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Price Rigidity in the German Grocery-Retailing Sector: Scanner-Data Evidence on Magnitude and Causes

Roland Herrmann, Anke Moeser, and Sascha Alexander Weber

Abstract

The theoretical and empirical macroeconomic literature suggests that price rigidity in industrialized countries is substantial and its causes are manifold. This article provides empirical evidence on the importance of price rigidity in the grocery-retailing sector and on the role of some major determinants of food price rigidity. The analysis is based on a comprehensive weekly dataset of 20 branded foods in German food stores. The statistical analysis shows that food price rigidity is strong in spite of the widespread use of retail sales. Moreover, the importance of psychological pricing in grocery retailing is overwhelming. Econometric results indicate that food prices get more sticky as the number of price actions declines and as psychological pricing becomes more concentrated on a few important price barriers. Firms' pricing strategies are crucial for food price rigidity, too.

KEYWORDS: price rigidity, food prices, grocery retailing, scanner data, Germany, retail sales, psychological pricing

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1. Introduction

Survey results confirm what many theories from the macroeconomic literature suggest: There is a substantial amount of price rigidity in industrialized countries (Blinder et al., 1998). It might be questioned whether this is also the case for the grocery-retailing sector given the high degree of price instability of agricultural commodity prices and the special importance of the sale phenomenon in the retailing sector (Hosken and Reiffen, 2001). First results for four national food brands in Germany revealed that price rigidity does exist in the grocery-retailing sector although sales are apparently an essential part of retailers' marketing strategies (Herrmann and Moeser, 2003).

In this paper, we will elaborate the magnitude of price rigidity in the German grocery-retailing sector for a much wider range of products and explain the evidence within an econometric analysis. A comprehensive set of scanner data for the German retailing sector will be utilized, which was available commercially until 2002. The dataset contains price and quantity information for many products and retailers and is available at a weekly basis for the period 1996 to 1999. The data include information on sales and details of promotion activities, too, and allow conclusions on differential marketing strategies of the individual firms.

It has been shown in the industrial-organization (IO) and macroeconomic literature that many causes of price rigidity may exist (Blinder et al., 1998). The following of these causes will be analyzed here primarily: the sales phenomenon as one major determinant of price variability (or price rigidity) in the grocery-retailing sector, the existence of psychological pricing points for foods, and different pricing strategies across grocery-retailing firms and store types.

The following detailed questions will be addressed:

(i) How important is price rigidity in German grocery retailing? Does it differ across products, firms and store types? We will answer this question by an analysis of mean durations of unchanged prices for a selection of 20 national food brands and will compare results across firms, store types and products.

(ii) How important is the sale phenomenon in German grocery retailing for the 20 selected food brands and how does it differ across products, firms and store types?

(iii) Is psychological pricing important in German grocery retailing and is it evenly distributed across firms, store types and the 20 food brands analyzed?

(iv) To what extent are differences in price rigidities driven by the frequency of price actions, by the existence of psychological pricing points, by the type of product and by differential pricing strategies of firms and store types? We

will examine this question by econometric techniques in which price rigidity is explained by its economic determinants.

The paper is organized as follows. In Section 2, a short literature review on magnitude and causes of price rigidity in grocery retailing is given. Then, in Section 3, the economic hypotheses are formulated and the scanner dataset is described. Section 4 contains the first of two quantitative parts. Based on descriptive statistics, an overview is given on the magnitude of price rigidity, the sale phenomenon and psychological pricing in German grocery retailing. The results are distinguished by products, by grocery-retailing firms, and by store types. In Section 5, econometric estimates are presented on how the cross-sectional evidence of price rigidity can be explained and how price rigidity, the sale phenomenon, psychological pricing and firm strategies are related. The paper ends with a summary and conclusions for future research.

2. Literature Review on Magnitude and Causes of Price Rigidity in Grocery Retailing

The food-retailing industry is characterized by a great variety of goods with a high degree of product differentiation. Although each grocery store carries only a small share of the available foods, thousands of items are typically available and pricing decisions are those of a multiproduct firm. Retail pricing is much more difficult even from a static profit-maximation point of view than the standard textbook case of profit maximization for one output. Substitutive and complementary relationships between products are crucial for static and, even more, for dynamic pricing decisions. Single goods are often used for promotion actions in order to attract consumers to relevant stores. Existing empirical studies show that many food products in retailing are characterized by relatively long periods of unchanged prices, followed by recurring periods of lower prices and after that a return to the initial level (Hosken and Reiffen, 2001; Moeser, 2002). The study by Hosken, Matsa and Reiffen (2001) points out that within each product category the same items are put on sale repeatedly, while others are rarely or never used for specific offers.

A large set of possible reasons for price rigidity does exist of which only a selection will be surveyed.

It is often argued that a strategical distinction does exist between retail formats. Owen and Trzepacz (2002) arrive at the conclusion that “firm strategy is the most important determinant of the probability of a price change” (p. 347). The two typical strategies are “everyday low price” (EDLP) and “high-low prices” (Hi-Lo). EDLP means that a retailer charges a constantly low everyday price with no temporary price discounts. A retailer following a Hi-Lo strategy charges a higher price on an everyday basis and will temporarily allow price discounts which are

below the EDLP level in order to attract new customers (Hoch, Drèze and Purk, 1994). Thus, retail prices following EDLP will have a higher degree of price stability.

With its special offers the Hi-Lo strategy represents the sale phenomenon. Within this strategy differences in frequency and magnitude of promotion activities occur across products (Hosken and Reiffen, 2001). But the corporate objective is to increase the quantity sold. It is only possible to reach this objective if consumers can be distinguished who are characterized by varying reservation prices. This point is analyzed in the study of Conlisk, Gerstner and Sobel (1984). The authors formulate a model to explain cyclical pricing by a durable-goods monopolist. The consumers are divided into two groups. One group consists of consumers with a low reservation price, i.e. this type of consumers is more willing to wait for price reductions. The other group consists of consumers with a high reservation price meaning that these consumers' willingness to wait is lower as their costs of waiting are higher. Thus, the latter group is willing to purchase now if the next sale is still far in the future. This dividing practice enables the monopolist to apply intertemporal price discrimination between the two groups of consumers. The authors' key result is that intertemporal price discrimination is more profitable than a uniform price as a higher share of consumer surplus is captured.

Another approach has received some attention, too, which has its origin in the marketing literature. It is more closely related to psychological concepts as to economic models of optimization behaviour (Blinder et al., 1998). This pattern is called "psychological pricing" or "odd pricing" and is discussed by Slade (1998) analyzing U.S. grocery-store pricing and Kashyap (1995) studying warehouse catalogue prices. Kashyap argued that "goods being near a price point in the low inflation period reduced the probability of a price change" (p. 268). Hereby retailers set the rightmost digits just below a round number, i.e. prices with 9- or 99-ending. It is the rationale for this practice that level and image effects of specific price endings are expected. Consumers often limit their search for information and use heuristics in their consumption behaviour. According to cognitive psychology, they round down prices or they compare price digits from the left to the right. Thus, prices will be underestimated by consumers. In the marketing literature these kinds of behaviour characterize level effects. Level effects are confirmed by the field experiment of Schindler and Kibarian (1996) with catalogue prices. Schindler and Kirby (1997) provide evidence, too, for an overrepresentation of the digit 9 with their analysis of price advertisements in newspapers. Additionally, price endings may lead to a quality image and a price image. Certain price endings may be associated with a high- or low-price image or a low- or high-quality image. These are image effects. Stiving and Winter (1997) prove the existence of such image effects of price endings.

Hence, the key implication of a 9- or 99-ending is that customers will spend larger amounts because these price endings represent the signal of a discount price. If retail prices will increase above that point, consumers will react with a declining demand. Thus, pricing points create rigidity in prices, because retailers wait longer until they alter prices. The theory behind this is a kinked demand curve – with several kinks at different pricing points – where demand is strongly elastic above the kinks. For the macroeconomic analysis of price stickiness, psychological pricing points provide one of the few possible explanations of nominal rigidity (Blinder et al., 1998).

A distinction between durable and nondurable goods can be useful in explaining price rigidity, too. Retailers use different pricing strategies for different products and these distinctions may be explained by product characteristics. Therefore, Hosken and Reiffen (2001) analyze differences in average price changes for durable and nondurable goods and whether price changes are negatively correlated at the individual store level between a selected durable and a nondurable product. The chosen durable is represented by different brands of peanut butter, and different brands of margarine stand for the selected nondurable. Key results are that prices for the durable and the nondurable good seem to be negatively correlated. Moreover, the magnitude of observed price changes is larger for the durable good.

3. Hypotheses and Data

From the presented theoretical and empirical approaches to analyze price rigidity, the following testable hypotheses can be derived.[1] A first hypothesis is that the sale phenomenon determines price rigidity. More specifically, a lower price rigidity (higher price flexibility) may be expected with an increasing role of sales. Moreover, an increasing role of psychological pricing may cause higher price rigidity for foods. The explanation could be the existence of important psychological pricing points which act as a barrier and lead to a kinked demand function. Another rationale could be the existence of level and image effects of price endings as stressed by cognitive psychology. Additionally, it is likely that strategies of store types and firms are heterogeneous and will affect food price rigidity, either directly or indirectly.

[1] Many other alternative or complementary hypotheses on price rigidity are explained, e.g., in Blinder et al. (1998) or Carlton (1986).

A very general summary of these hypotheses is for the analysis across store types

Price rigidity = f {retail sales, psychological pricing, store types} (1)

and across firms

Price rigidity = f {retail sales, psychological pricing, firms}, (2)

if store types and firms determine price rigidity itself for strategic reasons. It might be alternatively that store types and firms rather choose retail sales and psychological prices as strategic options and, thus, indirectly affect price rigidity. This would yield

Price rigidity = f {retail sales (store types), psychological pricing (store types)}(1')

and

Price rigidity = f {retail sales (firms), psychological pricing (firms)}. (2')

We will come back to the precise causalities in the econometric part.

The quantitative analysis is based on a commercially available scanner dataset provided by Madakom GmbH (Madakom, 1999a). It captures scanner data from the German food-retailing sector for 144 weeks, i.e. the period from September 30, 1996, to June 28, 1999. Four types of retailing firms were selected for this study: (i) large consumer markets (1,500 to 5,000 m^2 sales area); (ii) small consumer markets (800 to 1,499 m^2 area); (iii) supermarkets (400 to 799 m^2) and (iv) discounters. A further selection criterion was that data were available for 100 consecutive weeks. 38 stores remained in the sample after applying this criterion as well as the rule that the regional distribution of stores should approximately picture the structure of the German food-retailing sector. The empirical evidence will be provided at two different aggregation levels: (i) at the level of the four store types mentioned above; (ii) at the level of six grocery-retailing firms which stand behind the different stores and store types.

The selection of brands covers 20 national food brands[2], which are well-known in Germany. They belong to the group of breakfast products in the broadest sense.

[2] Brand 1 is a 170g-bottle of coffee cream with 12% fat (Baerenmarke "Feine 12", 170g), brand 2 is a 170g-bottle of evaporated milk with 8% fat (Baerenmarke Kaffeetraum 8%, 170g), brand 3 is a nine-piece package of frozen rolls (Coppenrath & Wiese "Unsere Goldstuecke", 9 Stueck), brand 4 is a 500g-package of ground coffee (Dallmayr Prodomo, 500g), brand 5 is a package of four bottles at 100g of a probiotic drink (Danone Actimel Drink Classic, 4x100g), brand 6 is a 500g-package of butter toast (Golden Toast Butter Toast, 500g), brand 7 is an eight-piece package of warm-up rolls (Golden Toast Sonntagsbroetchen, 8 Stueck), brand 8 is a 200g-tin of cappuccino with 10g milk chocolate extra (Jacob's Café Zauber Cappuccino, 200g plus 10g Milchschokolade),

It was possible to identify the individual articles within the considerably larger scanner dataset with their EAN codes. EAN codes contain 13 or 8 numbers which are printed on the product and they contain an identification of the manufacturer and the details of the product.

Comprehensive information was available on the items. This information includes the quantity sold, the product price, the name of the product and the package size. Information on different promotion activities at the point of sale were measured as those prices which remain for four weeks or less by at least five percent below the normal price. After more than four weeks, such low prices are counted as normal price (Madakom, 1999b).

It has to be stressed that this is a unique dataset at the individual retailers' level. Substantial work in recent years is based on consumer panel data (e.g., Fengler and Winter, 2001; Loy and Weiss, 2003; Bils and Klenow, 2002) which might include the customers' switching from store to store and, thus, a different type of price rigidity. The utilized scanner dataset covers the retailers' pricing decisions irrespective of potential consumer switching between stores. However, as is in most comparable studies, the data do not include sociodemographic variables of consumers as these are typically not available in either the retailer or consumer panels.

4. Empirical Analysis on the Magnitude of Price Rigidity and Its Potential Determinants

This section is supposed to give a broad statistical survey of price rigidity, the sales phenomenon and psychological pricing in the German grocery-retailing sector based on scanner data evidence. The empirical evidence presented here will be utilized then in Section 5 to investigate in detail how price rigidity depends on its economic determinants.

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brand 9 is a 375g-package of cornflakes (Kellogg's Cornflakes, 375 g), brand 10 is a 250g-piece of Irish butter (Kerrygold Original Irische Butter, 250g), brand 11 is a 1l-bottle of fresh milk with 3.8% fat (Landliebe Landmilch 3,8%, 1l), brand 12 is a 500g-package of full corn bread (Lieken Urkorn "Das Vollkorn-Saftige", 500g), brand 13 is a 500ml-beaker of chocolate drink (Muellermilch Schoko, 500ml), brand 14 is a 375g-package of breakfast cereals (Nestlé Cini Minis, 375g), brand 15 is a 375g-package of muesli-like breakfast cereals (Nestlé Nesquik fuer ein Knusperfruehstueck, 375g), brand 16 is a 400g-glass of nut-and-chocolate cream (Nutella, 400g), brand 17 is a 500g-beaker of margarine (Rama, 500g), brand 18 is a 450g-glass of strawberry jam (Schwartau Extra Erdbeerkonfituere Extra, 450g), brand 19 is a package of 25 tea bags (Teekanne Teefix, 43, 75g, 25 Teebeutel) and brand 20 is a 150g-package of crispbread with chocolate (Wasa Schoko Wikinger, 150g).

4.1 Magnitude of Price Rigidity

Highly aggregated indicators of price rigidity in the four store types are given in Appendix 1 and for the six grocery-retailing firms in Appendix 2. Price rigidity (*PRIG*) is measured as the mean duration of unchanged prices, following Powers and Powers (2001):

$$PRIG = w / w_{PCH}\,, \tag{3}$$

where w stands for the number of weekly price observations, and w_{PCH} is the number of weeks with price changes. Besides indicators of cost or demand transmission, the mean duration of unchanged prices is typically regarded as one major element of price stickiness.

Appendix 1 allows some important conclusions with regard to the magnitude of price rigidity in different store types:

1. There is a substantial degree of price rigidity at the retail level. There are brands where the median duration of unchanged prices across store types is as high as 116, 41 or 36 weeks (brands 1, 7 and 19 respectively). If we compute the median of the medians across brands, the mean duration of unchanged prices is nearly 13 weeks. This is a very substantial magnitude of price stickiness given the fact that demand as well as costs are fluctuating with a much higher frequency at the points of sale.
2. Apparently, the median price rigidity varies strongly across products, too. Price rigidity is much higher than 13 weeks for some brands, but for other brands it is considerably lower: 6.5 weeks for brand 4, 7.6 weeks for brand 17, and 7.7 weeks for brand 18.
3. Additionally, price rigidity varies widely across store types. Discounters, a store type with a very clear every-day-low-price (EDLP) strategy, have by far the highest price rigidity: The median of periods of unchanged prices is as high as 37.5 weeks, much above supermarkets (13.2 weeks), small consumer markets (11.1 weeks), and large consumer markets (9.0 weeks). Discounters on the one hand and large consumer markets on the other hand have continuously increased their market shares over the years in German grocery retailing (Clarke et al., 2002, Section 9). They are at the upper and lower end of a scale characterizing EDLP versus Hi-Lo pricing strategies.

The differences between store types are very interesting as they suggest that discounters tend to stabilize consumer prices. Up to now, we have only compared the magnitude of the medians across store types. It is possible, however, to regard the distribution of price rigidity for the 20 brands as a typical sample for all branded foods and to attach confidence intervals to the medians. Conclusions on the statistical significance of the differences in medians can then be drawn. Such median tests are presented in Table 1. The confidence intervals for median price rigidity at a 95%-level of statistical significance do not overlap for discounters

and small consumer markets as well as discounters and large consumer markets. It can be concluded that median price rigidity of branded foods is significantly higher in discounters than in small and large consumer markets.

Appendix 2, where the data on price rigidity are analyzed by grocery-retailing firms, reveals that firm strategies play an important role, too. Whereas median price rigidity is as high as 44.3 weeks in Firm E and 35.8 weeks in Firm A, median price rigidity in Firm C reaches "only" 7.3 weeks and in Firm B 8.8 weeks. In Firm E, three peak values between 139 and 134 weeks (brands 1, 2, and 18) indicate that prices are adjusted in some cases only very rarely, i.e. less than all two years. On the other hand, the median of unchanged prices for major brands like Dallmayr Prodomo (brand 4), Rama (brand 17) or Nutella (brand 16) range between 2.7 and 3.9 weeks in Firm B. Apparently, prices are adjusted much more actively for some brands and in some firms compared with others.

Table 1: Significance Tests for Differences in Mean Price Rigidity by Store Types and Firms: Median Tests[a)]

Store Type/ Grocery-Retailing Firm	Median Price Rigidity (*MPRIG*) (in weeks)	
	Point Estimate	Confidence Interval (95%)
Discounters	37.5	$15.8 \leq MPRIG \leq 67.0$
Supermarkets	13.2	$10.7 \leq MPRIG \leq 20.1$
Small consumer markets	11.1	$8.9 \leq MPRIG \leq 15.0$
Large consumer markets	9.0	$7.8 \leq MPRIG \leq 12.2$
Firm A	35.8	$17.9 \leq MPRIG \leq 42.6$
Firm B	8.8	$5.2 \leq MPRIG \leq 14.9$
Firm C	7.3	$6.9 \leq MPRIG \leq 10.2$
Firm D	26.3	$16.8 \leq MPRIG \leq 59.3$
Firm E	44.3	$18.0 \leq MPRIG \leq 69.6$
Firm F	11.9	$9.3 \leq MPRIG \leq 15.2$

[a)] The methodology of the median test is explained in Sachs (2004), p. 337.

Source: Appendices 1 and 2 and authors' computations.

Median tests in Table 1 indicate some marked differences between firms: Price rigidity for branded foods in Firms A, D, and E is significantly higher at a 95%-level of statistical significance than in Firms B, C, and F. Firms' pricing strategies clearly matter for food brands' price rigidity.

Up to now, it has not been discussed how product characteristics might be associated with price rigidity. One characteristic that could be most relevant is the price elasticity of demand. Brands with a high absolute value of the price elasticity of demand are major candidates as loss-leader products that might attract customers to the stores. In Moeser (2002), short- and long-run price elasticities of demand were estimated for all the selected products. We define brands with a price elasticity of demand above 1.5 in absolute terms as high-elasticity brands and those below 1.5 as low-elasticity brands. When price rigidity of high- and low-elasticity brands is then compared for all store types, the median price rigidity of low-elasticity brands is 19.1 weeks and, thus, clearly above the corresponding value of high-elasticity brands with 9.3 weeks. A median test yields the following confidence interval for median price rigidity of low-elasticity food brands:

$$13.9 \leq MPRIG \leq 24.5. \tag{4}$$

The confidence interval for high-elasticity food brands is:

$$7.8 \leq MPRIG \leq 12.4. \tag{5}$$

The statistical level of significance is 95% in both cases.

We can conclude that median price rigidity of low-elasticity food brands is significantly higher than of high-elasticity food brands. This suggests that high-elasticity food brands are strong candidates for promotion activities. Hence, their price variability over time is higher than for low-elasticity food brands.

4.2 Importance of the Sale Phenomenon

The sale phenomenon has been identified in the literature as a major determinant of pricing strategies in grocery-retailing firms. In particular with Hi-Lo strategies of food retailers, brands are put on sale periodically and, thus, price variability is raised. Within the scanner dataset utilized, the number of price actions was counted for the selected brands. A price action indicates when a brand is on sale. It was defined as a situation in which the brand was priced at least 5% below the normal price. Appendix 3 captures statistical evidence on price actions in the four store types, and Appendix 4 covers price actions in the six grocery-retailing firms.

The main results in Appendix 3 on the importance of the sales phenomenon in German food-retailing are as follows:

1. Retail sales are widespread for branded foods in Germany. Per store, the 20 selected foods together were 151 times on sale in large consumer markets, 120 times in small consumer markets, 116 times in supermarkets, and 44 times in discounters. The median number of price actions per store was 111. If we compute the median of price actions for each individual product per store, it is

5.6 – when derived across store types – and 5.4 – when derived across brands – respectively.

2. Not surprisingly, the brands differ substantially with regard to the frequency they are put on sale. Whereas brand 4 and brand 17 were put more than 10 times on sale, the corresponding median values for brands 1, 11, and 7 are below 2.
3. Additionally, the importance of the sale phenomenon is strongly dependent of the store types. It is most important in large consumer markets, small consumer markets and supermarkets. The median value of price actions per store is 7.5 for large consumer markets, but only 1.0 for discounters.

It is striking that the ranking of store types according to price actions is exactly opposite to that regarding price rigidity: Discounters realized the strongest price rigidity and the lowest number of price actions. Large consumer markets realized the lowest price rigidity, but the highest number of price actions per store.

Table 2 additionally shows some median tests. We again regard our 20 selected brands as a representative sample for branded foods in general and attach confidence intervals to the medians. The computation for the four store types reveal that significantly less price actions per store occur in discounters than in all other store types: supermarkets, small consumer markets, and large consumer markets.

Appendix 4 illustrates for the six grocery-retailing firms that the number of price actions per store varies widely across firms. Firms' promotion activities are very heterogeneous. Whereas the median number of price actions per store is as high as 9.6 for Firm C and 8.9 for Firm B, the corresponding values are much smaller for Firm E with 1.3 and Firm A with 1.7. Peak values per store are 31.3 (brand 4, Firm B) and 24.6 price actions per store (brand 17, Firm B). Other brands are not part of the promotion strategies of individual firms at all, like, e.g., brand 11 in Firms A and F. Like price rigidity, the importance of the sale phenomenon is very different across firms.

Median tests in Table 2 show the following significant differences, given a statistical significance level of 95%: The importance of price actions in Firms A and E is significantly lower than in Firms B, C, and F.

Table 2: Significance Tests for Differences in Price Actions per Store by Store Type and Firm: Median Tests[a)]

Store Type/ Grocery-Retailing Firm	Median of Price Actions per Store (*MACTION*)	
	Point Estimate	Conficence Interval (95%)
Discounters	1.0	$0.3 \leq MACTIONS \leq 1.2$
Supermarkets	5.1	$3.0 \leq MACTIONS \leq 6.3$
Small consumer markets	6.0	$3.8 \leq MACTIONS \leq 8.0$
Large consumer markets	7.5	$5.2 \leq MACTIONS \leq 9.8$
Firm A	1.7	$0.8 \leq MACTIONS \leq 3.5$
Firm B	8.9	$4.1 \leq MACTIONS \leq 11.4$
Firm C	9.6	$5.0 \leq MACTIONS \leq 11.4$
Firm D	2.6	$0.6 \leq MACTIONS \leq 5.4$
Firm E	1.3	$0.0 \leq MACTIONS \leq 3.3$
Firm F	5.1	$3.9 \leq MACTIONS \leq 7.3$

[a)] The methodology of the median test is explained in Sachs (2004), p. 337.

Source: Appendices 3 and 4 and authors' computations.

4.3 Extent of Psychological Pricing

Psychological prices have been suggested by economists as well as psychologists as a rationale for sticky prices. However, the marketing literature stressing psychological reasons for "odd pricing", "just-below-the-round-figure pricing" or "psychological pricing" is dominating. The economic literature has been hesitant against this theory and in their survey of business managers, Blinder et al. (1998) found no confirmation for it. However, the retailing sector was underrepresented in that study and most managers of firms which typically sell directly to consumers viewed the theory as being realistic. There is evidence in several empirical studies, too, that psychological prices are prevalent in food retailing (Friedman, 1967; Fengler and Winter, 2001).

We present an overview of psychological pricing in German grocery retailing in this section based on scanner data evidence for the selected 20 brands. Psychological prices are defined as those prices which are slightly below psychological pricing points, e.g. 0.49 DM, 0.99 DM or 4.99 DM. The most important psychological prices for all 20 products were studied in detail, i.e. those which represented 5% or more of all observed prices in the respective firms. Detailed results for all brands and the six grocery-retailing firms are presented in

Herrmann and Moeser (2004). Very aggregate indicators of psychological pricing are summarized in the Appendices 5 to 8 of this paper. Appendices 5 and 6 refer to the percentage share of the important psychological prices in all observed prices (*PSYCH*): Appendix 5 for the store types, Appendix 6 for the grocery-retailing firms. Additionally, concentration ratios for the two most important psychological prices (*CR*2) are provided for all 20 products – in Appendix 7 for the store types and in Appendix 8 for the six grocery-retailing firms.

PSYCH can be interpreted as a measure of the overall importance of psychological prices. A high value of *PSYCH* is generally compatible with either the economic or the psychological hypotheses on psychological pricing. We argue that *CR*2 yields valuable additional information. It is *CR*2 rather than *PSYCH* which will measure the economic presumption that psychological price barriers are valid. If *CR*2 is large, this suggests that retailers will expect a strong reaction by consumers if a psychological price barrier is exceeded. Therefore, they will only rarely change a price slightly below the barrier.

It is possible, too, that *PSYCH* is much higher than *CR*2. More prices, in some cases many more psychological prices are then set by retailers. In this case, it is likely that retailers' pricing strategies are rather flexible and not limited by major psychological pricing points, and despite relatively frequent price changes, 9- or 99-ending effects occur since customers do either round down prices or apply a left-to-right comparison. This constellation implies that psychological prices are then part of a pricing strategy in which firms move from one psychological price to the next. Major price barriers, as indicated by Sweezy's kinked demand function, are not necessary for such a pricing strategy. It is rather the level effects explained in cognitive psychology that seem to be crucial for this type of observed behaviour.

It can be derived from Appendices 5 and 6 that psychological prices are the rule rather than the exception in German grocery retailing. Across all stores, *PSYCH* ranges between 75.0 % (brand 4) and 94.7% (brand 7). The median across the 20 brands is 89.6 %. This high share is even a lower limit for the overall importance of psychological prices, as less important 9-ending prices are ignored which do not reach the 5%-minimum of all observed prices. The percentage share of important psychological prices is higher than 90% for all individual store types, when medians across the brands are calculated. Psychological pricing is even more widespread in discounters than in the other three store types: The median is an impressive 96.4 % of all prices for discounters.

Median tests were again performed in order to investigate whether the overall importance of psychological prices is significantly different between store types. Results are shown in Table 3, given a 95%-level of statistical significance. As psychological prices are very important in all store types, not all the differences between the computed medians are statistically significant. It can be derived,

however, that the overall importance of psychological prices, as measured by the median of *PSYCH*, is significantly higher for discounters than for large consumer markets.

Similarly important are the shares of psychological prices in all six grocery-retailing firms, as Appendix 6 shows. Median values across brands are for all firms above 90% with Firm E being extreme: In Firm E, the median of *PSYCH* is 99.2 %. Almost all prices are psychological prices. Almost all prices are important psychological prices, too, that cover 5% or more of all observed prices. As the medians of *PSYCH* are so high for several firms, the confidence intervals of the medians do overlap in a number of cases. But some examples do exist that show that firm strategies matter and the role of psychological prices varies significantly. Table 3 shows, at the 95%-level of statistical significance, that the overall importance of psychological prices is higher for Firm E than for Firms B and C. Moreover, the importance of psychological prices in Firm C is significantly lower than in Firm A although the medians are very high in both firms.

Table 3: Significance Tests for Differences in the Overall Importance of Psychological Prices in Store Types and Firms: Median Tests[a)]

Store Type/ Grocery-Retailing Firm	Median of the Share of Important Psychological Prices in All Prices (*MPSYCH*)	
	Point Estimate	Confidence Interval (95%)
Discounters	96.4	$93.2 \leq MPSYCH \leq 98.9$
Supermarkets	92.6	$89.6 \leq MPSYCH \leq 93.4$
Small consumer markets	93.2	$89.6 \leq MPSYCH \leq 95.0$
Large consumer markets	91.2	$87.6 \leq MPSYCH \leq 92.4$
Firm A	98.5	$96.2 \leq MPSYCH \leq 98.8$
Firm B	95.0	$90.7 \leq MPSYCH \leq 96.6$
Firm C	90.9	$89.2 \leq MPSYCH \leq 92.9$
Firm D	96.0	$93.2 \leq MPSYCH \leq 98.6$
Firm E	99.2	$97.1 \leq MPSYCH \leq 100.0$
Firm F	96.6	$90.2 \leq MPSYCH \leq 97.5$

a) The methodology of the median test is explained in Sachs (2004), p. 337.

Source: Appendices 5 and 6 and authors' computations.

It can be derived from Appendices 7 and 8 that the two most important psychological prices cover already a high share of the observed prices. The

variation of *CR*2, however, across store types and firms, is much higher than for *PSYCH*. Across all stores, the concentration ratio of the two most important prices ranges between 44.7% (brand 4) and 91.2% (brand 20) with a median of 66.0%. The respective concentration ratios are typically higher at the level of the individual store types: Median values for *CR*2 across brands are in the range between 66.1 and 69.4% for supermarkets, small consumer markets, and large consumer markets, and clearly higher for discounters with 85.1%. *CR*2 values for individual brands differ widely. Due to this wide variation, the confidence intervals shown in Table 4 for the median values are large and do overlap in all cases. No statistically significant differences between medians can be derived at the 95%-level.

Table 4: Significance Tests for Differences in the Concentration Ratios of the Two Most Important Psychological Prices in Store Types and Firms: Median Tests[a)]

Store Type/ Grocery-Retailing Firm	Median of the Concentration Ratio of the Two Most Important Psychological Prices (*MCR*2) (%)	
	Point Estimate	Confidence Interval (95%)
Discounters	85.3	$70.0 \leq MCR2 \leq 95.4$
Supermarkets	66.1	$53.7 \leq MCR2 \leq 76.5$
Small consumer markets	68.3	$57.2 \leq MCR2 \leq 83.8$
Large consumer markets	69.4	$61.6 \leq MCR2 \leq 78.9$
Firm A	91.1	$83.5 \leq MCR2 \leq 98.7$
Firm B	66.1	$60.6 \leq MCR2 \leq 81.7$
Firm C	79.8	$69.6 \leq MCR2 \leq 87.5$
Firm D	83.1	$72.4 \leq MCR2 \leq 95.7$
Firm E	98.3	$91.1 \leq MCR2 \leq 98.9$
Firm F	61.2	$57.8 \leq MCR2 \leq 72.7$

a) The methodology of the median test is explained in Sachs (2004), p. 337.

Source: Appendices 7 and 8 and authors' computations.

According to Appendix 8, the concentration ratios for the two most important psychological prices are also high for all grocery-retailing firms. Medians for the brands across store types range between 54.7 % (brand 4) and 98.5 % (brand 20), those for firms across brands between 61.2 % (Firm F) and 98.3 % (Firm E).

Table 4 reveals the importance of different firm strategies. Given a 95%-level of statistical significance, confidence intervals for the medians of *CR*2 do not overlap for several firms. The median of *CR*2 for food brands is significantly higher in Firm E than in Firms F, B, and C. Furthermore, the median of *CR*2 for food brands is significantly higher in Firm A than in Firms F and B. It appears that the way firms stick to the most important psychological prices varies starkly.

5. Econometric Tests: Some Determinants of Price Rigidity in Grocery Retailing

The statistical analysis has already proven that food price rigidity differs by store types and grocery-retailing firms. Correlation analysis additionally shows that price rigidity is negatively correlated with price actions per store and positively with the importance of psychological prices. Correlation, however, is not causality. Therefore, econometric results are presented in this section in order to test whether these potential determinants do affect food price rigidity within a causal analysis.

In all the following models, price rigidity is modelled across brands and either across firms or store types. *ACTIONS*, *PSYCH*, and *CR*2 are introduced as main determinants of price rigidity.[3]

In various model specifications, the two alternative hypotheses were tested whether strategies at the firm level or for store types affect price rigidity either directly or indirectly. The analysis clearly shows that different firm strategies are most relevant for the explanation of retail sales and for psychological pricing, but not for price rigidity directly when the influence of *ACTIONS*, *PSYCH*, and *CR*2 are controlled for. Analogously, the findings reveal that price rigidity was not directly affected by the store type when the variables for price actions and psychological pricing were additional explanatory variables. This suggests in both cases that an indirect influence of strategies on price rigidity does exist, caused by the strategies' effects on price actions and psychological pricing. These behavioural linkages are consistent with equation (1') and (2') rather than (1) and (2). Moreover, we allowed for linkages between price actions and psychological pricing.

[3] In the analysis of Table 5, the following assumption has been made. *PRIG* is set to 200 by assumption in those two cases where brands were distributed in all six firms but no price changes did occur in one of these firms: Golden Toast Sonntagsbroetchen/Firm D; Wasa Schoko Wikinger/Firm E. It would have been a distortion to leave the two cases with the highest price rigidity out. It would have been a distortion, too, to insert the value infinity which the equation (3) for *PRIG* yields in these two cases, if an infinitesimal value rather than zero is introduced for the number of price changes.

The preferred empirical model of price rigidity, price actions, psychological prices, and firm strategy has the triangular form of a fully recursive system:

$$PRIG = f(ACTIONS, PSYCH, CR2, Z), \quad (6)$$

$$CR2 = f(PSYCH, ACTIONS, Z), \quad (7)$$

$$PSYCH = f(ACTIONS, Z) \quad (8)$$

and

$$ACTIONS = f(Z). \quad (9)$$

The rationale for this structural model is as follows. The number of price actions and the characteristics of psychological pricing in different firms or store types are strategic decision variables and major determinants of price rigidity. There may be, additionally, linkages between the determinants of price rigidity themselves. In particular, more price actions might reduce the importance of widely used psychological prices, i.e. *PSYCH* or *CR*2.

Z is a vector of exogenous variables. In the structural model specified at the firm level, firms *A* to *E* (*FIRM A, FIRM B, FIRM C, FIRM D, FIRM E*) are included in the vector as dummy variables with *FIRM F* as a benchmark. In the structural model specified for store types, supermarkets (*SUPERMA*) and small and large consumer markets (*SMALLCONS, LARGECONS*) are included in *Z* as dummy variables. Discounters are used as the reference group against which the other store types are evaluated. Additionally, the short-run price elasticity of demand[4] (*ELAST*) is introduced as an exogenous variable in the model for firms and for store types.

Results in the specification search suggested, as indicated above, an indirect rather than a direct influence of firms' strategies and strategies for store types. Furthermore, a strong effect of the price elasticity of demand was found on price actions but not on price rigidity directly. Therefore, the empirical results shown in Table 5 and 6 do not include the whole set of exogenous variables in all equations of the system. The variables for firms and store types are excluded from the *PRIG*

[4] In Moeser (2002), short-run and long-run price elasticities of demand were calculated. The short-run elasticities from that source, which are based on a sample of 38 stores (ibid., p. 177), are used here for all firms and store types in order to characterize the general differences across brands. The estimated price elasticities are: -1.68 (brand 1), -1.13 (brand 2), -1.56 (brand 3), -4.28 (brand 4), -0.27 (brand 5), -1.16 (brand 6), - 0.78 (brand 8), -0.67 (brand 9), -2.64 (brand 10), -0,59 (brand 11), -1.30 (brand 12), -0.78 (brand 13), -1.44 (brand 14), -2.84 (brand 15), -3.46 (brand 16), -3.15 (brand 17), - 2.48 (brand 18), -0.21 (brand 19), -1.02 (brand 20). In the regression equations, the price elasticity of demand for brand 7 is posited as being the average value between those of brands 6 and 12.

equation, but kept in the equations for *CR*2, *PSYCH*, and *ACTIONS*. The price elasticity of demand is included in equation (9) of both structural models, but not in equations (6) to (8).

The system is estimated at the level of firms and store types with Zellners seemingly-unrelated-regression (SUR) technique in order to deal with cross-correlation between the error terms (Zellner, 1963). Table 5 presents the estimated model at the firm level, Table 6 the corresponding one for the level of store types.

Table 5 reveals, at the 95%-levels of statistical significance or higher, the expected positive effect of the psychological-pricing variables on price rigidity. The regression coefficient of *CR*2 means that a rise of *CR*2 by one percentage point leads to a 0.69-week increase in price rigidity, i.e., as psychological pricing becomes more important and more concentrated on few important price barriers, food prices get more sticky.

The expected negative effect of price actions on price rigidity is also supported by Table 5. The recursive structure of the models allows here interesting conclusions on direct as opposed to indirect effects. Actions reduce price rigidity directly. Furthermore, more actions lower the concentration on only a few psychological prices within the firm. As a higher concentration on few psychological prices raises price rigidity, too, *ACTIONS* reduces *PRIG* indirectly via its negative impacts on *CR*2 and *PSYCH*. When the multiplicator effects are computed from Table 5, indirect effects are about as strong as the direct effects: An additional price action per store leads to a decline in price rigidity by 3.4 (1.7) weeks, if direct and indirect (only direct) effects are taken into account.[5]

Column 1 in Table 5 additionally shows that the variables *PRIG* and *ACTIONS* are not just two sides of a coin. It is not the sales phenomenon alone, but also psychological pricing that explains price rigidity. Additionally, the coefficient of determination (0.38) indicates that other factors must exist which are not yet incorporated. Most notably, menu costs and changes in input prices seem important. Unfortunately, data on these explanatory variables are not available within our dataset.

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[5] Formally, the overall effect of *ACTIONS* on *PRIG* can be derived from equations (6) to (9) as follows:

$$dPRIG/dACTIONS = \partial PRIG/\partial ACTIONS + (\partial PRIG/\partial CR2)\cdot (\partial CR2/\partial PSYCH)\cdot(\partial PSYCH/\partial ACTIONS) + (\partial PRIG/\partial CR2)\cdot (\partial CR2/\partial ACTIONS) + (\partial PRIG/\partial PSYCH)\cdot(\partial PSYCH/\partial ACTIONS).$$

If the statistically significant coefficients from Table 5 are introduced, this yields (*d PRIG*/*d ACTIONS*) = -3.43. The first term on the right-hand side of the equation indicates the direct effect of *ACTIONS* on *PRIG* alone, i.e. -1.66. We thank a reviewer for his suggestion to choose this style of presentation.

Table 5: The Determinants of Price Rigidity, Price Actions, and Psychological Pricing in a Recursive Econometric Model, 20 German Food Brands, Six Firms: SUR Estimates[a)]

	Dependent Variables			
Independent Variables	*PRIG*	*CR*2	*PSYCH*	*ACTIONS*
Constant	-173.48*	39.43	98.27***	4.49***
	(-2.05)	(1.08)	(110.29)	(3.95)
*CR*2	0.69**			
	(3.34)			
PSYCH	1.70*	0.34		
	(1.97)	(0.90)		
ACTIONS	-1.66*	-0.99**	-0.64***	
	(-2.06)	(-2.91)	(-9.36)	
FIRM A		18.89***	1.42	-3.75**
		(4.41)	(1.30)	(-2.72)
FIRM B		7.95$^{[*]}$	0.86	3.60**
		(1.88)	(0.79)	(2.62)
FIRM C		15.43***	-1.51	1.77
		(3.70)	(-1.42)	(1.29)
FIRM D		12.43**	-0.16	-3.51*
		(2.96)	(-0.15)	(-2.55)
FIRM E		21.09***	1.16	-5.18***
		(4.83)	(1.04)	(-3.77)
ELAST				-1.52***
				(-4.36)
n	108	108	108	108
R^2	0.38	0.46	0.56	0.42

***, **, *, [*] Statistically significant at the 99.9%-, 99%-, 95%-, 90%-level.

a) The variables are defined in the text. Only those 18 products are included which are distributed in all firms (n = 18). Values in parentheses are t-values.

Source: Authors' computations with data from the Appendices.

The determinants of price rigidity – *ACTIONS* and *CR*2 in particular – are mainly driven by firms' strategies. Compared with *FIRM F*, price actions are for *FIRMS A*, *D*, and *E* significantly less important as strategic variables but more important for *FIRM B*. Psychological pricing is more important for all firms than for *FIRM F*, when *CR*2 is considered. A most interesting result is that the price elasticity of demand for the individual brands is a significant determinant of price actions. As we would theoretically expect, an absolutely high price elasticity of

demand implies that the respective brand is more often on sale. Given the recursive structure of the model, there is a high impact of the price elasticity of demand on price rigidity due to direct and indirect linkages. This is due to the fact that (i) the price elasticity of demand affects the number of actions starkly; (ii) the direct and indirect effects of price actions on price rigidity are strong, too. The expression (*d PRIG* / *d ELAST*) is 5.22 on the basis of the estimated coefficients in Table 5.[6] I.e., if the price elasticity of demand rises in absolute terms by 0.1 (1), price rigidity declines by 0.52 (5.2) weeks.

The quantitative results across store types are shown in Table 6. Price rigidity is raised by an increasing role of psychological pricing, as measured by *CR*2, and reduced by an increasing number of price actions. Again, *ACTIONS* affects *PRIG* directly and indirectly. The indirect effect implies that price barriers lose in importance and *CR*2 and *PSYCH* are reduced when an increasingly active price promotion takes place. The overall effect of price promotions on price rigidity, as measured in footnote 5, is identical to the result for firms: -3.43. This implies that an additional price action per store lowers price rigidity by 3.4 weeks. This time, however, the overall effect is dominated by the direct linkage between *ACTIONS* and *PRIG* of -2.82.

Price actions and psychological pricing in turn are driven by differential strategies for store types. Discounters have to be distinguished from all the other store types. Significantly more price actions occur in supermarkets and small consumer markets, but mainly in large consumer markets. Psychological prices, measured by either *PSYCH* or *CR*2, are widespread in all store types. However, the significantly lower *CR*2 for supermarkets and small consumer markets indicates that they are significantly less relevant as strategic variables in those store types than in discounters. Like in the data set for firms, brands with a higher absolute value of the price elasticity of demand are chosen more often for price actions than those with lower absolute values.

We can conclude that food price rigidity is driven by psychological pricing, price promotions and strategies by firms and for store types. Psychological pricing, if measured by *PSYCH*, has a limited influence on food price rigidity, too, if the latter is analyzed across grocery-retailing firms. A generally positive influence does exist for *CR*2 on food price rigidity. The more a few price barriers are relevant, the stickier are food prices. Furthermore, the importance of the sale phenomenon for food price rigidity is strongly confirmed. An increasing number of price promotions per store make food prices less rigid. It is striking that the sale

[6] The coefficient of -1.52 for $(\partial\, ACTIONS / \partial\, ELAST)$ is multiplied by the coefficient of -3.43 resulting from the equation in footnote 5 for the overall effect of *ACTIONS* on *PRIG*. If we apply the method to store types (Table 6), the marginal impact of *ELAST* on *PRIG* is again strong: 6.89.

phenomenon affects price rigidity, but also – to a significant degree – indirectly by its impact on psychological prices. Firm strategies and strategies for store types differ and food price rigidity is significantly affected by these differential strategies indirectly via their influence on price promotions and psychological pricing.

Table 6: The Determinants of Price Rigidity, Price Actions, and Psychological Pricing in a Recursive Econometric Model, 20 German Food Stores, Four Store Types: SUR Estimates[a)]

	Dependent Variables			
Independent Variables	*PRIG*	*CR2*	*PSYCH*	*ACTIONS*
Constant	-46.79 (-0.58)	78.76 (1.64)	97.79*** (117.54)	-1.06 (-1.18)
CR2	0.40* (2.15)			
PSYCH	0.65 (0.81)	0.08 (0.17)		
ACTIONS	-2.82* (-2.53)	-1.52* (-2.26)	-1.13*** (-10.76)	
SUPERMA		-9.18$^{[*]}$ (-1.79)	0.64* (0.54)	3.73*** (3.68)
SMALLCONS		-8.82$^{[*]}$ (-1.71)	1.33 (1.11)	3.77*** (3.72)
LARGECONS		-4.38 (-0.80)	0.53 (0.42)	5.54*** (5.47)
ELAST				-2.01*** (-6.29)
n	76	76	76	76
R^2	0.38	0.29	0.60	0.46

***, **, *, [*] Statistically significant at the 99.9%-, 99%-, 95%-, 90%-level.

a) The variables are defined in the text. Only those products are included which are distributed in all store types (n = 19). Values in parentheses are t-values.

Source: Authors' computations with data from the Appendices.

6. Open Questions for Future Research

In the analysis above some important determinants of food price rigidity were discussed. Other possible determinants that should be included in future research include menu costs; explicit contracts between processors and retailers, input costs, etc. Data on these determinants are typically lacking at the individual store level, but approaches are available to deduce, e.g., the presence of menu costs from observed scanner data evidence on prices (Levy et al., 1997, 1998; Carlton, 1986). In particular, the magnitude in addition to the number of price changes may provide information about the impact of menu costs in the grocery-retailing sector. This is based on the presumption that under menu costs the number of price changes is rather small and the magnitude of such changes is higher.

One interesting issue on which initial results are available refers to the type of product, in particular the distinction between national brands and private-label goods. A statistical analysis with a more recent scanner dataset for German grocery-retailing stores for the years 2000 and 2001 in the category of edible oils suggests that private-label oils are on the one hand cheaper and otherwise show a greater price stability (see Table 7). These results are consistent with the study by Slade (1998) which also confirms stickier prices for private-label items.

The first five brands in Table 7 are representative of private-label edible oils while the brands 6 to 15 are national brands. The mean duration of unchanged prices is again computed on the basis of equation (3) in Chapter 4.1.

In doing so, the comparison between the private-label items and the national brands shows that the mean duration of unchanged prices ranges from 15.2 weeks to 120.0 weeks for the private-label products. The range of mean weeks of sticky prices lies between 3.3 and 95.0 weeks for the national brands. Thus, several items in the group of the national brands are rarely put on sale as is the case for private labels. However, there are other brands where price changes are rather frequently. Apparently, brands 7 or 9 are often used as loss leaders in stores.

Altogether, it is apparent that the mean duration of unchanged prices is higher for private labels, since 37.1 weeks pass between two price changes while for national brands this time gap is only 26.2 weeks.

In addition, Table 7 illustrates that discounters and supermarkets are the store types that embark on stickier pricing strategies than the other store types. This is consistent with the findings in Section 4.1. Across all products, discounters change their prices only each 45 weeks on average and supermarkets each 31 weeks in the two-year sample period. The largest store types are found to have the highest number of price changes, the large consumer markets and self-service warehouses (more than 5000m^2 sales area) with 27 weeks of unchanged prices and 28 weeks respectively.

Table 7: Mean Weekly Duration of Unchanged Prices, Edible Oils, Germany, 2000-01

Brands[7]	All Stores	Dis-counters	Supermarkets	Small Consumer Markets	Large Consumer Markets	Self-service Warehouses
1	27.3	n. d.[a)]	31.2	35.6	-[b)]	15.2
2	22.6	n. d.[a)]	21.6	23.3	-[b)]	22.8
3	71.4	n. d.[a)]	n. d.[a)]	72.5	39.6	120.0
4	32.9	n. d.[a)]	33.7	34.3	34.2	29.4
5	35.9	n. d.[a)]	34.0	34.3	34.2	41.2
6	30.4	n. d.[a)]	66.8	15.9	25.7	13.1
7	5.7	n. d.[a)]	-[b)]	n. d.[a)]	6.4	5.0
8	11.0	22.9	7.5	7.9	11.4	5.2
9	10.7	24.5	10.2	8.5	6.7	3.3
10	23.0	n. d.[a)]	28.7	23.1	26.8	13.5
11	15.5	n. d.[a)]	20.0	19.5	13.3	9.4
12	56.6	50.5	73.2	65.1	36.9	57.0
13	22.8	33.4	41.7	20.9	9.9	8.0
14	29.0	n. d.[a)]	38.4	24.3	29.2	24.1
15	24.0	95.0	5.0	4.7	8.9	6.3
All brands	**32.4**	**45.3**	**31.2**	**30.6**	**26.8**	**28.3**

a) Not distributed. – b) Insufficient data.

Source: Authors' computations.

If this pattern of a differential dynamic pricing pattern for national brands and private labels is confirmed at a broader commodity basis, this adds an interesting

[7] Brand 1 is a 1-litre bottle of a vegetable oil ("EM Pflanzenoel", 1l), brand 2 is a 1-litre bottle of a sunflower oil ("EM Sonnenblumenoel", 1l), brand 3 is an 0.75-litre bottle of a safflower oil ("Goldhand Tip Disteloel", 0.75l), brand 4 is a 1-litre bottle of a vegetable oil ("Markant Pflanzenoel", 1l), brand 5 is a 1-litre bottle of a sunflower oil ("Markant Sonnenblumenoel", 1l), brand 6 is an 0.5-litre bottle of a safflower oil ("Mazola Disteloel", 0.5l), brand 7 is a 1-litre bottle of a germ oil ("Mazola Keimoel", 1l), brand 8 is an 0.75-litre bottle of a germ oil ("Mazola Keimoel", 0.75l), brand 9 is an 0.75-litre bottle of a sunflower oil ("Thomy Sonnenblumenoel", 0.75l), brand 10 is an 0.5-litre bottle of a safflower oil ("Olio Dante Extra", 0.5l), brand 11 is an 0.75 litre-bottle of a rape-seed oil ("Rapso 100%", 0.75l), brand 12 is an 0.5-litre bottle of a vegetable oil ("Union Bechts Spezial", 0.5l), brand 13 is an 0.75-litre bottle of a vegetable oil ("Biskin Oel", 0.75l), brand 14 is an 0.75-litre bottle of a vegetable oil ("Biskin Spezial", 0.75l), brand 15 is a 1-litre bottle of a sunflower oil ("Livio Sonnenblumenoel", 1l).

finding to the literature on private labels. Up to now, the theoretical and empirical literature on private labels concentrated mainly on statistical information on the development of private labels for different products and countries. Moreover, the determinants of this development were analyzed as well as implication for the relationships between retailers and manufacturers (Bergès-Sennou, Bontems and Réquillart, 2004). In most studies, the price gap between the two types of products was of special importance. Ward et al. (2002), e.g., elaborate that the price gap between national brands and private labels widens with an increasing share of private-label products within a commodity group. Our results in Table 7 suggest that price-setting behaviour of grocery retailers does not only differ with regard to the price level of private labels as compared to national brands. Price rigidity, or more generally the dynamic pricing behaviour, seems to differ between private labels and national brands, too. Microeconomic analyses are needed to explain in much more detail this issue of retailers' pricing behaviour, which has been widely neglected up to now.

7. Summary and Conclusions

The objective of this paper was to elaborate the magnitude of price rigidity in the German grocery-retailing sector on the basis of 20 selected food brands and to explain the evidence within an econometric analysis. A comprehensive set of scanner data for the period 1996-99 was utilized, which contains price and quantity information at the store level for different store types and grocery-retailing firms.

There is a substantial degree of price rigidity in the German grocery-retailing sector which varies substantially across products, store types, and firms. There are brands where the median duration of unchanged prices across store types is as high as 116, 41 or 36 weeks. If the median is computed across the brand medians, the mean duration of unchanged prices is nearly 13 weeks. Median price rigidity is significantly lower in discounters than in small and, even more so, in large consumer markets. An interesting finding is additionally that median price rigidity is significantly higher for low-elasticity food brands than for high-elasticity food brands.

Retail sales are widespread for branded foods in Germany. Per store, the 20 selected foods were 111 times on sale in the period under consideration. Price actions per store differ again widely across products, store types, and grocery-retailing firms. Significantly less price actions occur in discounters than in all other store types analyzed.

Although economists have been hesitant against the hypothesis that psychological pricing causes sticky prices, psychological prices are the rule rather than the exception in German grocery retailing. Across all 20 selected brands, the

median share of important psychological prices is about 90%. Nearly all psychological prices are based on 9- or 99-endings. Psychological pricing is widespread in all store types and firms and for all brands, but it is most relevant for the store type of discounters. However, the number of important psychological prices – as measured by the concentration ratio $CR2$ – differs widely across brands, store types, and firms.

In the econometric analysis, the importance of the sale phenomenon could be identified as a major determinant of food price rigidity. An increasing number of price actions lowers price rigidity directly and indirectly through its impact on psychological pricing. Food prices get stickier, as psychological pricing becomes more important and more concentrated on few important price barriers. Price rigidity is also indirectly and strongly affected by differential pricing strategies of firms and for store types.

It is argued that the analysis of food price rigidity should go beyond the important determinants identified here. Additional explanatory variables could be menu costs or input costs, i.e. variables that are much harder to identify at the individual store level.

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Appendix 1: Price Rigidity in German Food Stores, 20 Brands, Four Store Types, Weekly Prices, 1996-99[a)]

Brands	Average Price Rigidity (*PRIG*) in Four Store Types[b)]				Median
	Discounters	Supermarkets	Small Consumer Markets	Large Consumer Markets	
1	123.0	45.0	195.7	108.1	**115.6**
2	36.2	17.2	20.4	9.1	**18.8**
3	37.5	10.4	8.8	8.2	**9.6**
4	7.7	5.3	7.8	5.1	**6.5**
5	23.7	10.8	8.8	8.8	**9.8**
6	28.1	20.1	7.1	7.3	**13.7**
7	57.0	54.9	17.9	27.3	**41.1**
8	81.6	11.8	10.5	11.0	**11.4**
9	70.0	19.1	15.0	17.4	**18.3**
10	15.8	11.6	10.1	9.7	**10.9**
11	n. d. [b)]	66.3	9.8	18.6	**18.6**
12	67.0	20.8	25.8	12.2	**23.2**
13	15.3	13.9	11.7	6.8	**12.8**
14	93.8	10.7	12.2	7.8	**11.5**
15	51.5	12.4	13.0	8.2	**12.7**
16	14.5	7.8	10.0	8.8	**9.4**
17	8.8	6.4	8.9	4.9	**7.6**
18	24.3	7.8	7.5	6.5	**7.7**
19	43.5	31.9	39.5	30.3	**35.7**
20	77.3	31.8	19.1	24.5	**28.2**
Median	**37.5**	**13.2**	**11.1**	**9.0**	**12.2[c)]/12.8[d)]**

a) Sample period, store types and the computation of price rigidity are explained in the text, brands are described in Footnote 1 of the text. The number of observations differs across store types. – b) Not distributed. – c) Median of the medians, computed across the four store types. – d) Median of the medians, computed across the 20 brands.

Source: Authors' computations.

Appendix 2: Price Rigidity in German Food Stores, 20 Brands, Six Grocery-Retailing Firms, Weekly Prices, 1996-99[a)]

Brands	Average Price Rigidity (*PRIG*) in Six Grocery-Retailing Firms[b)]						Median
	A	B	C	D	E	F	
1	200.5	72.4	175.0	-[d)]	134.0	69.3	134.0
2	35.9	11.2	8.5	23.2	139.0	11.9	17.6
3	35.8	8.7	3.8	19.6	94.5	9.5	14.6
4	16.3	2.7	7.2	11.1	18.0	9.3	10.2
5	24.1	6.3	6.7	18.3	9.9	12.7	11.3
6	14.1	14.9	6.5	104.0	9.4	5.0	11.8
7	73.7	93.3	11.3	-[c)]	24.1	15.2	24.1
8	50.8	9.6	7.1	16.8	48.9	10.4	13.6
9	36.6	17.9	17.7	33.6	34.0	7.4	25.8
10	23.3	5.1	7.1	37.8	16.9	27.7	20.1
11	-[d)]	21.2	6.9	63.4	-[d)]	-[c)]	21.2
12	22.0	8.9	21.6	69.0	81.5	22.2	22.1
13	16.7	6.7	7.3	14.5	10.5	15.1	12.5
14	39.5	5.2	6.8	59.3	60.3	10.2	24.9
15	42.6	5.6	7.1	127.4	49.0	11.6	27.1
16	17.9	3.9	19.5	16.3	69.6	13.6	17.1
17	10.2	3.3	7.4	10.9	39.8	7.2	8.8
18	19.9	4.5	4.2	18.7	139.3	8.2	13.5
19	46.3	26.7	39.3	29.3	31.1	56.1	35.2
20	123.3	23.1	10.2	82.6	-[c)]	17.8	23.1
Median	**35.8**	**8.8**	**7.3**	**26.3**	**44.3**	**11.9**	**19.1[e)]/18.9[f)]**

a) The sample period and the included stores are explained in the text. The number of observations differs across the grocery-retailing firms and products. Brands are described in Footnote 1 of the text. – b) Price rigidity is measured as in equation (1) in the text. – c) Not computed as no price changes were observed. – d) Not distributed in this grocery-retailing firm. – e) Median of the medians, computed across firms. – f) Median of the medians, computed across brands.

Source: Authors' computations.

Appendix 3: Price Actions per Store in German Grocery Retailing, 20 Brands, Four Store Types, Weekly Prices, 1996-99[a)]

Brands	Discounters	Supermarkets	Small Consumer Markets	Large Consumer Markets	Median
1	0.0	1.6	0.3	0.3	**0.3**
2	2.8	7.0	5.2	10.8	**6.1**
3	1.2	3.1	6.8	8.0	**4.5**
4	12.8	19.3	13.4	15.9	**14.7**
5	0.3	3.0	5.8	7.5	**4.4**
6	1.5	5.3	9.4	10.2	**7.4**
7	0.0	1.3	2.7	2.5	**1.9**
8	1.3	6.9	8.8	10.2	**7.9**
9	0.7	6.0	8.2	6.7	**6.4**
10	2.7	7.2	8.0	7.5	**7.4**
11	n. d.[b)]	0.3	4.2	1.5	**1.5**
12	0.8	4.8	3.5	6.2	**4.2**
13	5.3	6.3	8.3	11.7	**7.3**
14	0.3	6.2	6.2	9.8	**6.2**
15	0.8	4.3	4.8	9.5	**4.6**
16	4.8	10.1	6.5	6.8	**6.7**
17	7.7	14.0	8.8	16.4	**11.4**
18	0.0	4.8	3.8	5.2	**4.3**
19	1.0	2.3	2.3	1.0	**1.7**
20	0.3	1.7	3.2	3.5	**2.5**
Sum	**44.3**	**115.7**	**120.2**	**151.0**	**111.4**
Median	**1.0**	**5.1**	**6.0**	**7.5**	**5.6[c)]/5.4[d)]**

a) Sample period and store types are explained in the text, the brands in Footnote 1 of the text. – b) Not distributed. – c) Median of the medians, computed across the four store types. – d) Median of the medians, computed across the brands.

Source: Moeser (2002), p. 200 and authors' computations.

Appendix 4: Price Actions per Store in German Grocery Retailing, 20 Brands, Six Firms, Weekly Prices, 1996-99[a)]

Brands	Price Actions per Store in Firm						Median
	A	B	C	D	E	F	
1	0.3	0.6	0.8	n. d.[b)]	0.0	1.6	**0.6**
2	2.0	9.6	11.4	5.4	0.0	9.6	**7.5**
3	1.3	4.3	18.0	3.8	0.0	5.9	**4.1**
4	6.8	31.3	16.2	7.8	5.8	13.9	**10.9**
5	0.5	7.6	10.4	1.5	3.8	4.7	**4.3**
6	10.3	4.0	12.8	0.9	3.3	17.1	**7.2**
7	2.8	0.4	5.0	0.0	1.3	3.7	**2.1**
8	1.0	11.4	9.4	8.0	4.5	7.3	**7.7**
9	5.3	5.7	4.6	5.5	3.5	11.0	**5.4**
10	2.0	14.9	12.8	2.4	1.8	3.9	**3.2**
11	0.0	0.8	11.8	0.4	n. d.[b)]	0.0	**0.4**
12	3.8	10.2	2.0	0.6	0.5	4.9	**2.9**
13	5.3	11.4	13.4	6.9	5.3	7.3	**7.1**
14	1.3	12.6	10.0	3.8	1.3	5.3	**4.6**
15	1.3	12.2	9.8	0.3	1.5	4.6	**3.1**
16	3.5	17.8	2.4	4.8	0.0	5.7	**4.2**
17	9.0	24.6	8.8	9.3	0.0	11.0	**9.2**
18	0.8	8.2	5.2	1.4	0.0	4.6	**3.0**
19	0.5	1.8	0.0	2.6	2.0	2.7	**1.9**
20	0.5	4.1	5.6	0.3	0.0	3.4	**2.0**
Sum	**58.3**	**193.5**	**170.4**	**65.7**	**34.6**	**128.2**	**97.0**
Median	**1.7**	**8.9**	**9.6**	**2.6**	**1.3**	**5.1**	**3.9[c)]/4.2[d)]**

a) Footnotes a), e) and f) of Appendix 2 are valid again. – b) Not distributed. – c) Median of the medians, computed across the six firms. – d) Median of the medians, computed across the brands.

Source: Moeser (2002), p. 206 and authors' computations.

Appendix 5: Psychological Prices in German Food Stores, 20 Brands, Four Store Types, Weekly Prices, 1996-99[a)]

Brands	All Stores	Discounters	Supermarkets	Small Consumer Markets	Large Consumer Markets
1	94.3	100.0	99.3	98.7	96.5
2	92.7	98.9	92.9	95.0	90.3
3	89.7	95.7	92.7	89.6	90.5
4	75.0	81.7	75.8	75.8	78.0
5	86.3	99.1	93.4	89.6	90.0
6	83.1	95.4	94.3	93.2	87.6
7	94.7	100.0	100.0	95.8	87.2
8	90.5	97.9	92.0	92.8	88.0
9	91.4	100.0	88.5	98.2	93.7
10	89.4	93.2	87.8	95.4	92.3
11	92.2	- [b)]	99.1	94.3	97.5
12	92.7	97.3	92.5	96.1	93.7
13	87.4	98.4	92.8	93.2	92.9
14	86.9	96.4	90.4	88.6	84.1
15	87.8	95.4	95.8	93.1	84.4
16	89.7	87.2	89.4	92.7	92.3
17	80.0	94.2	82.8	86.7	79.0
18	86.3	86.8	89.6	95.1	91.8
19	81.2	90.7	92.2	89.5	92.4
20	91.5	99.8	98.1	93.3	94.6
Median	**89.6**	**96.4**	**92.6**	**93.2**	**91.2**

a) The brands are explained in Footnote 1. Those psychological prices are included that cover 5% of all observed prices or more. Footnote a) of Appendix 3 is again valid. - b) Not distributed.

Source: Authors' computations.

Appendix 6: Psychological Prices in German Food Stores, 20 Brands, Six Grocery-Retailing Firms, Weekly Prices, 1996-99[a)]

Brands	Grocery-Retailing Firm						Median
	A	B	C	D	E	F	
1	99.8	99.7	96.8	n.d.[b)]	100.0	99.2	**99.5**
2	98.8	94.2	89.3	99.2	100.0	97.9	**98.4**
3	98.7	95.0	89.8	98.6	100.0	96.6	**97.6**
4	94.6	77.4	83.1	86.5	93.7	85.6	**86.1**
5	94.7	93.5	88.1	97.8	95.9	96.6	**95.3**
6	97.5	98.4	83.1	99.0	93.5	86.9	**95.5**
7	99.6	99.4	97.5	100.0	97.1	98.0	**98.7**
8	99.5	91.3	89.2	95.8	100.0	95.7	**95.8**
9	98.2	94.9	91.6	93.2	99.2	97.5	**96.2**
10	98.3	90.7	92.9	93.8	97.0	94.0	**93.9**
11	n.d.[b)]	96.6	91.1	n.d.[b)]	99.2	100.0	**97.9**
12	98.5	95.1	98.1	99.3	99.4	97.8	**98.3**
13	93.6	98.3	89.1	95.5	95.0	97.0	**95.3**
14	98.8	98.0	92.5	97.6	99.1	87.8	**97.8**
15	98.7	96.3	90.7	95.7	98.9	88.8	**96.0**
16	97.8	82.1	98.3	92.6	99.3	91.2	**95.2**
17	96.2	87.9	87.5	92.7	99.1	89.6	**91.2**
18	94.6	80.4	90.0	92.4	100.0	90.2	**91.3**
19	99.8	90.9	95.8	96.1	100.0	98.9	**97.5**
20	99.6	96.9	93.8	99.7	100.0	97.4	**98.5**
Median	**98.5**	**95.0**	**90.9**	**96.0**	**99.2**	**96.6**	**96.3[c)]/96.1[d)]**

a) Psychological prices, sample period, store types and the computation of price rigidity are explained in the text, brands are described in Footnote 1 of the text. The number of observations differs across store types. – b) Not distributed. – c) Median of the medians, computed across the six firms. – d) Median of the medians, computed across the brands.

Source: Herrmann and Moeser (2004), various Appendices.

Appendix 7: Concentration Ratios of the Two Most Important Psychological Prices for 20 Brands in Four German Store Types (*CR*2), Weekly Prices, 1996-99[a)]

Brands	All Stores	Discounters	Supermarkets	Small Consumer Markets	Large Consumer Markets
1	75.3	100.0	62.3	86.9	96.5
2	54.0	91.3	68.6	65.7	61.6
3	73.1	95.7	51.8	70.8	90.5
4	44.7	37.4	53.7	46.8	44.9
5	52.3	60.3	49.3	42.3	70.5
6	70.2	95.4	73.2	75.6	74.5
7	74.1	79.5	76.5	94.9	87.2
8	59.2	85.3	64.1	53.5	59.7
9	45.4	100.0	40.2	45.3	52.1
10	61.3	93.2	49.5	59.7	69.5
11	85.0	- [b)]	99.1	94.3	87.7
12	46.8	97.3	79.6	60.1	67.3
13	33.8	69.9	51.8	33.6	53.4
14	86.9	96.4	90.4	88.6	78.9
15	87.8	82.1	95.8	93.1	79.3
16	57.0	78.6	62.8	57.2	66.9
17	72.6	79.5	68.1	80.4	68.3
18	63.4	69.7	63.3	64.9	69.2
19	68.5	70.0	92.2	83.8	40.7
20	91.2	94.7	98.1	93.3	94.6
Median	**66.0**	**85.3**	**66.1**	**68.3**	**69.4**

a) Sample period and store types are explained in the text, brands are described in Footnote 1 of the text. The number of observations differs across store types. - b) Not distributed.

Source: Authors' computations.

Appendix 8: Concentration Ratios of the Two Most Important Psychological Prices for 20 Brands in Six German Grocery-Retailing Firms (*CR*2), 1996-99[a)]

	Grocery-Retailing Firms						Median
	A	***B***	***C***	***D***	***E***	***F***	
1	99.8	86.7	96.8	n.d.[b)]	100.0	91.3	96.8
2	92.3	63.5	69.2	77.8	100.0	62.7	73.5
3	92.9	95.0	89.8	83.1	100.0	58.1	91.4
4	67.0	42.9	50.1	58.2	51.6	57.8	54.7
5	83.6	55.3	72.2	55.1	71.1	40.5	63.2
6	76.3	66.0	83.1[a)]	99.0	93.5	58.9	79.7
7	83.5	99.4	92.3	100.0	97.1[a)]	59.6	87.9
8	99.5	66.1	65.3	65.9	91.1	68.3	67.2
9	84.1	65.4	75.7	50.7	82.4	47.3	70.6
10	98.3	65.3	77.9	81.9	97.0	50.7	79.9
11	n.d.[b)]	96.6[a)]	91.1	99.2	n.d.[b)]	100.0	97.9
12	87.7	55.6	88.7	99.3	99.4[a)]	56.9	88.2
13	73.5	46.6	69.6	82.7	95.0	36.2	71.6
14	98.8	83.0	81.6	85.3	99.1[a)]	87.8	86.6
15	98.7	81.7	83.5	95.7	98.9[a)]	88.8	92.3
16	83.6	56.9	75.2	72.4	98.3	72.7	74.0
17	91.1	60.6	87.5[a)]	83.4	99.1	58.4	85.5
18	71.9	66.4	63.7	74.1	100.0	84.1	73.0
19	99.8	66.3	68.4	83.3	74.7	64.8	71.6
20	99.6	84.5	88.3	99.7	100[a)]	97.4	98.5
Median	**91.1**	**66.1**	**79.8**	**83.1**	**98.3**	**61.2**	**81.5[c)]/79.8[d)]**

[a)] The sample period and the included stores are explained in the text. The number of observations differs across the grocery-retailing firms and products. Brands are described in Footnote 1 of the text. – b) Not distributed. – c) Median of the medians, computed across firms. – d) Median of the medians, computed across brands.

Source: Herrmann and Moeser (2004), Table 2.