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Empirical Analysis of Price Setting and Quantity Surcharges in the German Food Sector

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Abstract

This study examined the incidence and determinants of quantity price discounts and quantity price surcharges in the German food sector through a bivariate probit, using recent consumer scanner survey data. Selectivity bias was corrected for in estimating the degree of quantity price surcharge and quantity price discount, using Heckman's procedure. The findings reveal that almost 10% of the investigated products attract higher unit prices for larger package sizes, although the extent of price surcharges varied among product categories. The number of package sizes, the average package size, packaging form, storage form, as well as the price image of a product, were found to be significantly related to the probability and degree of quantity price surcharges and quantity price discounts.

JEL classification:

Keywords: price setting behavior, quantity surcharges, German food sector, bivariate probit estimation, two-step Heckman estimation

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1. Introduction

The on-going globalization has resulted in increasing competition in the European food sector, as both manufacturers and retailers vie for higher market shares. It has long been argued that product differentiation constitutes a relevant marketing strategy in ensuring positive profits in a competitive environment. Commodity bundling which involves producers supplying the same physical commodity in different package sizes in order to cater for the diverse tastes and demand of different consumers groups has been widely accepted as a form of product differentiation. Producers therefore choose package sizes and prices to maximize profits, while consumers select package sizes that maximize their utilities (Gerstner and Hess, 1987).

Given the significance of transparent unit pricing for consumers, the European Parliament and the European Council established a directive 1998, on consumer protection that compels stores to display unit prices of products offered to consumers. The directive stipulates that the selling price and the unit price of all products must be indicated in an unambiguous, easily identifiable and clearly legible way for all products offered by traders to consumers.[1]

Concerning price setting behavior in the context of multiple package sizes, three different mechanisms can be observed. First, unit prices decrease with rising package size, thus, a quantity discount is offered to the consumer. Furthermore, concerning linear pricing the unit price of a product proportionally increases to package size. Last, quantity surcharges occur when the unit price increases with rising package size.

In view of the significance of unit price differences for different package sizes, several studies have been conducted to examine the incidence of quantity price surcharges in the food sector. However, most of the empirical work undertaken has been on the United States, and do show evidence of quantity price surcharges in the US food sector (Widrick (1979a,b); Nason, Della Bitta, 1983; Walker, Cude (1984); Gerstner and Hess, 1987; Agrarwal et al., 1993; Gupta and Rominger, 1996; Manning et al., 1998; Sprott et al., 2003). The studies generally reveal quantity surcharges ranging from 7 to 34% of the investigated products.

In contrast to the plethora of empirical studies on the United States, only few empirical studies have been carried out on the European food sector (McGoldrick, Marks (1985); Zotos, Lysonksi (1993); Benner, Heidecke (2005). In particular, none of the studies investigates the joint determination of the quantity price surcharges and quantity price discounts. Studies on the degree of quantity price surcharges are also conspicuously absent in the analysis on European food markets.

This paper therefore makes a contribution in this direction by developing a firm-level model of price setting behavior with regard to quantity price surcharges and quantity price discounts and presenting new empirical results, using a unique consumer scanner data of the German food sector. We specifically examine the incidence of quantity price surcharges and discounts, and also analyze the impact of product characteristics and firm attributes on the probability of occurrence of quantity price surcharges and quantity price discounts. The determinants of the extent of quantity price surcharges and quantity price discounts are then analyzed, controlling for sample selectivity bias. The expected value of the returns from purchasing the largest package size for each product is also computed to determine if large package sizes result in losses or savings for consumers.

The remainder of the analyses is organized as follows. The next section presents a review of recent empirical research on the incidence of quantity surcharges. Section 3 outlines the theoretical model employed in the analysis, while the next section presents the empirical specification, and the fifth section provides a description of the data and definition of the variables. The results from the analysis are then presented in section 6, while the final section presents concluding remarks.

2. Review

Earlier studies of firm-level price-setting behavior focused on documenting the incidence of quantity price surcharges and providing the rationale for the existence of quantity surcharges in the food sector (see, for example, Widrick, 1979; Cude and Walker, 1984; Gerstner and Hess, 1987; Agrawal et al., 1993). For instance, Widrick (1979) and Cude and Walker (1984) empirically showed how extensive this price setting behavior is in several different markets. Gerstner and Hess (1987) focused on the demand side of unit price variation and present a theoretical model to explain the determinants of unit price and package size variation, under the assumption of fully informed consumers. They argued that consumers with low storage costs prefer large packages and are therefore willing to pay higher unit prices.

This is in contrasts to the model of Salop (1977) who did not assume that consumers are fully informed. He indicated that quantity price surcharges are a price discriminating device directed towards customers with high search costs. Empirical evidence on price search for groceries revealed that customers who search more generally pay lower prices than those who search less (e.g., Carlson and Gieseke, 1983). Given that theories presented by Salop (1979) and Gerstner and Hess (1987) are not able to explain the systematic variations in quantity price surcharges across product categories, Walden (1988) presented an explanation for the systematic variations in quantity surcharges across products by examining supply characteristics. Walden's model basically describes the decision to impose quantity price surcharge as a function of package costs, product turn-over rates and retailer storage costs.

These studies were followed by several studies that incorporated the impact of information search on the incidence of quantity price surcharges in their analyses (Agrawal et al., 1993; Gupta et al., 1996; Manning et al., 1998; Sprott et al. 2003; Schmidt, 2003). A common theme in these studies is that consumers can make product choices based on price search during a particular trip and that unit prices posted for products provide useful information at the point of purchase. While the findings from the study by Sprott et al. (2003) support their contention that common pricing practices aimed at establishing a favorable store-price image can result in quantity surcharges, the results obtained by Schmidt et al. (2003) showed no evidence of quantity price surcharges. The present paper attempts to explain the existence of both quantity price surcharges and price discounts across products by examining supply side characteristics. We present below a simple model to explain the incidence of both quantity price surcharges and price discounts across products.

3. Theoretical Model

Consider a supermarket that sets unit prices according to package sizes. Without loss of generality assume that the supermarket is a profit maximizing agent with some degree of market power. This is under the assumption that once consumers entered a specific store, time and travel costs of changing the store exceeds additional consumer utility from purchasing from a different store. Let $y = f(x_{1i}, x_{2i})$ denote the amount of output produced from x_{1i} (small package sizes) and x_{2i} (large package sizes). Let $p(y)$ denote the inverse demand function and $R(y) = p(y)y$ the revenue from sales of y units of output of product. If $C(x_{1i}, x_{2i})$ denotes the cost associated with the output y, the profit function for the agent can be specified as:

$$\max_{x_{1i};x_{2i}} \pi = R(f(x_{1i};x_{2i})) - C(x_{1i};x_{2i}) \qquad i=1,....,N \qquad (1)$$

The goal of profit maximization is subject to display space restriction, such that the positioning of small (t_{1i}) and large (t_{2i}) package sizes of different products are not allowed to exceed display space s:

$$s \geq \sum_{i=1}^{N} t_{1i} x_{1i} + \sum_{i=1}^{N} t_{2i} x_{2i} \qquad t_{2i} > t_{1i} \tag{2}$$

Additionally, the retailer has to offer small as well as large package sizes:

$$x_{1i}, x_{2i} > 0 \tag{3}$$

The decision problem includes the package size selection process of products as well as the determination of the unit prices for the different sized packages of the products. This can be restated formally as in equation (4):

$$\Phi = R(f(x_{1i}; x_{2i})) - C(x_{1i}; x_{2i}) + \lambda(s - \sum_{i=1}^{N} t_{1i} x_{1i} - \sum_{i=1}^{N} t_{2i} x_{2i}) \tag{4}$$

where λ represents the Lagrangian multiplicator of the display space constraint.

Since constraints (2) and (3) represent inequalities, maximization of the Lagrangian function with respect to x_{1i}, x_{2i} and λ requires consideration of first-order conditions, non-negativity restrictions, and complementary slackness restrictions:

$$\frac{\partial \Phi}{\partial x_{1i}} = \frac{\partial R}{\partial x_{1i}} - \frac{\partial C}{\partial x_{1i}} - \lambda t_{1i} \leq 0; \qquad x_{1i} \geq 0; \qquad x_{1i} \frac{\partial \Phi}{\partial x_{1i}} = 0 \tag{5}$$

$$\frac{\partial \Phi}{\partial x_{2i}} = \frac{\partial R}{\partial x_{2i}} - \frac{\partial C}{\partial x_{2i}} - \lambda t_{2i} \leq 0; \qquad x_{2i} \geq 0; \qquad x_{2i} \frac{\partial \Phi}{\partial x_{2i}} = 0 \tag{6}$$

$$\frac{\partial \Phi}{\partial \lambda} = s - \sum_{i=1}^{N} t_{1i} x_{1i} - \sum_{i=1}^{N} t_{2i} x_{2i} \geq 0; \qquad \lambda \geq 0; \qquad \lambda \frac{\partial \Phi}{\partial \lambda} = 0 \tag{7}$$

Equation (5) implies that in the optimal solution, the marginal revenue of package size x_{1i} has to be equal to the marginal costs of x_{1i} plus a component depending on the small package size (λt_{1i}). The complementary slackness condition in equation (5) means that, if the optimal solution calls for active offer of package size x_{1i} ($x_{1i} \geq 0$), the marginal revenue of x_{1i} must be equal to the marginal cost of x_{1i} plus the component λt_{1i} ($\frac{\partial \Phi}{\partial x_{1i}} = 0$). If the marginal revenues of x_{1i} falls short of the marginal costs plus the component λt_{1i} ($\frac{\partial \Phi}{\partial x_{1i}} < 0$), then the retailer has not to offer the package size of the product ($x_{1i} = 0$).

Accordingly, equation (6) express that in optimum, the marginal revenue of the large package size has to be equal to the marginal costs of x_{2i} plus the component λt_{2i}. The complementary slackness condition in equation (6) imply that an x_{2i} has to be found that either the partial derivation of the Lagrangian function holds as an equality ($\frac{\partial \Phi}{\partial x_{2i}} = 0$) or x_{2i} must take a zero value, or both.

Equation (7) restates the display space restriction of the retailer. The complementary slackness condition then stipulates that the retailer has to optimize the use of his display space due to the supply of small and large package sizes of product i ($\frac{\partial \Phi}{\partial \lambda} = 0$). Otherwise, the Lagrangian multiplier as an indicator of the shadow price of display space must be set equal to zero ($\lambda = 0$).

The differentiation of revenue with respect to x_{1i} and the following transformation of equation (5) yields:

$$\lambda \geq \frac{p_{1i} - \frac{\partial C}{\partial x_{1i}}}{t_{1i}}. \qquad (8)$$

Equation (8) represents the producer surplus per unit of the small package size that means the difference between price and marginal cost in ratio to the small package size. To obtain the unit price ratio of the larger package size to the smaller package size, requires substitution of equation (8) into equation (6):

$$p_{2i} - \frac{\partial C}{\partial x_{2i}} - \left(\frac{p_{1i} - \frac{\partial C}{\partial x_{1i}}}{t_{1i}} \right) t_{2i} \geq 0. \qquad (9)$$

Equation (9) can be rearranged to yield:

$$\frac{p_{2i}}{t_{2i}} - \frac{\frac{\partial C}{\partial x_{2i}}}{t_{2i}} \geq \frac{p_{1i}}{t_{1i}} - \frac{\frac{\partial C}{\partial x_{1i}}}{t_{1i}}. \qquad (10)$$

If the unit price ratio of the larger to the smaller package size is greater than 1, a quantity surcharge exists. In contrast, a quantity discounts occurs if the unit price ratio is smaller than 1. Equation (10) can be reformulated to yield equation (11) that indicates the incidence of quantity surcharges:

$$\frac{\frac{p_{2i}}{t_{2i}}}{\frac{p_{1i}}{t_{1i}}} \geq \frac{\frac{\partial C}{\partial x_{2i}}}{t_{2i}} \cdot \frac{t_{1i}}{p_{1i}} - \frac{\frac{\partial C}{\partial x_{1i}}}{p_{1i}} > 1 . \qquad (11)$$

Accordingly, equation (12) denotes the incidence of quantity discounts:

$$\frac{\frac{p_{2i}}{t_{2i}}}{\frac{p_{1i}}{t_{1i}}} \geq \frac{\frac{\partial C}{\partial x_{2i}}}{t_{2i}} \cdot \frac{t_{1i}}{p_{1i}} - \frac{\frac{\partial C}{\partial x_{1i}}}{p_{1i}} < 1 . \qquad (12)$$

A reduced form of equation (11) indicates that the unit price ratio of the larger and the smaller package size is greater than 1 if

$$\frac{\partial C}{\partial x_{2i}} \cdot \frac{t_{1i}}{t_{2i}} > \frac{\partial C}{\partial x_{1i}} . \qquad (13)$$

Similarly, the reduced form of equation (12) indicates that the unit price ratio is less than unity if

$$\frac{\partial C}{\partial x_{2i}} \cdot \frac{t_{1i}}{t_{2i}} < \frac{\partial C}{\partial x_{1i}} . \qquad (14)$$

Equation (13) implies that if the marginal cost per unit of the large package size exceeds the marginal cost per unit of the smaller package size, a quantity surcharge occurs. In contrast, a quantity discount exists if the marginal cost per unit of the larger package size is less than the marginal cost per unit of the smaller package size (equation 14).

The marginal cost per unit of a product can be affected by several factors. For example, products differ in their storage requirements. Some products need a refrigerated or frozen storage, whereas the time requirement per unit to cool a given sized product decreases with increasing surface area. Since larger package sizes possess smaller surface areas in comparison to an equivalent quantity packaged in a smaller container, the cost per unit associated with cooling refrigerated and frozen products increases with package size (Ditchev, Richardson (1999)). Thus, larger package sizes of refrigerated and frozen products are subject to a higher probability of quantity surcharges than smaller sized packages due to cost differentials.

Due to economies of scale, material costs per unit decrease with larger package sizes for food products. Less packaging material per unit of a product is used for larger sized packages than for smaller sizes. However, these packaging efficiencies may vary by packaging form and material. For example, the stability of boxes or bags may need to be increased for larger package sizes, resulting in a quantity surcharge. Therefore, the probability of quantity surcharges is expected to vary by packaging material.

Annually, food manufacturers and retailers bargain about prices and purchase conditions of products. Depending on market power and bargaining skills, different retailers can achieve varying purchase prices. Further, the turnover rates of small and large package sizes of retailers could vary due to different population structures depending on regional differences. Large households often live in rural areas whereby a higher demand of large package sizes may occur. Retailers located in rural areas order larger amounts of large package sizes and thus, they may get better purchase conditions than other retailers. Thus, the incidence of quantity surcharges varies by retailers.

In equation (13), the package size ratio ($\frac{t_1}{t_2}$) influences the incidence of quantity surcharges. The left-hand side term decreases with rising package size difference. Thus, the probability of quantity surcharges decreases with increasing percentage difference between small and large package size of a product. A negative effect is expected. Accordingly, the unit prices of non-integer ratios of package size pairs are more difficult to compare for consumers than integer ratios. Therefore, non-integer ratios of package size pairs are more likely to quantity surcharges than integer package size ratios of a product.

The probability of quantity surcharges increases with an increasing number of package sizes available. A positive influence of quantity surcharges is expected for products with an increasing number of package sizes available.

The extent of quantity surcharges and quantity discounts are derived by the unit price difference between larger and smaller package sizes. This can be specified by rearrangement of equation (10):

$$\frac{p_{2i}}{t_{2i}} - \frac{p_{1i}}{t_{1i}} \geq \frac{\frac{\partial C}{\partial x_{2i}}}{t_{2i}} - \frac{\frac{\partial C}{\partial x_{1i}}}{t_{1i}} \tag{15}$$

Equation (15) can be restated in the following general form

$$\frac{\Delta p_i}{\Delta t_i} \geq \frac{\Delta \frac{\partial C}{\partial x_i}}{\Delta t_i} \tag{16}$$

Equation (16) suggests that the extent of unit price difference between the two package sizes is affected by the difference between the marginal cost per unit of large and small package sizes. This relationship indicates that the factors influencing marginal costs per unit discussed above also affect the extent of quantity surcharges and quantity discounts.

4. Empirical Estimation

A number of important steps need to be laid out to link the analytical and empirical models. With three possible states, price setting decisions can be modelled using a probit specification yielding the estimated probability that the firm i imposes quantity surcharge, linear pricing or quantity discount. The bivariate probit is a natural extension in this case. The close relationship between the empirical probability and the theoretical model can be envisioned with a set of structural equations comparing marginal costs of smaller of larger and smaller sized packages to determine how firms set the unit prices of different package sizes. As argued in the theoretical section, a quantity surcharge is observed, if the marginal cost of the larger sized package is greater than the marginal cost of the smaller sized counterpart of a product. Conversely, a quantity discount will be observed for the product if the marginal cost of the larger sized package is less than the marginal cost of the smaller sized package. Using Y_{si}^{*} to denote the occurrence of quantity price surcharge and C_{1i} and C_{2i} to denote marginal costs of larger and smaller packaged sizes, respectively, we can write for firms that impose quantity price surcharges

$$Y_{si}^{*} > 0 \Leftrightarrow C_{1i} - C_{2i} > 0 \tag{17}$$

Similarly, using Y_{di}^{*} as the occurrence of quantity price discount, we can write for firms that practice quantity price discounts

$$Y_{di}^{*} > 0 \Leftrightarrow C_{1i} - C_{2i} < 0 \tag{18}$$

However, the latent variables are not observable, since they are subjective. What is observed are the price setting behaviours $Y_{si} = 1$ if $C_{1i} - C_{2i} > 0$ and $Y_{si} = 0$ otherwise, for quantity price surcharge and behaviours $Y_{di} = 1$ if $C_{1i} - C_{2i} < 0$ and $Y_{di} = 0$ otherwise, for quantity price discount. The unit price setting decision on quantity price surcharges and discounts is then modelled as:

$$Y_{si} = \beta X_{si} + \xi_{si} \tag{19}$$

$$Y_{di} = \gamma X_{di} + \xi_{di} \tag{20}$$

We assume that $E(\xi_{si}) = E(\xi_{di}) = 0; \mathrm{var}(\xi_{si}) = \mathrm{var}(\xi_{di}) = 1$; and $\mathrm{cov}(\xi_{si}) = \mathrm{cov}(\xi_{di}) = \rho$. The *t*-statistic on parameter $\hat{\rho}$ is a Wald test of the hypothesis that the cross-equation error term correlation is statistically significant. This provides information as to whether full information likelihood bivariate probit estimates should be used in the estimation, or if single equation estimates are adequate.

As pointed out by Walden (1988), both the degree of quantity price discount and the degree of quantity price surcharge can be as interesting as the probability of both quantity price discount and quantity price surcharge. An additional issue is therefore the impact of the exogenous variables identified above on the degrees of quantity price discount and quantity price surcharge. These can be specified as

$$Y_{si}^{e} = \alpha X_{si}^{e} + e_{si} \tag{21}$$

$$Y_{di}^{e} = \delta X_{di}^{d} + e_{d1} \tag{22}$$

where Y_{si}^{e} and Y_{di}^{e} are the degrees of quantity price surcharge and quantity price discount, respectively; X_{si}^{e} and X_{di}^{e} are vectors of variables influencing the degrees of quantity price discount and quantity price surcharge, respectively; α and δ are vectors of parameters to be estimated; and e_{si} and e_{di} denote error terms with zero means and finite variances.

Applying OLS to the extent of quantity price surcharge and quantity price discount equations in (19) and (20) to estimate the α and δ coefficients will result in sample selection bias, since they do not take into account the process generating the observed quantity price surcharge and quantity price discount decisions of firms.

The estimation strategy employed in the present study is a straightforward extension of the Heckman (1979) two-step procedure. The first step, in this application, involves the estimation of equations (14) and (16) using a bivariate probit model. This provides estimates of the joint probabilities of the decision to impose quantity price surcharge and the decision to offer quantity price discounts for each firm and estimates of β, γ and ρ. These estimates are then used to calculate the selection terms for quantity surcharges and quantity discounts. The selection terms are added to the degree of quantity surcharge and quantity price discount to adopt equations (21) and (22) to yield the following equations

$$Y_{si}^{e} = \alpha X_{si}^{e} + \theta^{s}\lambda_{i}^{s} + \theta^{d}\lambda_{i}^{d} + e_{si}^{*} \tag{23}$$

$$Y_{di}^{e} = \delta X_{di}^{e} + \theta^{d}\lambda_{i}^{d} + \theta^{s}\lambda_{i}^{s} + e_{di}^{*} \tag{24}$$

where λ_i^s and λ_i^d are quantity price surcharge and quantity price discount variables, respectively and e_{1i}^* and e_{2i}^* are the error terms satisfying the usual assumptions. The selection variables are given as

$$\lambda_i^s = \phi(W^s) \cdot \frac{\Phi\left[(W^d - \hat{\rho} Z_i^d)/(1-\hat{\rho}^2\right]}{\Phi_2}$$

$$\lambda_i^d = \phi(W^d) \cdot \frac{\Phi\left[(W^s - \hat{\rho} Z_i^s)/(1-\hat{\rho}^2\right]}{\Phi_2}$$

$$W^s = -X_i^d \hat{\beta}, \; W^d = -X_i^d \gamma$$

The quantity Φ_2 denotes the bivariate normal cumulative distribution function whose probability density function is denoted by ϕ_2 (Limdep, 8.0, User's Manual, pp. 660-661). It is obvious from equations (23 and (24) that if the selection terms are not considered in the estimation, the estimates would suffer from omitted variable bias.

5. Data and Variable Definition

The data used for the analysis are obtained from a unique home scanned consumer panel surveyed by the German Society of Consumption Research (GfK, Nuremberg). In this panel, over 14,000 households record their daily purchasing activities with a home scanner. For the purposes of the present analysis, purchase information for 20 product groups of the categories diary products, soft drinks and convenience products during 2003 in the distributive channels of the German Top 30 food retailers is extracted from this panel. Furthermore, no promotional purchases are considered to exclude the case where a quantity surcharge is based on a higher unit price of the larger package size due to a temporary promotion on the smaller sized package of the product (Widrick (1979a,b); Zotos, Lysonski (1993)).

After this first extraction, the panel still includes almost 2.5 million single purchase observations that extend to 4,678 different products. An essential condition for the determination of quantity discounts and surcharges constitutes the offer of multiple package sizes of a product. Following, a selection process identifies those products that are offered in multiple package sizes and by visual audit in stores, equivalent packaging is ensured. Thus, in the following analysis 635 products have been considered. Depending on the availability of package sizes of product *i* in any stores, unit price comparisons have been independently made for each product in any store. Finally, 4421 unit price-size comparisons could be made.

Comparisons of unit prices for different package size pairs then identify the incidence of quantity surcharges. This is determined when the ratio of the unit price of a larger size (UP_L) to the unit price of the smaller size (UP_S) is greater than 1. If it is less than 1, then there is a discount. For products available in more than two different package sizes, several unit price comparisons could be made. In the case of multiple higher unit prices of large package sizes in comparison to a smaller package size for a single product, this product is once marked as surcharged. Equally, when a product available in more than two package sizes only contains about one surcharged unit price comparison, it is once marked as surcharged. Definitions, means and standard deviations of all the variables employed in the analysis are contained in Table 1.

In the bivariate probit model, the dependent variables are dichotomous and coded as "1" to represent quantity surcharges and "0" otherwise and inverse to represent quantity discounts, respectively. As independent variables, several product and supply side characteristics are included. The average number of package sizes available of a product in any store is 2.2 and a positive effect on the likelihood of quantity surcharges is expected. The ratio of large to small package size is coded as "1" if the ratio is non-integer (i.e. 400g and 890 g; package size ratio=2.225) and also a positive influence is expected due to harder unit price comparison possibilities for the consumer. The variable $PDIFF\_PS_i$ is computed as the average percentage difference between the quantity volume of the large package size and the small package size. As indicated in equation (13), a negative influence on the likelihood of quantity surcharges is expected. Further, the dummy variable *STORAGE* represents the storage requirements of the investigated products. This variable is coded as "1" for refrigerated and frozen products and as "0" for shelf stored products. A higher probability of higher unit prices of larger package sizes is expected for refrigerated and frozen products due to higher marginal costs per unit of cooling larger package sizes.

The price image of a product is represented by the average price. A negative effect is expected due to higher information search of consumers with increasing prices. Concerning the varying incidence of quantity surcharges by retailers, dummy variables for different retailers are included in the analysis. Similarly, dichotomous variables are included for the different packaging forms. The next section will present the results obtained for the German food sector.

6. Empirical Results

6.1 Qualitative Analysis

The results from the qualitative analysis are presented in Table 2. The results of the package size and unit price variations across the 4421 unit price-size comparisons reveal that about 9.6% of the brands are sold at a quantity surcharge and 84.7% at a quantity discount. Thus, in contrasts to Schmidt (2003) who find no incidence of quantity surcharges in the Danish food sector, our findings show that quantity price surcharges is used as a pricing strategy in the German food sector. The average unit price surcharge is 20.3%, with a standard deviation of 15.7 and the average discount is 27.9%, with a standard deviation of 14.3. The standard deviations clearly indicate that package size and unit price variations in the German food sector are quite substantial. About 5.7% of the brands have uniform unit prices.

Table 3 presents an overview of the incidence of quantity discounts and surcharges for different product groups. The highest incidence of quantity surcharges is found in milk cream product group, with an average surcharge of 21.5%. However, the highest average unit surcharge of 45.0% is observed for fruit nectars. The product groups of vegetable juice, cereals and yogurt also show high rates of quantity surcharges with in incidence of over 10%, respectively. No incidence of quantity surcharges is found for acerbic drinks, isotonic drinks and soups/mulligan. Milk indicates also a very low incidence of quantity surcharges (0.9%).

6.2 Econometric results

Table 4 presents the results of the maximum likelihood bivariate probit estimates of the equations explaining the probability of the incidence of quantity surcharges and quantity discounts. The estimates of ρ (correlation between the errors) that maximized the bivariate probit likelihood function is -0.99 and is significantly greater than zero at the 1% level. This suggests that the random disturbances of the price setting decision of quantity surcharges and quantity discounts are affected in the same direction by random shocks and that their occurrence is not statistically independent. Thus, inefficient parameter estimates may be obtained if the equations are estimated separately. The log-likelihood ratio test statistic is significant at the 1% level, suggesting that the independent variables taken together influence the price setting decision.

The coefficient of the variable for number of package size is positive and significantly different from zero, suggesting that the larger the number of package sizes for a product, the higher the probability of quantity surcharge. This finding is consistent with the results reported by Agrarwal et al. (1993). Secondly, the coefficient for average size of the package is negative and significantly different from zero, indicating that the greater the percentage of package size difference between multiple sizes of a product, the smaller is the probability of a higher unit price of the larger package size. This is probably due to the fact that material costs per unit generally decline with larger package sizes.

The results also reveal that compared to shelf stored products, refrigerated or frozen products have a higher probability of attracting a quantity surcharge, a finding that supports the assertion of Walden (1988) for those products where carrying costs are higher for retailers, retailers should have less incentive to provide discounts. Further, the results show that products offered in non-integer multiple package sizes have a higher probability of attracting quantity surcharges. Price comparisons of products are more difficult for consumers when package size ratio is non-integer. The packaging form also appears to influence the likelihood of a higher unit price for larger package size. Products packaged in a bag-board combination, in plastic cups or in coated films have a significantly higher probability of attracting quantity surcharges than the reference package form.

Several of the individual dummy variables included to capture the fixed retailer effects were significantly different from zero. Moreover, tests of the null hypotheses that these variables are jointly equal to zero are rejected for both quantity price surcharge and price discount equations. Thus, for both quantity surcharge and discount, product characteristics alone do not explain unit price differences for smaller and larger package sizes. The price image of the product, captured by the average price appears to negatively influence the probability of a quantity price surcharge, indicating that products that are positioned with lower average prices are less likely to attract quantity surcharges, while those products with generally higher average prices are more likely to attract quantity price discounts.

Table 5 presents results of the unit price difference equations. Since the two-step procedure employed in the analysis results in heteroskedastic residuals, White's formula is used to calculate the standard errors. The inverse Mills ratios (λ) are significant for both quantity price surcharge and quantity price discount equations, indicating that selectivity bias would have resulted if the price setting equation had been estimated without taking into account the decision to impose quantity price surcharge and quantity price discount.

The negative and significant coefficient of the number of package sizes available indicates that the degree of quantity surcharge on a surcharged product decreases with rising number of package sizes. Similarly, the negative and significant coefficient of the number of package sizes in the quantity discount equation indicates that the degree of quantity discount decreases with rising number of package sizes The significant negative coefficient of the storage characteristics also suggests that refrigerated and frozen products generally attract lower quantity surcharges, provide that there is a surcharge. While the estimated coefficient for storage characteristics is negative significant for quantity discounts, it is positive and significant for quantity surcharge. This finding suggests that refrigerated and frozen products generally attract lower quantity surcharges for surcharged products, but higher quantity discounts for discounted products. The significant negative effect of products offered in non-integer multiple package sizes on quantity discount shows the higher the difference between the unit prices of a non-integer sized package pair the lower the degree of quantity discount. On the other hand, the significant positive effect of the same variable on quantity price discount indicates that the higher difference between the unit prices of a non-integer sized package pair, the higher the quantity discount for discounted products.

The coefficient of the variable representing percentage difference of package sizes is positive and significantly different from zero, suggesting that the larger the difference between the packaged quantity of small and large package size, the larger is the magnitude between the unit prices of small and large package size. The negative and significant coefficient on bag-board for quantity surcharge regression and positive and significant coefficient for quantity discount estimation indicate that the degree of quantity price surcharge is lower for products in bag-boards, while the degree of quantity price discount is higher for products packaged this way.

The estimated coefficients for individual dummy variables representing retailer fixed effects are individually significantly different from zero, with the exception of Karstadt for quantity surcharges and metro, karstadt and tengel for quantity discounts. Moreover, joint tests of the null hypothesis that all retailer effects are equal using a likelihood ratio test, was rejected for both quantity surcharge and discount equations, indicating that these effects are important in explaining the degrees of quantity price surcharge and quantity price discount.

As argued by Agrawal et al. (1993), grocery expenditures account for a substantial proportion of disposable income of households. Hence, quantity price surcharges over long periods of time could mean significant losses for consumers purchasing such items. We employ an approach proposed by Cude and Walker (1984) to analyze the expected value of return from purchasing a larger size of products. The approach involves multiplying the percentage incidence of quantity surcharges and discounts with the mean surcharge or discount for each product, respectively. The expected value of return from purchasing larger package size of products from our analysis is 0.05 Euro, suggesting that quantity discounts also dominate the frequency and magnitude of quantity surcharges in the German food sector. Accordingly, the expected value of return from purchasing always the largest package size of any product as a shopping strategy reveals that consumers can save about 253.08 Euros. The sum of the unit prices of all largest package sizes are 253.08 Euro less expensive than the sum of the unit prices of the smallest package sizes of the according products.

Conclusion

This study examined the incidence and determinants of quantity price discounts and quantity price surcharges using a consumer panel data for the German food sector. The empirical results from the study provide several new insights into the pricing behavior of stores in the German food sector. Quite interesting is the finding that almost 10% of the investigated products showed higher unit prices for larger package sizes, although the extent of price surcharges varied among product categories. However, quantity price discounts (lower unit prices for larger packages) appear to dominate supermarket products, with the degree of quantity discounts varying among different product groups.

The findings from the econometric analyses indicate that several factors significantly influence the probability of and the degrees of quantity price surcharges and quantity price discounts. In particular, product characteristics and retailer fixed effects were found to significantly influence quantity surcharging and discounting decisions of retailers. The results indicate that refrigerated and frozen products are more likely to attract higher unit prices for larger package sizes than items stored on shelves. These findings are probably due to the increased storage costs per unit for larger packages that must be refrigerated or frozen. Both the probability and the degree of quantity price surcharges and quantity price discounts were found to vary with package form and material. Products packaged in a bag-board combination, in plastic cups or in coated films have a significantly higher probability of attracting quantity surcharges.

The finding of quantity price surcharges in the German food sector, despite the practice of unit pricing suggests that consumers either do not adequately price search, or that households with large families and high demands still purchase large packages to avoid frequent trips to the supermarkets. Thus, while unit price information could help increase awareness and ease of information processing, it is not able to prevent quantity surcharges.[2] The empirical results also suggest that quantity surcharges are often a consequence of cost differentials between large and small package sizes that the retailer passes down to the consumer. Thus, quantity surcharges do not occur as a technique of consumer extraction but rather as a consequence of cost differentials.

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Table 1: *Variable definitions and Descriptive Statistics*

Variable name	Variable definitions	Sample mean	Standard deviation
Dependent variables			
QS	1 if product includes a quantity surcharge, 0 otherwise	0.09	0.30
QD	1 if product includes a quantity discount, 0 otherwise	0.85	0.36
PDIFF_PR*i*	Average unit price difference between larger and smaller package size of product *i* [%]	-0.22	0.21
Independent Variables			
N_PSAVAI	Number of package sizes available	2.16	0.45
PS_RATIO	1 if package size ratio is non-integer, 0 otherwise	0.48	0.50
PDIFF_PS*i*	Average package size difference between larger and smaller package size of product *i* [%]	1.29	1.21
STORAGE	1 if product has to be stored in a refrigerator or freezer, 0 otherwise	0.44	0.50
PRICE	Average price of a product	1.00	0.72
METRO	1 if distribution channel belongs to Metro Group, 0 otherwise	0.09	0.29
KARSTADT	1 if distribution channel belongs to Karstadt, 0 otherwise	0.09	0.09
TENGEL	1 if distribution channel belongs to Tengelmann, 0 otherwise	0.05	0.22
GLOBUS	1 if distribution channel belongs to Globus St. Wendel, 0 otherwise	0.03	0.18
WALMART	1 if distribution channel belongs to Wal-Mart, 0 otherwise	0.03	0.18
COOPSH	1 if distribution channel belongs to Coop Schleswig-Holstein, 0 otherwise	0.03	0.16
OTHER_S	Reference store	0.03	0.11
BOARDBAG	1 if product is packaged in a bag and a board, 0 otherwise	0.13	0.33
PET_CUP	1 if product is packaged in a plastic cup, 0 otherwise	0.30	0.46
C_FILM	1 if product is packaged in a coated film, 0 otherwise	0.03	0.18
OTHER_PT	Reference package types	0.09	0.21
Sample size		4421	

Table 2: *Incidence of quantity discounts and quantity surcharges on the German food sector, 2003*

	Number of products	Proportio n [%]	Average discount or surcharge [€]	Standard deviation	Average discount or surcharge [%]	Standard deviation
Quantity discount	3743	84.7	-0.06	0.08	-27.9	14.3
Linear pricing	251	5.7	0.00	0.00	0.0	0,0
Quantity surcharge	427	9.6	0.04	0.04	20.3	15.7
Total	4421	100	-	-	-	-

Table 3: *Incidence of quantity discounts and quantity surcharges for different product groups, 2003*

Product group	Number of products	Incidence of quantity surcharges [%]	Average surcharge [%]	Incidence of quantity discounts [%]	Average discount [%]
Acerbic drinks	10	0	0.0	70.0	-31.7
Cola / cola containing drinks	383	3.1	17.7	83.8	-24.1
Fruit nectar	128	1.6	45.0	86.9	-37.6
Fruit juice	222	6.3	20.6	90.5	-34.5
Mixed fruit juice	330	3.3	18.9	94.2	-39.1
Vegetable juice	37	16.2	16.1	70.3	-21.5
Table / mineral water	227	3.9	24.7	82.4	-32.1
Soda drinks	244	5.3	29.1	77.9	-24.3
Isotonic drinks	4	0	0.0	100.0	-27.3
Tea drinks	69	1.4	25.0	94.2	-47.3
Near water drinks	101	2.9	32.5	91.1	-27.6
Butter / butter containing products	149	7.4	22.8	91.9	-28.6
yogurt	457	10.9	24.3	83.4	-25.1
Milk	309	0.9	17.9	98.1	-32.1
Milk drinks	199	6.5	10.2	89.9	-22.9
Milk cream products	346	58.9	21.5	31.8	-13.5
Curd cheese	558	2.3	11.9	95.9	-26.9
Cereals	505	12.1	14.2	85.1	-18.8
Soups/mulligan	81	0	0.0	100.0	-49.1
Pizza frozen	62	1.6	12.9	95.2	-26.5
Total	4421	9.6	20.3	84.7	-27.9

Table 4: *Bivariate probit estimates of the price setting equation of quantity surcharges and quantity discounts*

	Quantity surcharges		Quantity discounts	
Variable	Coefficients	*t*-value	Coefficients	*t*-value
INTERCEPT	-2.083**	-11.435	1.178**	8.505
N_PSAVAI	0.316**	4.647	-0.133**	-2.322
STORAGE	0.281**	2.157	0.026	0.202
PS_RATIO	0.609**	8.762	-0.729**	-12.245
PDIFF_PS$_i$	-0.360**	-8.442	0.338**	8.415
PRICE	-0.409**	-5.066	0.443**	6.079
METRO	0.192**	1.969	-0.238**	-2.841
KARSTADT	0.344	1.225	-0.468*	-1.935
TENGEL	0.382**	3.241	-0.337**	-3.078
GLOBUS	0.241	1.536	-0.197	-1.395
WALMART	0.189	1.247	-0.353**	-2.691
COOPSH	0.342**	2.102	-0.277*	-1.873
BOARDBAG	0.866**	6.431	-0.595**	-5.026
PET_CUP	0.366**	2.681	-0.253*	-1.892
C_FILM	0.407**	2.299	-0.229	-1.401
Rho (1,2)	-0.996** (-135.055)			
McFadden R^2	0.151			
Log-likelihood ratio	708.196			

Table 5: *Two-step Heckman estimation of the extend of quantity surcharges and quantity discounts*

	Quantity surcharges		Quantity discounts	
Variables	Coefficients	White's *t*-value	Coefficients	White's *t*-value
INTERCEPT	0.931**	4.844	-0.372**	-25.493
N_PSAVAI	-0.058**	-2.027	0.057**	10.185
STORAGE	-0.085*	-1.942	0.030**	4.124
PS_RATIO	-0.152**	-3.845	0.028**	3.490
PDIFF_PS$_i$	0.052**	2.127	-0.043**	-16.377
METRO	-0.093**	-3.662	-0.008	-1.044
KARSTADT	-0.053	-0.831	-0.016	-0.720
TENGEL	-0.128**	-3.936	0.005	0.467
COOPSH	-0.084*	-1.789	0.024*	1.745
BOARDBAG	-0.154**	-4.208	0.089**	13.212
PET_CUP	-0.059	-1.073	0.031**	3.764
C_FILM	-0.037	-0.488	-0.009	-0.742
λ-A	0.198**	2.801	0.295**	5.407
λ-B	-0.256**	-3.730	-0.048*	-1.665
Adjusted R^2	0.080		0.237	
Log-likelihood ratio	171.016		1037.185	

Notes

[1] This directive became effective in Germany in September 2000. Afterwards, all retailers in the country are obliged to indicate the unit price next to the selling price of a product.

[2] A recent study on unit pricing in Great Britain by Lennard et al. (2003) revealed that 51% of the respondents frequently use unit pricing as information source to find the best buy option. Further, 28% stated that unit pricing is too complicated to use, 37% agreed that their time is too valuable to select the best buy for everything and 32% mentioned that they do not have the time to use unit pricing. These findings indicate that unit pricing alone is not enough to protect consumers against price quantity price surcharges.