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Price Rigidity and Market Power in German Retailing

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This paper presents empirical evidence on the interplay important topics of consumer price rigidity and market power in the German food retail industry. In particular, the analysis addresses the causal relationship between market structure—collusion—and pricing behaviour highlighted in the industrial organization literature. Extensive analysis of retail scanner data across beef and pork products reveals considerable differences in price rigidity across store types. Supermarket pricing behaviour is evaluated with respect to all price changes retail sales action and price adjustments indicating that food discounters exhibit the highest degree of rigid prices. Retail concentration, as an important explanatory factor of price stickiness is investigated via the analysis of retail market power employing a conjectural-variation approach. The analysis of market conduct in the marketing of beef and pork products indicates simultaneous oligopolistic and oligopsonistic behaviour of retail firms. Copyright © 2007 John Wiley & Sons, Ltd.

INTRODUCTION

The relationship between market structure and pricing behaviour has been a focus of microeconomic and industrial organization (IO) research for decades. Different approaches have been developed to estimate the effect of price–cost mark ups and interference on the degree of imperfect competition (Bresnahan, 1989). The phenomenon of sticky prices across different sectors in the economy has gained attention in macroeconomics as being of central importance for the micro-theoretic foundation of economic behaviour (Hall, 1986, 1988). Empirical studies (Carlton, 1986; Rotemberg and Saloner, 1987; Levy *et al*., 2002) emphasize that prices are more rigid in concentrated industries and higher collusion is associated with increasing degrees of price rigidity.

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Regardless of the high levels of retail concentration that have been confirmed for many industrialized countries the determinants of retail-price rigidity are underrepresented in the analysis of Blinder *et al*. (1998) for the United States and Stahl (2005) for Germany. Major results of both studies do not reflect the current situation of retail industries. With respect to retailing in Europe, Herrmann and Moeser (2006) and Herrmann *et al*. (2005) provide empirical evidence on the overall importance of retail-price rigidity and its determinants.

In view of an increasing market share of discounters in German retailing, particularly the hard discounters Aldi and Lidl, the intensification of interretail competition has raised public and legal concern. Within the process of consolidation and increasing concentration, an intensification of retail-price competition can have major impacts on consumers as well as on preliminary stages of food marketing. The question arises whether retail market power exists and if the level of price

transmission across the preliminary market stages will be affected.

The purpose of this study is to provide further evidence on the pricing behaviour of German retailers. This aim is addressed empirically through the linkage between market power and the occurrence of price stickiness in German food retailing using two different methodological approaches. In the first part of the analysis, strategic pricing behaviour of retailers is identified across different store types based on Owen and Trzepacz (2002) theory on retail-pricing strategies. We analyze the degree of price rigidity in contradiction to competition theory and the law of market clearing. The second analysis then presents an IO framework and empirical analysis of simultaneous oligopsony–oligopoly retail market power. Based on a conjectural-variation approach, the competitive behaviour of retailers, the degree of retail market power from perfect competition is estimated. Lerner indices and mark-up and mark-down ratios of retail prices are computed based on the regression results.

The analysis of consumer price rigidity is based on weekly scanner data for the period 2000–2001. Empirical tests of the retail market power hypothesis are carried out using monthly time-series data for the period 1995–2000 that includes important information on consumer demand and processor supply relations. Both analyses are focused on the distribution of beef and pork products at the retail level.

The paper is organized as follows. The following section reviews theoretical concepts and empirical studies on consumer price rigidity. The scanner data set is presented in section 'Price Rigidity Analysis' followed by the empirical analysis and discussion of price rigidity in German food retailing across different meat products and retail-store types. As market concentration and imperfect competition are major justifications for the existence of sticky prices, 'Market Power in German Food Retailing' introduces the methodological framework for the analysis of retail market power. Selected estimates on simultaneous oligopsony–oligopoly retail market power are discussed. Conclusions are summarized in the last section.

CONSUMER PRICE RIGIDITY

Theoretical models of pricing under perfect competition suggest that prices will immediately adapt to changes in the market environment following the law of market clearing (Waldman and Jensen 2001). Thus, changes in costs or demand conditions will induce changes in market output and prices. Pricing behaviour in relation to market shifts, where immediate and perfectly competitive price adjustments are lacking, is named price rigidity. According to earlier studies on pricing behaviour (Means, 1935; Carlton, 1986; Hall, 1986; Kashyap, 1995; Barksy *et al*., 2003; Bils and Klenow, 2004; Barro and Tenreyro, 2006) mark-up pricing dominates across many industries.

The notion of price rigidity, or sticky prices, is not restricted to single industries, thus many theories have been developed which try to explain the causes of rigid prices. Among the several theoretical approaches of the costs-of-price adjustment theory—menu costs—has gained considerable attention (Mankiw, 1985; Blinder *et al*., 1998).

Blinder *et al*. present the most comprehensive survey on the theoretical foundation of price rigidity. However, not all theoretical concepts discussed by the authors are relevant regarding the German food retailing sector. The following review therefore discusses only a selection of relevant concepts, including the theory of contracts between trading partners, the concept of the costs-of-price adjustment and psychological pricing points.

The theory of contracts between the processors and retailers is manifold due to the fact that much of the contents of contracts is not publicly accessible. Price adjustment costs, in particular menu costs (Carlton, 1986; Levy *et al*., 1997, 1998, 2002; Owen and Trzepacz, 2002), are viewed to have a significant impact on the frequency of price changes. These are, primarily costs associated with the assignment of material or labour, but also management costs that occur along with pricing decisions. Menu costs appear for every single price change but are independent from the size of the price change. Thereby even small magnitudes may be sufficient to create substantial price inflexibility. Fishman and Simhon (2005) ascribe this to the consumers' willingness to pay but also attribute it to the existence of coordination failures of firms. One problem of the price adjustment concept is, the measurement of menu costs, which are in general difficult to observe. Empirical data on menu costs are widely unavailable, forcing most empirical applications to make oblique

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assumptions. The survey of Levy *et al*. (1998) is an exception. The study investigates the time expenditure in the process of price adjustment and converts the results into labour costs. Their central thesis is that when menu costs exist, prices remain constant over a certain period so that fewer but larger price changes will be observable (Blinder *et al*., 1998; Slade, 1998). In a recent analysis of price rigidity in the product category of packed hard and sliced cheese, Weber (2005) provides further evidence on the significance of menu costs in German food retailing. While his results reveal significant differences across retail-store types, the magnitudes of absolute price changes may also indicate the existence of retail market power.

According to Blinder *et al*. (1998), the theoretical concept of psychological pricing points and its effect on retail-pricing behaviour is of secondary order since the retail industry is underrepresented in their survey. However, psychological prices, as a price setting strategy, and their impact on consumer purchase decisions have been widely discussed in numerous surveys (Schindler and Kibarian, 1996; Schindler and Kirby 1997; Stiving and Winer, 1997). Herrmann *et al*. (2005) reveal a significant effect of psychological pricing points in the pricing strategies of German retailers and thus on the degree of price rigidity.

Two further explanations of price stickiness are relevant. First, the IO literature highlights the causal connection between market structure, in particular collusion, and pricing behaviour. Several market surveys (Stigler, 1947; Carlton 1986; Rotemberg and Saloner, 1987) investigate the causal relationship between market concentration and the frequency of price changes. If this hypothesis is empirically confirmed, the motivation of such behaviour clearly follows the rule that oligopolists face different, if any, incentives in responding to exogenous shocks.

Second, retail-pricing strategies are of general importance since different firms and/or management strategies will result in diverse price settings. Owen and Trzepacz (2002) emphasise that firm strategy is the key factor of the probability of price changes. With regard to food retailing, typical pricing strategies are 'every-day-low-prices' (EDLP) and the 'high–low price' strategy (Hi–Lo). Firms adopting EDLP charge daily constant low prices without temporary price discounts. In contrast, firms following the Hi–Lo strategy generally charge higher mean prices and allow for temporary price discounts below the level of EDLP (Hoch *et al*., 1994). Hence, firms with an EDLP-strategy, *ceteris paribus*, will exhibit less frequent price changes than firms applying a Hi–Lo strategy (Levy *et al*., 1997, 1998). Weber (2005) tests this hypothesis for the product category of packed hard and sliced cheeses. He shows that private label cheeses as opposed to branded cheeses exhibit lower absolute magnitudes of mean-price changes. However, the results vary if only sales promotions or real-price changes are considered. Differences in the magnitudes of absolute price changes emerge mostly from store types characteristics. While discounters typically feature an EDLP strategy, all other store types, including self-service warehouses, follow a Hi–Lo strategy.

PRICE RIGIDITY ANALYSIS

Using a panel of weekly retail-scanner data from January 2000 to December 2001, we will examine the impact of Owen and Trzepacz theoretical concept.[1] The panel includes 207 retail outlets with scanning technology and 24 retail product groups. Individual product information includes product-codes (EAN), prices, quantities sold and information on promotional activities (PA). Retail-store types include discounters, supermarkets of 400–700 square meters (sqm) sales area, small consumer markets of 800–1499 sqm, large consumer markets of 1500–4999 sqm sales area and self-service warehouses of more than 5000 sqm.[2]

Table 1 presents weekly mean prices of meat products across retail-store types, including temporary price reductions due to sales promotions.[3]

Interestingly, the results reveal different pricing strategies when product prices are compared across store types. With the exception of Armour's Pork 400 g, which is only listed in two store types at a uniform price, Table 1 highlights altering pricing strategies. All other tinned meat products vary in their prices at the store type level. For example, while Armour's Beef 400 g is offered for 1.30 € in both small and large consumer markets, consumers have to pay less in supermarkets (1.29 €) and more in self-service warehouses (1.31 €). The hypothesis of overall lower prices at discounters only holds for three pork products: Halber's Lard Meat 300 g, Landsknecht's Spam 340 g, and

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Table 1. Weakly Mean Prices of Tinned Meat Across Store Types (€)[a]

Commodity	DISC		SM		sm CM		CM		SSW	
	μ	s	μ	s	μ	s	μ	s	μ	s
Armour Beef 400 g	—[b]	—	1.29	0.0954	1.30	0.1121	1.30	0.1159	1.31	0.1799
Dreistern Beef 300 g	1.29	0.0171	—	—	—	—	—	—	—	—
Halber Beef 300 g	—	—	—	—	—	—	1.97	0.0000	2.03	0.1862
Goldhand Tip Beef 400 g	—	—	—	—	1.20	0.0967	1.20	0.1063	1.19	0.1856
Rewe Beef	—	—	1.50	0.1826	1.41	0.1736	1.43	0.1912	—	—
Simon Lard Meat 400 g	1.12	0.1549	1.02	0.0000	—	—	0.88	0.2641	0.88	0.2273
Simon Beef 300 g	1.44	0.1973	1.96	0.1342	1.45	0.1989	1.39	0.2009	1.38	0.2298
Simon Beef 400 g	1.30	0.0883	1.34	0.2169	1.23	0.1704	1.42	0.1399	—	—
Yanno Beef 300 g	1.70	0.0000	—	—	1.80	0.0938	1.57	0.4185	1.77	0.2101
Armour Lard Meat 400 g	—	—	0.97	0.0000	—	—	0.92	0.0000	—	—
Armour Pork 400 g	—	—	1.02	0.0000	—	—	1.02	0.0000	—	—
Döbel Belly of Pork 720 g	0.85	0.1723	—	—	0.86	0.1802	0.82	0.0555	0.84	0.1098
Goldhand Tip Pork 400 g	—	—	—	—	—	—	—	—	1.06	0.1349
Halber Lard Meat 300 g	1.35	0.0000	—	—	1.87	0.7387	1.36	0.4173	1.43	0.4146
Halber Pork 300 g	—	—	—	—	—	—	2.18	0.8090	2.14	0.5952
Homann Lard Meat 300 g	—	—	—	—	—	—	1.25	0.0727	1.23	0.0552
Landsknecht Spam 340 g	1.08	0.1719	—	—	1.13	0.1097	1.14	0.1003	1.11	0.1049
Omnia Lard Meat 400 g	0.83	0.0680	—	—	—	—	—	—	—	—
Schulte Pickled Pork 400 g	1.52	—	—	—	—	—	2.32	0.2822	2.38	0.2338
Simon Pork 300 g	1.19	0.3549	1.55	0.2742	—	—	1.31	0.0869	1.42	0.3536
Simon Pork 400 g	0.61	0.1490	1.17	0.3646	1.09	0.1498	1.34	0.1632	1.27	0.1902
Werner Spam 200 g	—	—	2.24	0.6348	1.94	0.6958	1.99	0.5808	—	—
Yano Pork 300 g	1.93	0.1205	2.12	0.2791	2.10	0.3095	1.97	0.2980	2.03	0.2685

[a] The mean price μ consists of the charged normal price and the price while sales promotion activity, s is the standard deviation. DISC, discounters; SM, supermarkets; sm CM, small consumer markets; CM, large consumer markets; SSW, self-service warehouses.
[b] Not distributed or lack of data.

Yano's Pork 300 g. In the group of beef products, discounters are most expensive for Simon's Lard Meat 400 g with 1.12 €, while all other products are priced midfield. This result is plausible and can be ascribed to the absence of the leading hard discounters, Aldi and Lidl, of which information on firm strategy and detailed business information is not available.

The theoretical concept of perfect competition implies the law of one price. However, this rule is violated when price rigidity exists. Following Powers and Powers (2001) we compute the mean weekly duration of unchanged prices as

$$PRIG = w/w_{ch}. \quad (1)$$

The magnitude of absolute price rigidity *PRIG* is calculated by dividing the number of weekly price settings per product by the weeks with price changes. The results presented in Figure 1 indicate that the law of one price implied by perfect competition is definitely violated.

To allow for a more differentiated consideration, Figure 1 illustrates retail-price stickiness as a result of all price changes (ALL), while the centre and right column present measures of price rigidity due to temporary retail PA and long-run real price adjustments (SKIP) being price adjustment due to exogenous market shocks. On average discounters exhibit the highest degree of price stickiness for beef of 63.2 weeks, whereas 61.1 weeks elapse between price changes in supermarkets. In comparison, self-service warehouses reveal the highest price flexibility with only 26.8 weeks of unchanged prices. Since sales actions and price adjustments have a significant impact on the determination of retail-pricing strategies, measures of the mean price rigidity will be biased.

When only sales promotions of discounters are considered the level of price rigidity noticeably increases. This finding is consistent with theory and the hypothesis that discounters represent an EDLP strategy, and consequently carry out fewer sales. On average 83.2 weeks elapse between sales promotions in discounters. All other store types clearly exhibit more promotions, reflecting less price stability. Self-service warehouses reveal the highest rate of promotional activity with 62.6 weeks of unchanged prices, the least duration between two price adjustments. When considering only retail-price adjustments, supermarkets are the

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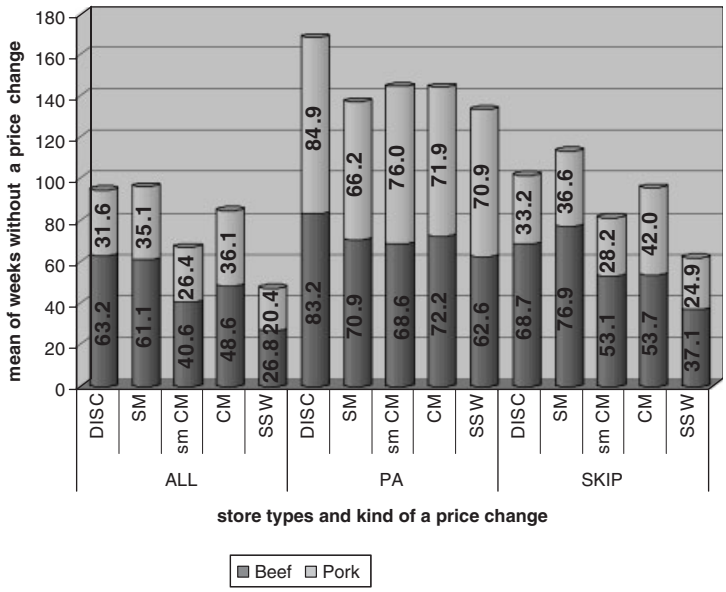

Figure 1. Mean Weekly Duration of Price Rigidity for Tinned Meat—Cross Section by Store Types: ALL, all price changes; PA, sales actions or other price changes; SKIP, price adjustments due to exogenous market shocks.

store type with stickiest prices, on average 76.9 weeks. Discounters are second with 68.7 weeks and the self-service warehouses again show the highest price flexibility of 37.1 weeks.

Our results on the magnitudes of price rigidity for pork products are also very interesting. Pork prices overall change more frequently when all price changes and price adjustments are considered. Regarding all price changes, large consumer markets exhibit the highest price rigidity of 36.1 weeks, while supermarkets and discounters reveal 35.1 and 31.6 weeks of stable prices, respectively. Again self-service warehouses show the most flexible prices of 20.4 weeks.

Compared to beef, pork features less sales actions so that price rigidity due to promotional activity rises. In line with theory, discounters, following an EDLP strategy, reveal the highest level of price rigidity of almost 85 weeks. In contrast, supermarkets feature the highest frequency of sales actions for meats. When only price adjustments are considered, price changes appear much more frequently. Self-service warehouses carry out most price alignments, on average every 24.9 weeks. The pricing strategy for large consumer markets seems to respond least to exogenous market shocks with a rigidity of 42 weeks, while discounters range midfield with 33.2 weeks.

To test for the statistical significance of differences in price rigidity across retail-store types we perform *t*-tests. The results presented in Tables 2–4 are differentiated by product category and the eliciting factor of price rigidity. Significant differences in rigidity exist between discounters and self-service warehouses with respect to all price changes and price promotions of beef products. The same is true for supermarkets, small and large consumer markets, and self-service warehouses. Finally, small consumer markets and self-service warehouses differ significantly in their adjustment behaviour due to exogenous shocks.

For the category of pork only discounters stand out in terms of price stickiness. This pattern can largely be attributed to the fact that leading German retailers make excessive use of meat products, and particularly pork, in sales actions to attract costumers. Moeser (1999) and Drescher (1999) provide comprehensive discussions of this issue. Our analysis suggests that the pricing strategy of discounters differs significantly from all other store types. When only price promotions are considered, discounters, large consumer markets and self-service warehouses show significant differences.

Another remarkable finding is the significance of differences in price rigidity across store types in response to exogenous market shocks. To some

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Table 2. Test of Statistical Differences Among Store Types for 'All Price Changes'[a]

Product	Store type	Pork Disc	SM	Sm CM	CM	SSW
	Disc		(*)	*	*	*
	SM	—[b]		—	—	—
Beef	Sm CM	—	—		—	—
	CM	—	—	—		—
	SSW	(*)	—	—	—	

[a](*), *, **, *** stand for the 90, 95, 99 and 99.9% levels of significance. DISC, discounters; SM, supermarkets; sm CM, small consumer markets; CM, large consumer markets; SSW, self-service warehouses.
[b]No statistical difference.

Table 3. Test of Statistical Differences Among Store Types for 'Price Actions'[a]

Product	Store type	Pork Disc	SM	Sm CM	CM	SSW
	Disc		—	—	*	(*)
	SM	—[b]		—	—	—
Beef	Sm CM	—	—		—	—
	CM	—	—	—		—
	SSW	(*)	—	—	—	

[a](*), *, **, *** stand for the 90, 95, 99 and 99.9% levels of significance. DISC, discounters; SM, supermarkets; sm CM, small consumer markets; CM, large consumer markets; SSW, self-service warehouses.
[b]No statistical difference.

Table 4. Test of Statistical Differences Among Store Types for 'Real Price Adjustments'[a]

Product	Store type	Pork Disc	SM	Sm CM	CM	SSW
	Disc		*	*	(*)	*
	SM	—[b]		—	—	—
Beef	Sm CM	—	*		—	—
	CM	—	*	—		—
	SSW	—	*	(*)	—	

[a](*), *, **, *** stand for the 90, 95, 99 and 99.9% levels of significance. DISC, discounters; SM, supermarkets; sm CM, small consumer markets; CM, large consumer markets; SSW, self-service warehouses.
[b]No statistical difference.

extent this points to the existence of market power as the law of one price is violated. Only if firms possess market power will their pricing strategy deviate from perfectly competitive behaviour. A few studies have identified market concentration as a driving force in explaining the rigidity of prices, not only with respect to food retailing (Jones and Laudadio, 1990; Neumark and Sharpe, 1992; Barro and Tenreyro, 2006). Our results on price rigidity in food retailing provide strong evidence on the presence of market power in the German food retailing sector.

While a large number of studies has analysed price rigidity across different industries or in explicit industry case studies (Stigler, 1947; Rotemberg, 1982; Stiglitz, 1984; Carlton, 1986; Rotemberg and Saloner, 1987; Kashyap, 1995; Blinder *et al.*, 1998; Clerides, 2002; Eckert, 2003) the issue of sticky prices in many food markets has gained limited attention. Only few authors have included food industries in cross-section analysis of price setting behaviour (Shonkwiler and Taylor, 1988; Slade, 1998; Fengler and Winter, 2001; Hosken *et al.*, 2001; Levy *et al.*, 2002; Herrmann and Moeser, 2003; Bils and Klenow, 2004). Many contributions lack a direct investigation of the magnitudes of prices stickiness, as the duration of unchanged prices. If included, the findings reported in the studies cited above largely confirm the levels of price stickiness revealed in our analysis. However, to our knowledge this is the first analysis of price rigidity that differentiates between different determinants of sticky prices at the retail level, namely the frequency/impact of all price changes, PA and long term price adjustments.

Since market structure and increased concentration are crucial factors in explaining retail-pricing behaviour, a number of empirical studies assume a causal connection between the level of concentration and price adjustment costs. In concentrated industries menu costs exert a larger impact on price setting behaviour and the degree of price rigidity than in less concentrated industries (Carlton, 1986). Hence, oligopolistic firms will adjust prices less frequent relative to firms in competitive markets. Although this theory has broad acceptance, it will be necessary to determine to what extent German retailers exercise market power. Therefore, an econometric analysis of retail market power in the marketing of beef and pork products is presented in the next section.

MARKET POWER IN GERMAN FOOD RETAILING

With regard to the analysis of market power the computation of mark-up ratios over marginal cost

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present an important strand in the IO literature (see Schmalensee, 1989). However, the measurement of imperfect competition has proven to be elusive since important information on industry or firm level marginal cost and measures of inputs and outputs are usually unavailable in public data sources. Instead, much effort has been devoted to estimate industry-level mark-ups (Domowitz *et al.*, 1988; Morrison-Paul, 1999).

Typically mark-up ratios are computed based on observable profit data or based on estimates of industry marginal from aggregate census data for those industries where relatively rich data are available. As Shapiro (1987) points out, mark-up ratios only reflect deviations from perfect-competitive pricing and hence incomplete indicators of market power exertion, since market elasticities of supply and demand are not considered.

Regardless of the empirical evidence on mark-up pricing across manufacturing and food industries, the estimation of retail market power using advanced IO methods has received limited attention in the literature. McCorriston (2002) and Dobson *et al.* (2003) point out that empirical tests of retail market power in Europe are particularly rare. This is surprising since high levels of retail concentration and merger activity across Europe raise concern about the consequences for consumers.

Empirical evidence clearly shows that food retailing in Germany is highly concentrated, offering opportunities to exert market power in both factor and consumer product markets. As a partial indicator of competition, the concentration ratio of the 10 largest firms (CR10) exceeded 84% in 2002, indicating an oligopolistic industry structure. The case of Germany is of particular interest among European countries since the rapid growth of discounters has driving competition in the food retail market.

With regard to the marketing of meat products, consumer trends led to an increase in the share of convenience and packaged goods in retail stores, which account for over 50% of all meat products purchased. The introduction of packaged meat products by leading hard discounters is expected to switch consumer spending toward discounters. On the other hand, the intensification of retail competition led to decreasing price–cost margins. This is particularly true for the category of meat products which is predominantly used in retail promotion activities (Drescher, 1999; Moeser, 2002).

Among the studies that provide empirical evidence on market power in European retailing, Dobson and Waterson (1997) prove significant correlations between consumer prices and the level of retail concentration. Gohin and Guyomard (2000), Koerner (2004) and Anders (2005) are among the few studies that apply econometric models of IO theory to measure retail market power in Europe.

Measuring Retail Market Power

Given the lack of quantitative evidence on retail market power as a driving factor of price rigidity, the objective of this section is to estimate the degree of imperfect competition in retail marketing of beef and pork products in Germany. The degree of imperfect competition and mark-ups at the retail level is estimated based on a structural IO framework. Values of market power parameters are obtained by simultaneous estimating retailer profit-maximization conditions together with processor supply relations and consumer demand equations. The hypothesis of oligopoly–oligopsony market power in German food retailing is tested using aggregate monthly data on the categories of beef and pork products for the years 1995–2000. Our data set includes all necessary information on prices, product quantities and costs for the stages of meat processing, retail distribution and consumer demand that were compiled from publicly available data sources.

Considering a non-competitive retail industry of N firms, that produce homogenous final meat products, retail firms buy corresponding wholesale products from processors and employ additional inputs in the marketing process. The retail production technology is presumed to be of fixed proportions so that input and output quantities can be represented by the same variable. The retail industry is assumed to be a price taker in other factor markets but exercises market power when purchasing meat from processors as well as in selling final consumer products.

The cost function of the retail industry is defined as $C = c(Q, w, z)$. Following Gohin and Guyomard (2000), the total cost of retail distribution can be expressed as

$$CT_i(Q, w, z, CF) = w_i \cdot Q_i + C(Q_i, z) + CF_i, \qquad (2)$$

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where Q_i is the total industry production of meat products i, w_i are weighted mean wholesale prices for meat products and z are additional inputs of retail distribution. The supply function of the upstream meat processing industry is given by

$$Q_i = S_i(w_i, X), \tag{3}$$

where X is a vector of additional supply shifters, including costs of labour, capital, specific material inputs, and a trend. Finally, the retail meat demand function is

$$Q_i = D_i(p_i, p_j, y), \tag{4}$$

where p_i is the consumer price of the ith final meat product, p_j are prices of close substitutes in demand, y are exogenous demand shifters that include per-capita income, seasonality in demand and a variable that accounts for the impact of the BSE crisis. The variable BSE covers media information of the German BSE crisis available to consumers; it is assumed to have a negative effect on meat purchases.

Assuming profit maximization, the problem is to choose optimal quantities of Q_i which maximize the aggregate industry profits with respect to market supply (3) and demand (4) conditions. The retail industries profit function for the distribution of i meat products is then

$$\prod_i = \sum_{i=1}^{m} p_i \cdot Q_i - \sum_{i=1}^{m} w_i \cdot Q_i - C_i(Q_i, z) - CF, \tag{5}$$

where C_i is the total cost function of the industry and CF represents fixed costs. We assume that the demand for different meat products is interdependent, while the supply of beef and pork products are independent. Taking the first order condition of the maximization problem and simplifying yields[4]

$$p_i - w_i - \frac{\partial C}{\partial Q_i} = -\left(\frac{\theta_i}{Q_i}\right) \times \left[\sum_{i=1} \varepsilon_i \cdot p_i \cdot Q_i - \eta_i \cdot w_i \cdot Q_i\right], \tag{6}$$

where $\varepsilon_i = (\partial Q_i/\partial w_i)*(w_i/Q_i)$ is the price elasticity of supply at the processors level and $\eta_i = (\partial Q_i/\partial p_i)*(p_i/Q_i)$ is the price elasticity of final consumer demand. $\theta_i = (\partial Q/\partial q_i)*(q_i/Q_i)$ is the average conjectural variation at the industry level.

To empirically test the hypothesis of retail market power, functional forms for the above equations have to be specified. Since our analysis applies aggregate industry data, all necessary assumptions have been imposed to assure a consistent measurement of the cost function and market power parameters across retail firms in the industry (Schroeter and Azzam, 1991; Wann and Sexton, 1992).

The aggregate industry cost function is specified in the Gorman Polar form with constant and identical marginal costs but fixed costs varying across retail firms:

$$CT(Q, w, z, CF) = \sum_{i=1}^{m} w_i \cdot Q_i + G_i(z) + \sum_{i=1}^{m} H_i \cdot Q_i + CF, \tag{7}$$

where H_i are additional and competitively priced input factors labour, energy and capital applied in the retail distribution of meat products. In Equation (7) the marginal cost of the ith final product are constant.

Another aggregation concern in Equation (6) is the parameter of conjectural variation. Following the original work of Appelbaum (1982) we assume that in equilibrium θ_i is identical across retail firms. As shown by Schroeter and Azzam (1991) the latter assumption can be achieved without loss of generality if constant and identical marginal costs are assured in the aggregation procedure. Further aggregation of Equation (6) then leads to

$$p_i = w_i + H_i(z) - \sum_{i=1} \sum_{i=1} \eta_i \cdot \theta_i \cdot p_i \cdot \left(\frac{Q}{Q_i}\right) + \sum_{i=1} \varepsilon_i \cdot \theta_{ii} \cdot w_i \cdot \left(\frac{Q}{Q_i}\right), \tag{8}$$

where $\theta_i = \theta_{ii} = \sum(\partial Q/\partial q_i)*(q_i/Q_i)$ are average conjectural variations with respect to retail output (θ_i) and meat processors' input (θ_{ii}).

In Equation (8) the coefficients of conjectural variation θ_i and θ_{ii} are the crucial conduct parameters. They provide benchmarks for various tests of market conduct, i.e. monopoly–monopsony versus price-taking behaviour and hence perfect competition on both market sides. The plausible range of θ_i/θ_{ii} lies between zero and 1. In the case where θ_i/θ_{ii} equals zero (8) reduces to consumer price equals marginal cost. At the other extreme where θ_i/θ_{ii} equals one, Equation (8) represents the optimal condition of a simultaneous monopoly–monopsony situation, where marginal costs equal perceived net marginal revenues.

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In other words, when the estimates of θ_i/θ_{ii} are zero, the hypothesis of retail-price taking behaviour on both, upstream and downstream sides of the meat market cannot be rejected. However, if θ_i/θ_{ii} significantly deviate from zero, the parameters reveal oligopoly and/or oligoposony conduct in meat marketing, with a retail monopoly and/or monopsony in the case of $\theta_i = \theta_{ii} = 1$.[5]

Equation (8) is the basis for tests of oligopoly–oligopsony conduct. A simultaneous system of Equations (3), (4) and (8) is estimated using full-information maximum-likelihood estimators (FIML), Based on aggregate monthly data for Germany and the years 1995–2000 mean weighted retail prices of beef and pork products were computed from weekly price data across different meat items. The same is true for mean weighted processor output and farm-gate prices for beef and pork. Retail cost data and consumer demand shifters were calculated based on data from different official sources (Anders, 2005).

We estimate separate model regressions for the retail marketing of beef and pork.

MODEL RESULTS

Selected parameter estimates of the retail market power models are presented in Table 5. Since the models were specified in double logarithmic terms, the coefficients represent elasticities. The equations fit the data reasonably well as indicated by corrected R^2. Moreover, the vast majority of coefficients are significantly different from zero. Tests for serial correlation were conducted using non-parametric runs-tests, suggested by Gujarati (1988) for in simultaneous equation models. The hypothesis of zero serial correlation could not be rejected based on χ^2 statistics with the exception of the retail optimality equation for beef.

The price elasticities of supply and demand for beef and pork products all have the expected signs. While the pork market elasticities reveal inelastic market reactions, supply and demand elasticities in the beef market are clearly elastic. This result can be attributed to the shock of the German BSE crisis.

Of particular interest is, of course, the degree of retailer oligopoly–oligopsony conduct expressed by the market power coefficients θ^i and θ^{ii}. From Table 5 it is apparent that three out of four estimates of retail market-power deviate significantly from zero and hence perfect competition. Consequently, the hypothesis of retail-price taking behaviour in both the upstream meat processing market and the downstream consumer market is rejected. With regard to the category of beef products, the degree of retail oligopsony power is of the largest magnitude with a coefficient of 0.173.

The estimates of oligopoly coefficients show a different picture. Here, parameter values range from 0.0035 to 0.08 and retailers' deviation from perfectly competitive conduct in sales to consumers is comparatively smaller. The magnitude of beef by far exceeds the level of pork. These findings were stable across alternative specifications verified by

Table 5. FIML-Estimates of Oligopsony–Oligopoly Retail Market Power in Meat Marketing

Test of retail market power in		Coefficient	t-ratio	R^2	DW
Pork distribution					
Processor supply elasticity	ε	0.419*	1.79	0.56	2.42
Consumer demand elasticity	η	−0.588***	−3.23	0.63	1.79
Oligopsony market power	θ^S	0.0125*	1.76		
Oligopoly market power	θ^D	0.0035***	3.28	0.95	1.57
Price of labour		0.48×10^{-3}***	4.03		
Price of capital (index)		0.0232*	1.89		
Beef distribution					
Processor supply elasticity	ε	1.706*	1.79	0.25	1.65
Consumer demand elasticity	η	−2.74***	−6.39	0.67	1.45
Oligopsony market power	θ^S	0.173	1.62		
Oligopoly market power	θ^D	0.08***	4.61		
Price of labour		0.8×10^{-3}***	11.19	0.88	1.39
Price of capital (index)		0.246***	2.68		
Impact of BSE crisis on consumers		−0.0172**	−3.62		

*, **, *** stand for the 90, 95 and 99% levels of significance.

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likelihood-ratio tests. In addition, tests of pure monopoly and/or monopsony retail market power were rejected for all model specifications.

Table 5 also shows selected estimates of retail cost parameters.[6] In both models the coefficients of labour costs and costs of capital have the expected signs, indicating a significant effect of increasing factor costs on the mean price of retail-meat products. To specifically account for the effect of the German BSE crisis on retail performance, a BSE variable was included in the retailers' optimality condition (8). The results reveal that negative media information had a significantly negative effect on the mean retail price of beef. No significant effect was found on pork prices.

For each meat category the degree of retailers' oligopoly–oligopsony power can also be measured by the Lerner index as the relative monopoly (L) or monopsony (M) price distortion, $L(M) = \theta^{i}/\eta$ (θ^{ii}/ε). Table 6 presents monopoly and monopsony Lerner indices and percentage mark-ups and mark-downs of retail-meat prices compared to the expected levels under perfect competition.

As anticipated, the values of Lerner indices and mean price distortions due to retailers' exertion of market power are of limited magnitude. About 11% of the retail-unit marketing margin for beef products can be explained by retailer monsopony market power, whereas the corresponding value for pork is 3.1%. Lerner indices and mean monopsony price distortions are of smaller magnitude with price mark-ups of 2.9 and 0.6%. The model results illustrate notable oligopoly and oligopsony distortions in the pricing of meat products by retailers. Despite the differences in magnitudes of market power estimates between beef and pork, overall retail behaviour in the sales to downstream consumers reflects oligopolistic rather than competitive behaviour.

The measurement of industry mark-ups over marginal and computation of mark-up ratios in the IO literature by Hall (1986) and others has presented empirical evidence that supports the rejection of the marginal-cost pricing and perfect-competition hypothesis in food industries. Hall presents mean mark-up ratios for the retail trade and food and kindred products industries of 2.4 and 5.3%. For the Austrian pork meat sector Jumah (2004) reveals a mark-up over marginal costs of 71% at the retail level. Dobbelaere and Mairesse (2005) indicate imperfectly competitive pricing in the concentrated French food and retail sector. Their estimated mark-up ratio for the meat and other foods industries is of the factor 1.5. For Sweden the study of Lundin (2004) presents an average mark-up ratio over marginal costs of 1.31 for the food and beverage industries. One of the few studies that explicitly focus on the magnitudes of retail mark-up pricing in the US is Barsky *et al.* (2003). Based on scanner data their results reveal retail mark-up levels raging from 3.44 for toothbrushes and 2.23 for soft drinks to 1.15 for canned tuna and the category of frozen entrées. Although the study of Barsky *et al.* did not include the category of meat products, the analysis strongly suggests non-competitive retail pricing in the US.

Comparing our results with the empirical evidence provided by previous studies, retailers' exertion of upstream and downstream market power with respect to the marketing of beef and pork products is limited. In particular our results support the conclusion that retailers have a limited ability to raise consumer price above marginal cost, whereas we find greater potential for the exertion of retail oligopsony power and mark-down pricing versus meat processors. Although retailers dominate many food supply chains, increasing market shares of hard discounters and resulting intensification of interretail-price competition has limited retailer ability of extensive mark-up pricing in meat sales to German consumers. This result is particularly supported by work of Drescher (1999) and Moeser (2002) which state that meat products are predominantly used in retail promotion activities.

Table 6. Retailers' Monopsony and Monopoly Price Distortions[a]

Indices of market power	Beef	Pork
Input market	0.101	0.030
	(11.235)	(3.093)
Output market	0.029	0.006
	(2.987)	(0.604)

[a] Values in parentheses are computed percentage deviations of per-unit margins for beef and pork products compared to the perfect-competition benchmark.

CONCLUSIONS

Public and legal discussions of increased concentration in food retailing in many industrialized countries have raised concern about the potential

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implications of retail-market power on consumers. Therefore, the objective of this paper is to present empirical evidence on two important research subjects relating to this concern, consumer price rigidity and retail-market power. In this study we successfully apply different IO methodologies in order to estimate the degree of price rigidity and retail market power for the category of meat products, in particular beef and pork products, in the German food retailing industry. We are able to derive important conclusions across different retail-store types and companies.

Price analysis of scanner panel data clearly reveals empirical evidence of price rigidity and hence rejection of the hypothesis of perfectly competitive retail pricing for the categories of beef and pork products. Items are sold at varying and temporarily rigid prices across retail-store types. Pricing behaviour is evaluated with respect to all price changes at the store level, retail sales actions, and price adjustments due to exogenous market shocks. The analysis reveals significant differences in pricing behaviour across store types with discounters featuring the highest degrees of price rigidity for beef and pork products.

The analysis of retail market power employed a structural conjectural variation approach to parameterize the retail industries' oligopoly–oligopsony equilibria. Market power coefficients and Lerner indices indicate significant deviations from perfectly competitive behaviour in the consumer purchase of meat products. Percentage price distortions due to retail market power range from 0.6 to 3%. The analysis of retail-pricing strategies and the explicit analysis of retail market power in meat marketing clearly highlight that the hypotheses of perfect competition in German food retailing has to be rejected.

NOTES

1. The data set is provided by MADAKOM GmbH, Cologne.
2. The hard discounters Aldi and Lidl are not included.
3. In order to ensure comparability packaging prices have been averaged to trading units of 400 g.
4. Cross-conjectural elasticities between the market segments of beef and pork are assumed to be equal to zero and therefore are eliminated from the theoretical derivation.
5. A comprehensive discussion of the interpretation of the conjectural-variation parameter in the IO literature can be found in Sexton and Lavoie (2001).
6. The complete model results can be obtained from the authors upon request.

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