (for example, lettuce), are adjusted very often, whereas prices of products with stable producer prices (for example, thanks to CAP, sugar) display much less variation. The finding that the volatility of important input prices amplifies the incidence of retail price changes suggests that the typical product-specific "unconditional" degree of price flexibility is endogenously determined in response to the (in)stability of the specific market environment. Moreover, we find – as Levy *et al* (2002) did – that grocery prices respond to product-specific input price shocks. Hence, we may conclude that it is not so much price setting in supermarkets or discount stores, which is generally less flexible than price setting at gas stations, it is the difference in the market conditions of specific products.

With respect to the direction of price changes, sequences of price adjustments in the same direction are found to be much more strongly influenced by product-specific cost and price developments than price adjustments in opposing directions. This finding can be interpreted as indicating that the motives for some of the price adjustments in opposing directions are different from the motives for price adjustments in the same direction. Short-term bouncing of prices is often related to promotions and special sales. The nature of such price adjustments is, however, of a different nature from that of price changes related to, say, changing input prices. Hence, as it has been emphasises by (Taylor 1999), it is necessary to distinguish between "regular" and promotional price changes, particularly when comparing evidence on price flexibility between countries. It is the responsiveness of prices to changing market conditions which matters, not the frequency of price adjustments as such.

In particular, the composition of the outlet sample with respect to shops following an "every day low price" (EDLP) price strategy or a "high low" (Hi-Lo) price strategy with frequent promotions is crucial. In Rotemberg (2005), for example, evidence for a Hi-Lo supermarket chain is presented. While the "regular" price of saltines in this chain was changed only five times over a period of 380 weeks, the actual number of price changes was more than ten times as high. Levy *et al* (2002) also observe many promotional, but few "regular" price changes for orange juice products. Owen/Trzepacz (2002) report that in a sample consisting of four EDLP shops and four Hi-Lo shops, the latter accounted for 95% of the recorded (weekly) non-zero price changes for an identical basket of goods! And even in Germany, Herrmann/Möser (2002) observed that the median price duration for an identical basket of grocery products varied between 11 and 87 weeks among supermarket chains. Since in Germany most of the highly successful discount stores pursue an EDLP strategy, this might distort comparisons of the "flexibility" of German consumer prices with other countries.

Moreover, we find that variations in the overall and most sector-specific inflation rates are closely related to variations in the frequency of upward price adjustments, but not to that of downward adjustments. As price increases are more numerous than price decreases, a larger share of the latter is related to promotions. This also implies that a larger share of price increases corresponds to "true" price changes, whereas the opposite is the case for price decreases. Hence, many price decreases may simply wash out in the aggregate or contribute to noise. Our finding that overall inflation is driven mainly by the variation in the frequency of price increases is, therefore, not surprising.

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 and to product- and outlet-specific changes in demand and supply, summarised by Golosov/Lucas (2006) under the heading "idiosyncratic shocks". We find strong evidence that prices respond to idiosyncratic shocks. Owing to the relatively short period, we cannot, however, assess how strongly and how quickly German consumer prices react to macroeconomic fundamentals. As Golosov/Lucas (2006) point out, adjustments to idiosyncratic shocks, which account for most of the price changes may, however, be coupled with more fundamental revisions of prices. Still, the simultaneity of price increases and price reductions across items found even for narrowly defined products indicates that the motives behind price setting are much more complex than is acknowledged in macro models.

There is no evidence of a general downward rigidity in consumer prices. The slightly greater number of upward price adjustments found in the data can be rationalised by the moderate rate of positive inflation which prevailed in the period under review. However, small price decreases seem to be missing to some extent. This phenomenon, which has also been observed with U.S. data by Levy *et al* (2005a) and Davis/Hamilton (2005), has two important implications. Statistically, while the median size of downward price adjustments is almost identical to that of upward adjustments, the average size of price reductions is significantly greater than the average size of price increases. Economically, we have to concede that there is a partial downward rigidity in consumer prices. Levy *et al* (2005b) rationalise the reluctance to cut prices in small steps by rational inattention of consumers to small price changes, which gives outlets an incentive to adjust prices upwards by small amounts, but to reduce prices in large chunks only.

Even after controlling for product-specific input price developments, services prices appear to be much more rigid than goods prices. It is probably the long-term relationship between customers and service providers that stands in the way of more frequent price revisions. The outstanding rigidity of housing rents, which is also observed in US data (Genesove, 2003), stems from the peculiarities of long-term contracting, asymmetric information and high transaction costs, which give rise to public regulation and tenancy discounts. Tenancy discounts in the variant of sit discounts mean that, for new tenants who behave well, rents are not adjusted to the market trend for some periods until a discount is established, which locks the tenant in.

Regulation of rent adjustment may add to the exceptional rigidity in this market. As detailed in Hoffmann/Kurz (2002), tenancy discounts are quite important in Germany.

The seasonality found in price adjustment can be explained, to some extent, by the seasonality in the driving factors. There remains, however, some seasonality even after controlling for input price inflation. This residual seasonality is characterised firstly by a below-average incidence of price adjustments in November/December and secondly by an above-average incidence of price adjustments in January/February. The above-average inclination to change prices at the beginning of the year has often been interpreted as indicating time-dependent pricing strategies. However, such strategies should evenly diminish the probability of price changes throughout the rest of the year, and not mainly in November/December. Levy *et al* (2005b) claim that retailers face higher menu costs during holiday periods, since the opportunity costs of changing prices are particularly high in periods of higher store traffic and higher sales. This conjecture can explain both the relatively few price adjustments in December and at least a substantial share of the excessive number of price adjustments in January. A slightly modified version of this line of reasoning might also explain the small number of price adjustments in the main vacation period in August, as – owing to vacation leave – the number of staff available for pricing is smaller in this period.

The changeover to the euro led to a significant increase in the incidence of price changes and to a reduction in the size of price changes in January 2002. Both upward and downward adjustments occurred in January 2002 much more often than in any other month in the period under review. This is exactly what models with non-zero costs of price adjustments would predict. Since retail outlets and service providers had to switch from D-Mark prices to euro prices, the changeover can be understood as a negative shock on menu costs, which was conducive to a bunching of price changes (Hobijn *et al*, 2006), but should have reduced the average size of price changes (Gaiotti/Lippi, 2004). Like Baudry *et al* (2004) and Jonker *et al* (2004) we do not, however, find any evidence that the period six months before and after the changeover was characterised by a below-average intensity of price adjustments, which is at variance with pure menu-costs explanations. However, as prices are revised only very infrequently for quite a number of goods and services, we would probably expect the changeover to affect the incidence of price adjustments over a more extended period.

Most interestingly, the transition to euro prices led to a greater variety in pricing. As the introduction of euro banknotes and coins reduced the number of distinct pricing points available approximately by half (the conversion rate was DM 1.95583 per euro), we would have expected a decline in the number of distinct prices actually employed. However, changing over to prices denominated in euro resulted in attractive prices becoming less important as well as an increase in the number of distinct prices used. Hence, the changeover to euro cash does not seem to have added to nominal rigidities in Germany. There is some partial evidence that price adjustments have been less frequent in the euro era than in the D-Mark period, but this is due mainly due to a smaller number of upward price adjustments. The average size of price changes has not been affected by the changeover.

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Annex

Table A1: Summary statistics on price adjustment

Product	Frequency of price adjustments			Size of price adjustments			Mean price
	AD	IN	DE	AD	IN	DE	duration
Filet of beef	8.8	5.2	3.6	10.7	10.0	11.6	23.0
Cod	32.8	18.2	14.6	11.7	11.6	11.9	8.8
Lettuce	84.7	42.6	42.1	36.9	36.5	37.2	1.5
Banana	53.4	27.4	25.9	20.0	19.4	20.7	5.2
Spinach, frozen	11.4	5.7	5.8	15.1	14.4	15.7	16.4
Milk	10.2	5.0	5.3	9.4	10.6	8.1	15.8
Sugar	6.6	3.4	3.1	7.8	8.0	7.4	23.2
Mineral water	8.6	4.7	3.9	11.5	11.0	12.1	22.2
Coffee	22.3	9.1	13.3	12.2	12.5	11.9	10.0
Whisky	9.4	5.1	4.4	7.9	7.4	8.6	21.5
Bottled beer	8.2	4.8	3.4	8.3	8.1	8.4	21.5
Regular fuel	90.7	48.8	41.9	3.1	3.3	2.9	1.2
Premium grade fuel	90.8	48.7	42.1	3.1	3.2	2.8	1.2
Heating oil	92.9	50.3	42.7	6.4	6.5	6.3	1.2
Gas	13.8	9.6	4.4	6.8	7.4	5.1	9.2
Electricity	10.7	8.6	2.2	4.8	4.1	7.1	11.8
Shirt	7.4	3.8	3.7	17.0	16.3	17.7	26.7
Jeans	6.8	3.9	2.9	14.1	13.0	15.5	26.3
Socks	6.5	3.9	2.6	12.9	11.7	14.5	25.4
Sport shoes	6.2	3.5	2.7	12.1	9.6	15.1	27.4
Acrylic paint	7.6	5.4	2.2	7.2	6.8	8.3	20.9
Filler	5.0	3.5	1.5	9.3	8.1	12.0	25.5
Toaster	5.5	2.6	2.8	9.3	8.3	10.3	28.8
Electric bulb	4.7	2.9	1.8	12.8	11.3	15.3	27.4
Suite	6.9	5.1	1.9	5.7	4.6	8.8	24.2
Towel	6.2	3.5	2.7	14.7	12.9	16.7	27.3
Steel radial tyre	10.0	5.8	4.1	6.2	4.9	8.1	18.8
Hi-fi system	8.2	2.7	5.5	11.6	11.6	11.6	23.9
Television set	10.4	3.9	6.6	9.4	8.4	10.0	19.4
Dog food	6.7	3.7	3.0	12.2	11.3	13.2	23.5
Football	4.8	2.4	2.4	12.3	10.7	13.9	32.0
Construction game	6.6	3.9	2.8	10.2	8.5	12.5	27.8
Toothpaste	10.0	5.2	4.9	15.1	14.5	15.7	17.9
Suitcase	6.5	3.4	3.1	10.9	9.6	12.6	26.6
Dry-cleaning	4.2	3.4	0.8	6.5	6.0	8.6	28.3
Sanding and sealing of parquet flooring	4.2	2.9	1.3	4.8	4.3	5.7	33.5
Repair of washing machine	4.0	3.5	0.4	6.7	6.2	11.1	32.3
Car main service	6.5	5.3	1.1	5.6	4.8	9.6	25.3
Car wash	3.5	2.7	0.8	10.0	9.6	11.0	31.6
Brake service	6.3	4.8	1.4	7.3	5.8	12.4	26.3
Taxi journey	4.1	3.3	0.8	8.3	9.3	3.4	25.9
Cinema admission	3.7	2.7	1.1	9.8	9.7	9.9	29.5
Video hiring	2.7	1.6	1.1	12.7	12.9	13.0	33.4
Photo processing	3.7	2.2	1.5	11.8	12.1	11.3	30.5
Overnight accommodation	5.3	3.7	1.6	10.8	9.5	13.9	30.1
Glass of beer	4.1	3.3	0.8	6.7	6.7	6.8	27.1
Meat dish	4.9	3.5	1.4	6.6	6.2	7.5	26.2
Glass of non-alcoholic beverages	3.3	2.7	0.6	8.4	7.7	11.1	29.7
Hairdressing services, men	4.4	3.7	0.7	6.0	5.8	7.6	27.5
Hairdressing services, women	4.6	3.9	0.7	6.6	6.5	7.5	27.0
Rent, privately financed apartment	1.8	1.5	0.2	7.5	7.8	6.0	49.5
Rent, subsidised apartment	2.4	1.9	0.5	6.3	6.3	6.1	45.1

Sources: German Federal Statistical Office and authors' calculations.
Notes: 52-product sample, February 1998 to Jan 2004; quality-adjusted prices; Frequency: monthly incidence of price changes as percentage of monthly price observations. Size: percentage changes in prices computed from first difference in logs. Duration: mean duration in months, all spells, adjusted for oversampling of short spells. AD: price adjustment; IN: price increase; DE: price decrease.

A1 Data characteristics, sample selection and weighting

The analysis in this paper is based on data collected for the compilation of the German CPI.[1] As the German CPI is computed from about 350,000 price quotes for 750 – sometimes broadly, sometimes narrowly defined – products, a thorough analysis of the full data set would have been very time-consuming.[2] We therefore decided to restrict the investigation to a relatively small number of products, which can be considered as being representative in terms of pricing behaviour for other goods and services.

As a starting point for the selection of goods and services, we took the list of 50 products chosen for the comparative analysis of price adjustment in the euro area (Dhyne *et al* 2005; Table A2). The products were sampled at the ten-digit COICOP (Classification Of Individual COnsumption according to Purpose) level, which is the deepest available breakdown. For most products, this ensures 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". While we were broadly successful in matching goods and services in the German CPI basket to the euro-area sample (it was only for two products that no match was possible), for the present 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 pattern different from that of crude oil products, we extend the coverage to these two types of energy. In many other euro-area countries individual data on rents are unobtainable for pricing studies and the prices of electricity and gas are often regulated and do not show much regional variation and, hence, no additional insights can be expected at the item level. In the end, the sample underlying this study consisted of 11 types of foodstuff, 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 (Table A2).

1 The German component of the HICP is assembled from the same data set.

2 The German CPI sample is much larger than those of other countries are. According to Klenow/Kryvtsov (2005), the BLS, for example, surveys the prices of "only" 85,000 items for the non-shelter portion of the US-CPI.

Table A2: Product definitions

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 Verrechnungs-preis 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 Außen-anstrich, 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, Doppelkassettendeck, 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	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^2 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^2 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* (2005), German Federal Statistical Office, translated by the authors.

Table A3: The variable "reason for 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 disappears 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.

In addition to actual prices, the German CPI data set provides 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 meta-data including the COICOP 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 for change" (*Änderungsgrund*). This variable may take 16 different values, detailed in Table A3, which explain whether a change in the price or in the characteristics of an item has taken place.

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.[3] 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, which meant that the within-period price difference were neutralised 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. Rents are also collected at a monthly frequency, but with a rotating sample, which means that only one-third of rents are actually observed each month. Rents that are not surveyed are carried forward from the previous month. We also include January 2004 in our sample. By doing so, 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 European System of Central Banks for monetary policy purposes (Table A4). The results are presented separately for unprocessed food, processed food, energy, non-energy industrial products and services (including rents).[4] When trying to generalise item-specific estimates, it might seem a straightforward matter to take the corresponding ten-digit COICOP weights. Weighting is crucial for the representativity of the results as unweighted data would only be representative if exactly

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3 On the quality adjustment procedures in the German CPI, see Hoffmann (1998, 1999).

4 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.

the same number of price quotes per euro of consumer expenditure were collected for each product and each month. This is not the case. The number of price quotes is much higher for unprocessed food and fuels than, say, for apparel. Most likely, however, taking ten-digit weights 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. On the other hand, there are only four types of fuel available in Germany, of which three are sampled for the CPI. In our restricted 52-product sample, taking ten-digit weights without any adjustments would give excessive weight to fuels and too small weight to unprocessed food.

Hence, we derive weights from the four-digit COICOP level. If there is single price representative for a four-digit COICOP category in our product sample, it receives the full four-digit weight. If two or more products are representing a four-digit COICOP category, the weight is either allocated proportionally 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. Finally, as for the euro area comparative analysis (Dhyne *et al,* 2005), we rescale the weights in such a way that the original weights of the main CPI components are reproduced. Only the four-digit weight of rents is not inflated. The final weights are detailed in Table A4.

The individual price data underlying this study are a subset of the data assembled at the Federal Statistical Office for reviewing the quality adjustment procedures in the German CPI. This is not the final data set from which the CPI is compiled, as in Germany the product-specific CPI aggregates are computed by the statistical agencies of the federal states. The federal states do, however, report preliminary data to the Federal Statistical Office. From this data set, 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, the data set had to be cleaned and edited – a job that was performed by the experts of the Federal Statistical Office.

Table A4: Summary statistics on the composition of the product sample

Product	Main component	Weight in ‰	Observations per month
Filet of beef	UN	22.7	647
Cod	UN	2.9	121
Lettuce	UN	7.7	647
Banana	UN	7.0	694
Spinach, frozen	UN	4.3	200
Milk	PRO	29.2	212
Sugar	PRO	15.5	714
Mineral water	PRO	17.0	499
Coffee	PRO	9.3	207
Whisky	PRO	4.3	563
Bottled beer	PRO	20.2	500
Regular fuel	EN	19.6	652
Premium grade fuel	EN	19.6	653
Heating oil	EN	9.1	326
Gas	EN	10.8	146
Electricity	EN	21.5	152
Shirt	IND	28.7	188
Jeans	IND	45.0	165
Socks	IND	8.2	474
Sport shoes	IND	19.3	155
Acrylic paint	IND	6.4	136
Filler	IND	6.4	136
Toaster	IND	4.2	178
Electric bulb	IND	7.8	209
Suite	IND	55.3	261
Towel	IND	9.5	382
Steel radial tyre	IND	10.6	157
Hi-fi system	IND	4.3	127
Television set	IND	9.2	145
Dog food	IND	8.5	172
Football	IND	6.0	108
Construction game	IND	6.5	115
Toothpaste	IND	20.5	221
Suitcase	IND	7.4	117
Dry-cleaning	SER	3.4	368
Sanding and sealing of parquet flooring	SER	3.3	75
Repair of washing machine	SER	2.9	81
Car main service	SER	32.6	166
Car wash	SER	1.3	176
Brake service	SER	30.0	168
Taxi journey	SER	5.1	40
Cinema admission	SER	21.5	263
Video hiring	SER	10.8	95
Photo processing	SER	10.8	156
Overnight accommodation	SER	26.2	77
Glass of beer	SER	29.3	112
Meat dish	SER	62.6	105
Glass of non-alcoholic beverages	SER	7.4	110
Hairdressing services for men	SER	5.8	736
Hairdressing services for women	SER	18.6	736
Rent for privately financed apartments	SER	232.9	2237
Rent for subsidised apartments	SER	11.2	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: four-digit COICOP weights of the 2000 CPI basket of consumption rescaled to the original main-components weights.

The main problems were caused by absent price observations and outlets disappearing from the market. If a price was absent, but the price observed in the preceding period was identical to the price in the consecutive period, the observation that was missing was imputed by carrying the price forward. If the price observations were missing for two or more consecutive periods, the price trajectory (*ie* the sequence of price observations) for this specific item in the specific outlet was discarded. Price trajectories 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. Each price trajectory with missing, defective or inconsistent information, which could not be repaired, was discarded entirely. As a result, we got a balanced panel of price trajectories covering the full period from January 1998 to January 2004. These price trajectories may refer to a specific item in a specific outlet, or to the initially sampled item and the replacement item(s), with the replacements being flagged by the indicator variable.

Before editing, the data set consisted of about 47,000 price trajectories, of which nearly 20,000 were complete but sometimes defective. 27,000 price trajectories either ended before January 2004 or started after January 1998. Some of these incomplete price trajectories are rather short, some of them cover nearly the full period under review. A premature end of a price trajectory might occur, for example, if an item vanishes from the market and no replacement item can be identified in the data set. After imputing missing values, linking trajectories with outlet replacements and discarding trajectories with inconsistent (for instance, the raw prices indicating unchanged prices, the quality-adjusted price series indicating a price change, and the indicator variable "reason of change" indicating a "true" change in price) or missing information (if, for example, the variable "reason for change" was missing), the cleaned data set contained nearly 19,000 full trajectories. 28,000 trajectories were still either incomplete or delivering conflicting information and were to be discarded.[5] Still, the

[5] We had to discard entirely the observations for three small German states, as these were particularly defective.

Table A5: The effect of quality adjustment on the measured rate of inflation

Main component	Unadjusted price change	Quality-adjusted price change	Effect of quality adjustment
Unprocessed food	+1.4	+0.9	-0.5
Processed food	+0.0	+0.3	+0.3
Energy	+4.3	+4.5	+0.2
Industrial goods	+1.0	+0.1	-0.9
Services	+1.7	+1.5	-0.2
Overall	+1.5	+1.2	-0.3

Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product, February 1998 to Jan 2004, rescaled four-digit weights, average annualised rate of change (%). Effect of redesigned product and outlet sample in February 2000 taken out.

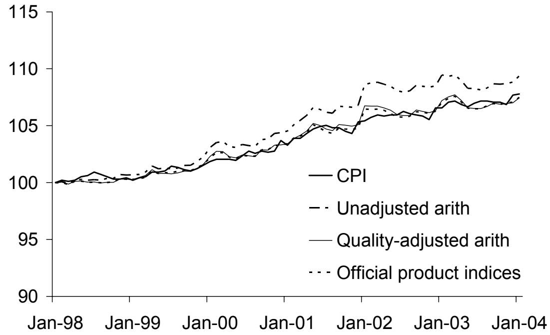
cleaned data set includes nearly 60% of the prices collected for the sampled products. Over the period under review, the nearly 19,000 monthly price quotes add up to 1.4 millions observations.

The number of monthly price observations per product in the final sample is quite uneven. It ranges from 40 for taxi journeys to 2,858 for rents in subsidised housing (Table A4). Generally, the number of price observations per product is higher in the case of housing, energy and food than it is for industrial products and services. 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.

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. 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 matched-models price change was, in fact, negative. Only the consideration of replacements turned the measured rate of inflation positive for these products. Hence, disregarding item replacements probably gives a distorted picture of price adjustment.

We are in the fortunate position of having information on both actual market prices and quality-adjusted prices. The latter feed into the measured rate of inflation, but also reflect the decisions of the statistical agency on how to link prices for items with differing characteristics. In the 52-product sample, the differences between the measures of unadjusted price change and of the quality-adjusted price change are significant, but not huge. 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 quality-related and neutralised for the calculation of the CPI (Table A5). The "decline" in quality of processed food is probably related to outlet replacements.[6]

Figure A1: Price developments according to the 52-product sample and the CPI



Sources: German Federal Statistical Office and authors' calculations.

Notes: CPI: Consumer Price Index. Official product indices for the 52-product sample weighted with rescaled four-digit COICOP weights. Unadjusted (quality-adjusted) arith: Weighted arithmetic average (rescaled four-digit COICOP weights) of the product-specific geometric mean of unadjusted (quality-adjusted) item prices series in the cleaned 52- product sample. Rebased to January 1998=100.

An inflation measure based on unadjusted market prices of the 52-product sample, as well as a measure based on the quality-adjusted prices, weighted as described above, tracks the original CPI rather well (Figure A1), which suggests that the products chosen for this study are approximately representative of the full CPI. Even more encouraging is the fact that the index derived from the cleaned data set is nearly indistinguishable from an identical weighted average of the official product price indices.[7] This indicates

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6 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 und taken out for the measurement of inflation (Hoffmann 1998). As we computed the product-specific price indices using a Jevons aggregator instead of a Dutot aggregator, this might also contribute to the differences.

7 Admittedly, at the level of the main components the differences are more pronounced. For unprocessed food, the actual annual average rate of price of price change is 0.5% instead of 0.9%, for processed food 1.4% instead of 0.3% (this is the effect of the tobacco products not being 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%.

that the data loss resulting from the cleaning process does not seem to have affected the representativity of our results negatively.[8]

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[8] Veronese *et al* (2005) 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.

A2 Decomposing the rate of inflation

The German CPI is computed using a fixed-base (arithmetic) Laspeyres formula,[1] meaning that price relatives referring to the base period are averaged using base period weights α_i:

$$I_t = \sum_i \alpha_i \frac{p_{i,t}}{p_{i,0}}$$

As an approximation, we calculate a CPI proxy - based on the 52 product sample - by using a geometric Laspeyres formula instead of the arithmetic variant. For each period, the index is computed as a geometric mean of product-specific price relatives, weighted by base-period expenditure shares α_i:

$$I_t = \prod_i \left(\frac{p_{i,t}}{p_{i,0}}\right)^{\alpha_i}$$

Taking logs on both sides gives

$$I_t = \sum_i \alpha_i (\ln p_{i,t} - \ln p_{i,0})$$

and the inflation rate between t-1 and t as the difference of the price indices I_t and I_{t-1}:

$$\pi_{t,t-1} = I_t - I_{t-1} = \sum_i \alpha_i (\ln p_{i,t} - \ln p_{i,t-1})$$

Hence, with the geometric Laspeyres formula, the weights in short-term inflation rates are time-invariant (which is not the case with the arithmetic Laspeyres index).

In the German CPI, the product-specific price indices are computed by taking unweighted arithmetic averages of item prices p_{ij} (Dutot index):

$$\frac{p_{i,t}}{p_{i,0}} = \frac{\sum_j p_{ij,t} / m}{\sum_j p_{ij,0} / m}$$

[1] For the various index formula, see ILO (2004). The decomposition of the inflation rate resembles that of Klenow/Kryvtsov (2005).

Again, as an approximation, we choose the geometric variant (Jevons index):

$$\frac{p_{i,t}}{p_{i,0}} = \frac{\prod_j p_{ij,t}^{1/m}}{\prod_j p_{ij,0}^{1/m}}$$

Taking logs on both sides gives

$$\ln p_{i,t} - \ln p_{i,0} = \sum_i \frac{1}{m_i} (\ln p_{ij,t} - \ln p_{ij,0})$$

Combining upper-level and lower-level aggregation results in the following expression for short-term inflation rates:

$$\pi_{t,t-1} = \sum_i \alpha_i \sum_j \frac{1}{m_i} (\ln p_{ij,t} - \ln p_{ij,t-1})$$

In any period, at the product level the inflation rate can be decomposed into the incidence of price changes and the average size of price changes. We define the product- and period-specific average incidence of price increases and price decreases as

$$I_{i,t}^{+} = \sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{+} \quad \text{with} \quad i_{ij,t}^{+} = 1 \quad \text{if} \quad \ln p_{ij,t} - \ln p_{ij,t-1} > 0$$

$$\text{and} \quad i_{ij,t}^{+} = 0 \quad \text{if} \quad \ln p_{ij,t} - \ln p_{ij,t-1} \leq 0$$

$$I_{i,t}^{-} = \sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{-} \quad \text{with} \quad i_{ij,t}^{-} = 1 \quad \text{if} \quad \ln p_{ij,t} - \ln p_{ij,t-1} < 0$$

$$\text{and} \quad i_{ij,t}^{-} = 0 \quad \text{if} \quad \ln p_{ij,t} - \ln p_{ij,t-1} \geq 0$$

and the product and period-specific size of price changes

$$S_{i,t}^{+} = \frac{1}{\sum_{j=1}^{m} i_{ij,t}^{+}} \sum_{j=1}^{m} i_{ij,t}^{+} (\ln p_{ij,t} - \ln p_{ij,t-1}) = \frac{\sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{+} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I_{i,t}^{+}}$$

$$S_{i,t}^{-} = \frac{1}{\sum_{j=1}^{m} i_{ij,t}^{-}} \sum_{j=1}^{m} i_{ij,t}^{-} (\ln p_{ij,t} - \ln p_{ij,t-1}) = \frac{\sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{-} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I_{i,t}^{-}}$$

Aggregating across products and weighting results in formula for the economy-wide average period-specific frequency and size of price changes:

$$I_t^{+} = \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{+}$$

$$I_t^{-} = \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{-}$$

Averaging the size of price changes across products may take either the form of averaging the product-specific mean price changes or – and this is the variant chosen here – taking the mean of all price changes, which is equivalent to weighting the product-specific averages with the relative product-specific incidence of price changes:

$$S_t^{+} = \sum_{i=1}^{n} \alpha_i \frac{I_{i,t}^{+}}{I_t^{+}} \frac{\sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{+} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I_{i,t}^{+}} = \sum_{i=1}^{n} \alpha_i \frac{\sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{+} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I_t^{+}}$$

$$S_t^{-} = \sum_{i=1}^{n} \alpha_i \frac{I_{i,t}^{-}}{I_t^{-}} \frac{\sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{-} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I_{i,t}^{-}} = \sum_{i=1}^{n} \alpha_i \frac{\sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^{-} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I_t^{-}}$$

The period-specific aggregate rate of inflation is recovered by multiplying the period-specific average size and the period-specific average frequency of upward and downward price adjustments:

$$I_t^{+} S_t^{+} + I_t^{-} S_t^{-}$$

$$= \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} i^{+}_{ij,t} (\ln p_{ij,t} - \ln p_{ij,t-1}) + \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} i^{-}_{ij,t} (\ln p_{ij,t} - \ln p_{ij,t-1})$$

$$= \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} \sum_{j=1}^{m} (\ln p_{ij,t} - \ln p_{ij,t-1})$$

$$= \pi_{t,t-1}$$

Aggregating over time gives the formula for the economy-wide average frequency of price changes:

$$I^{+} = \sum_{t=1}^{T} \frac{1}{T} \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} i^{+}_{ij,t}$$

$$I^{-} = \sum_{t=1}^{T} \frac{1}{T} \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} i^{-}_{ij,t}$$

Averaging over time the size of price changes may take either the form of averaging the period-specific mean price changes or – and this is the variant chosen here – taking the mean of all price changes, which is equivalent to weighting the period-specific averages with the relative period-specific incidence of price changes:

$$S^{+} = \sum_{t=1}^{T} \frac{1}{T} \frac{I^{+}_{t}}{I^{+}} \sum_{i=1}^{n} \alpha_i \frac{\sum_{j=1}^{m} \frac{1}{m} i^{+}_{ij,t} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I^{+}_{t}}$$

$$S^{-} = \sum_{t=1}^{T} \frac{1}{T} \frac{I^{-}_{t}}{I^{-}} \sum_{i=1}^{n} \alpha_i \frac{\sum_{j=1}^{m} \frac{1}{m} i^{-}_{ij,t} (\ln p_{ij,t} - \ln p_{ij,t-1})}{I^{-}_{t}}$$

Again, the average aggregate rate of inflation can be recovered by multiplying the average size and average frequency of upward and downward price adjustments:

$$I^{+}S^{+} + I^{-}S^{-}$$

$$= \sum_{t=1}^{T} \frac{1}{T} I_t^+ \sum_{i=1}^{n} \alpha_i \frac{\sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^+ (\ln p_{ij,t} - \ln p_{ij,t-1})}{I_t^+} + I^- S^-$$

$$= \sum_{t=1}^{T} \frac{1}{T} \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} i_{ij,t}^+ (\ln p_{ij,t} - \ln p_{ij,t-1}) + I^- S^-$$

$$= \sum_{t=1}^{T} \frac{1}{T} \sum_{i=1}^{n} \alpha_i \sum_{j=1}^{m} \frac{1}{m} (\ln p_{ij,t} - \ln p_{ij,t-1})$$

$$= \frac{1}{T} \pi_{T,0}$$

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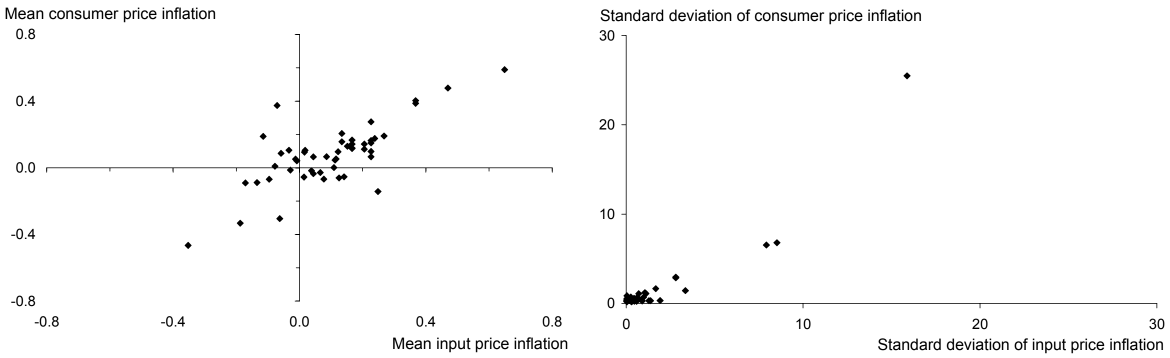
A3 The matching of input price indices to consumer prices

At the retail level, the most important price determinant of a specific good is probably the price of that good at the wholesale level. Therefore, we match the food and energy products and the industrial goods in our sample with subindices of the German Producer Price Index and the German Import Price Index. For 21 products we achieved an exact or close match, for 13 products an approximate match (see Table A6). In the case of services, wages are typically the most important cost factor. Therefore, we approximate the development of costs with wage figures taken from the Index of Negotiated Wages as compiled by the Deutsche Bundesbank.[1] For 11 services, the match can be considered close, for three services approximate. Housing rents are not considered in this exercise as not even a poor proxy for the input price inflation is available.

With respect to the mean rate of inflation and its standard deviation, the product-specific consumer price indices and the corresponding input price measures are highly correlated (Figure A2), which can be interpreted as an indication that the input price measures are connected with the consumer prices not only by definition.

Figure A2: Input prices and consumer prices



Sources: German Federal Statistical Office and authors' calculations.

Notes: Period: February 1998 to February 2004. Consumer prices: 50-product sample, geometric mean of quality-adjusted prices. Input prices: see Table A6. Monthly rate of price change (percentage) computed from the first difference of logs.

[1] As this index also takes into account Christmas and vacation allowances and bonus payments, there is a pronounced seasonal pattern. As this short run variability is of quite a different nature from, for example, the volatility of crude oil prices, we decided to smooth the wage index series.

Table A6: The matching of input price indices to consumer prices

Product in CPI sample	Matched product	Source	Quality of match
Filet of beef	Beef	Producer price index	Close
Cod	Fish and fish products	Import price index	Close
Lettuce	Lettuce and chicory	Import price index	Exact
Banana	Banana	Import price index	Exact
Spinach, frozen	Vegetables, processed	Producer price index	Close
Milk	Milk	Producer price index	Exact
Sugar	Beet sugar	Producer price index	Exact
Mineral water	Mineral water	Producer price index	Exact
Coffee	Ground coffee	Producer price index	Exact
Whisky	Spirits	Import price index	Approximate
Bottled beer	Beer	Producer price index	Exact
Regular fuel	Regular fuel	Producer price index	Exact
Premium grade fuel	Premium grade fuel	Producer price index	Exact
Heating oil	Heating oil	Producer price index	Exact
Gas	Gas	Producer price index	Close
Electricity	Electricity	Producer price index	Close
Shirt	Clothes	Import price index	Approximate
Jeans	Women's outer garments	Import price index	Approximate
Socks	Hosiery	Import price index	Close
Sport shoes	Shoes	Import price index	Approximate
Acrylic paint	Acrylic paint	Producer price index	Approximate
Filler	Putty	Producer price index	Approximate
Toaster	Other electrical appliances	Import price index	Approximate
Electric bulb	Electrical bulbs and lamps	Import price index	Approximate
Suite	Chairs (without steel frame)	Import price index	Approximate
Towel	Linen	Producer price index	Approximate
Steel radial tyre	Steel radial tyre	Producer price index	Exact
Hi-fi system	Radio receiver	Import price index	Close
Television set	Television sets	Import price index	Exact
Dog food	Food for pets	Producer price index	Close
Football	Sports equipment	Import price index	Approximate
Construction game	Toys	Import price index	Approximate
Toothpaste	Toothpaste	Producer price index	Exact
Suitcase	Travelling articles	Producer Price Index	Approximate
Dry-cleaning	Textile cleaning trade	Index of negotiated wages	Close
Sanding and sealing of parquet flooring	Carpenters trade	Index of negotiated wages	Close
Repair of washing machine	Electrician trade	Index of negotiated wages	Close
Car main service	Automobile trade	Index of negotiated wages	Close
Car wash	Retail trade	Index of negotiated wages	Approximate
Brake service	Automobile trade	Index of negotiated wages	Close
Taxi journey	Retail trade	Index of negotiated wages	Approximate
Cinema admission	Retail trade	Index of negotiated wages	Approximate
Video hiring	Retail trade	Index of negotiated wages	Approximate
Photo processing	Retail trade	Index of negotiated wages	Approximate
Overnight accommodation	Hotel and restaurant industry	Index of negotiated wages	Close
Glass of beer	Hotel and restaurant industry	Index of negotiated wages	Close
Meat dish	Hotel and restaurant industry	Index of negotiated wages	Close
Glass of non-alcoholic beverages	Hotel and restaurant industry	Index of negotiated wages	Close
Hairdressing services for men	Hairdressing industry	Index of negotiated wages	Close
Hairdressing services for women	Hairdressing industry	Index of negotiated wages	Close

A4 Censoring and weighting of price spells

Our quality-adjusted sample consists of 261,601 price spells, of which 216,396 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).[1] 45,205 price spells are censored. In the following analysis, we distinguish two main variants of censoring.[2]

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 1,631 strictly double-censored price spells lasting from January 1998 to January 2004.[3] These spells refer mostly to housing rents, but some are also found among other services and industrial goods. This leaves us with 17,307 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 a price change related to an item (or outlet) replacement. We observe 8,960 such spells in our sample. The reason for item replacements in the CPI sample is 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 reach the conclusion that an item previously priced for the CPI is no longer representative and exchange it for a different item. 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

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1 Item and outlet replacements not resulting in a quality-adjusted price change are not regarded as breaking price spells. This assumption biases measures of the number of distinct price spells somewhat downwards (-0.1%) and biases measures of the average length of price spells somewhat upwards.

2 On this subject, see also Aucremanne/Dhyne (2004) and Baudry (2004) *et al.*

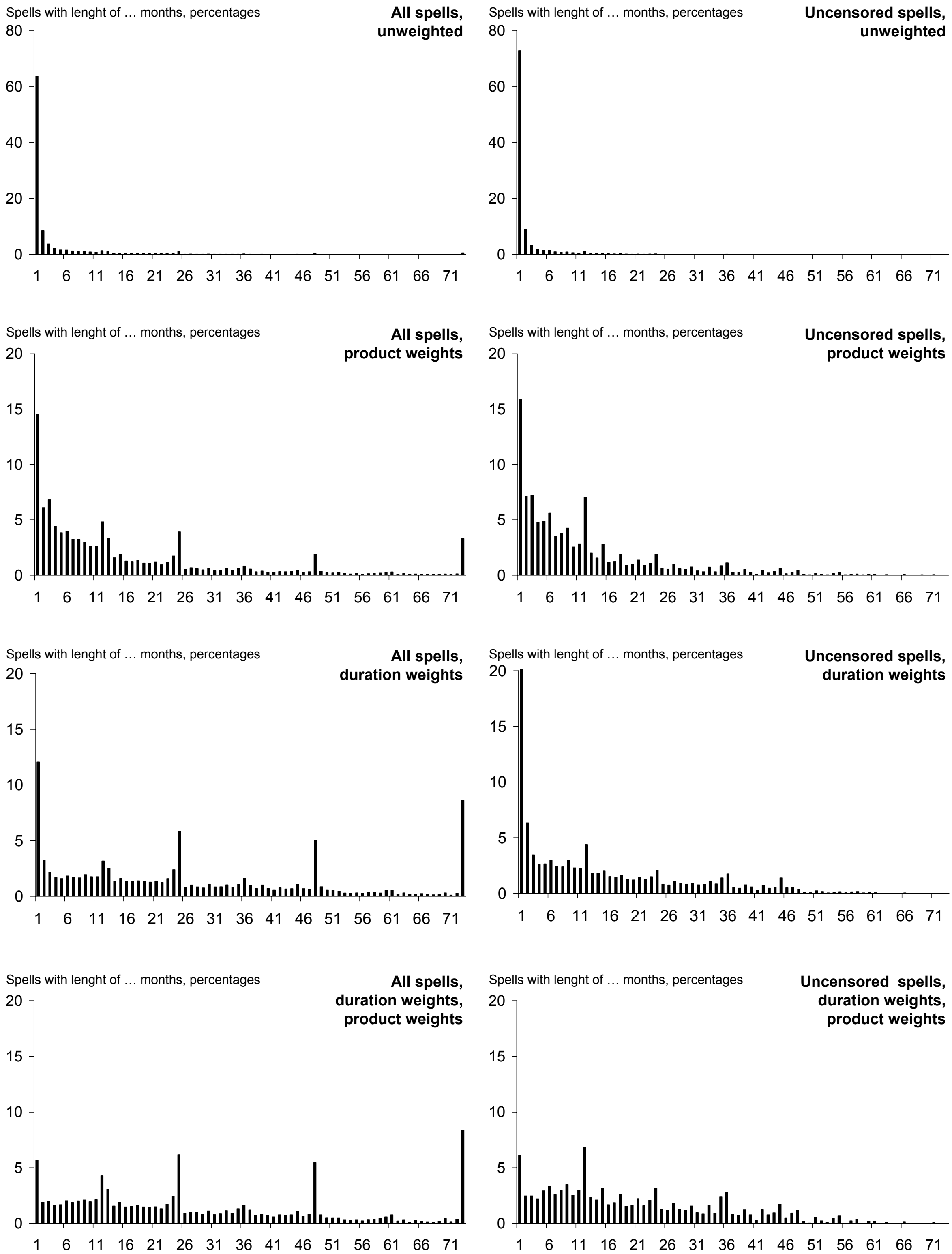
3 Veronese *et al* (2004) also find extremely long price durations. Taking into account replacements which did not result in a quality-adjusted price change, reduces the number of strictly double censored price spells to 1,010.

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 in 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 (nearly 9% of the price spells starting in January 1998 lasted until January 2004) indicates that, at least for some products, 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. Also excluding 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 have a duration which, typically, differs from that of 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. 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 undue prominence to products with short price durations. In our sample, 64% of the price spells (73% of the uncensored price spells) last only one month (Figure A3, at the top). Averaging per product and weighting with the product weights reduces the share of price spells with one-period-length to 15% (16% for uncensored spells) (Figure A3, in the middle). However, even this weighting procedure gives undue weight to short spells if the perspective is that of a typical period. By simply averaging the length of price spells we would not take into account the fact that in our sample which extends over several periods short price spells are observed more often than long price spells. Instead

Figure A3: Weighting the length of price spells



Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample, January 98 to January 04; quality-adjusted prices; product weights: four-digit COICOP weights rescaled with original main-components weights; duration weights: adjustment for oversampling of short spells as described in the main text.

Table A7: The average length of price spells

Across products	Unweighted	Weighted	Unweighted	Weighted
Across durations	Unweighted	Unweighted	Weighted	Weighted
Unprocessed food	2.2 (1.8)	6.5 (4.7)	10.4 (5.8)	15.4 (10.6)
Processed food	8.8 (6.4)	8.8 (6.5)	20.7 (14.7)	19.0 (13.9)
Energy	1.3 (1.2)	3.9 (4.2)	2.6 (2.5)	5.3 (5.4)
Oil products	1.1 (1.2)	1.1 (1.1)	1.2 (1.7)	1.2 (1.2)
Electricity, gas	7.4 (9.0)	7.7 (8.5)	10.5 (14.6)	10.9 (11.1)
Industrial goods	11.6 (8.4)	11.6 (8.8)	25.0 (18.2)	24.8 (18.2)
Services	22.1 (15.5)	23.0 (15.8)	39.4 (25.5)	37.7 (25.6)
Ex rents	16.7 (14.0)	15.9 (12.7)	28.3 (23.6)	27.7 (22.0)
Housing rents	28.4 (19.2)	31.0 (19.2)	47.0 (28.8)	49.2 (29.7)
Overall	5.3 (2.9)	16.1 (11.5)	26.8 (13.7)	28.6 (20.0)
Ex rents, electricity and gas	4.0 (2.6)	11.8 (9.1)	19.6 (12.1)	23.3 (17.7)

Sources: German Federal Statistical Office and authors' calculations.

Notes: 52-product sample, January 1998 to January 2004, mean duration in prices, quality-adjusted prices, all price spells, uncensored price spells in brackets, product weights: four-digit weights rescaled with original main-components weights; duration weights.

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 is a method of adjusting for the excessive importance given to short spells. The corresponding formula for the average duration of price spells is given by

$$\overline{T} = \frac{n_T T^2}{\sum_T n_T T}$$

This weighting scheme was originally proposed by Baharad/Eden (2004) and, for time-invariant product- and outlet-specific price durations, produces the same estimate of the average price duration as does averaging the product- and outlet-specific mean price durations as performed by Baudry *et al* (2004) and Álvarez/Hernando (2004).[4] After the adjustment, the fraction of price spells with a length of one month is reduced to 12% (25% for uncensored sample) (Figure A3, in the middle). Combining both weighting schemes results in a share of one-month spells of just 6% (Figure A3 at the bottom).

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 months (Table A7). Applying product weights gives an estimate of 15 months. Adjusting for the overrepresentation of short spells increases the estimate to 27 months.

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[4] For a discussion of various methods of averaging durations, see also Veronese *et al* (2004).

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