ISSUES IN UK FOOD RETAIL PRICING

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Summary

In this PhD we analyse some topics about food-retail pricing behaviour from the point of view of the empirical industrial organisation. Large UK supermarkets chains are actively involved in quality discrimination; they offer three quality variants for most of the products they sell. These quality variants are from higher to lower quality: branded products, high quality own brand products and low quality own brands. Hence, the first two empirical chapters of this PhD are aimed at studying the implications of the supermarkets chains multiquality nature over supermarkets patterns of price competition. The first of these chapters compares the pattern of price dispersion and price competition for each quality variant. In the second of them we build an econometric model that allows to take into account the effects of competition over the price setting for each quality variant of: different quality variants sold at the same supermarkets, and variants of the same and different quality sold at different supermarkets. The results of these two chapters suggest that competition is less intense for the quality variant with greater possibilities of supermarket product differentiation, the high quality own brand products. The joint consideration of this softer price competition and the higher market share of this quality variant in UK food retailing (if compared with continental food retailing) offers a new explanation for the high profits enjoyed by the UK supermarkets in comparison with their continental counterparts.

Claims for antitrust actions against low-price guarantees have been quite common in the USA for some time now. In the UK, the report "Competition in Retailing" written by London Economics for the Office of Fair Trade recognises the anticompetitive effects of low-price guarantees. However, the analysis of Tesco's Unbeatable Value low-price guarantee did not detect any anticompetitive effect. Tesco's Unbeatable value triggered a process of reduction of the prices of the products included in the guarantee. Further analysis of the data and the consideration of the supermarket as a multiproduct firm lead us to analyse the possible relationship between this low-price guarantee and a loss-leaders strategy. Our analysis seriously advises to reconsider the effects of low-price guarantees when the firms offering them are multiproduct firms.

Large UK supermarket chains face not only the competition of other supermarkets but also the competition of discounters. Whereas large UK supermarkets chains offer a homogeneous level of service quality, the level of service quality offered by the discounters is manifestly lower. We propose a model controlling both for locational asymmetries and service quality differentials to analyse the ability of service quality as a market segmentation tool. Also with the aim of analysing this segmentation ability, we study the differential effects of Tesco's Low Price Guarantee over a supermarket and a discounter store affected by it. The results of these two analysis confirm the ability of service quality differentials to segment the market and advice the consideration of supermarkets and discounters as forming part of two different relevant markets.

All the empirical analysis is carried out using a panel of prices that were collected in three supermarkets and a discounter in the south area of Coventry.

Aknowlegments

First of all I have to thank my father and my mother, as since I was a child they have supported me in any new project I started and this is probably one of the most important ones. Always with my mother in mind, I would like to make a special mention for my father; I am sure that he would have followed closely my work for this dissertation but life did not allow him to see even its start. Also my brothers and sisters deserve my thank, they know that without them it would not have been possible to stay in Warwick for so long.

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Declaration of the Author

No material contained in this thesis has been previously published. I declare that this thesis has not been submitted for a degree in another university.

Contents

Chapter 1

Introduction

Food retailing is the most important component of UK retail sales, covering in 1997 46.9% of the total market. In the nineties, the large supermarket chains have become the main player of food retailing as indicated by the fact that in 1997 four supermarket chains (from larger to smaller Tesco, Sainsbury, Asda and Safeway) controlled 67.5% of the market.

All these large supermarket chains are actively involved in quality segmentation and offer a range of three quality variants for most of the products they sell. The top quality variant is the branded product sold under the manufacturer brand name (e.g. Heinz Baked Beans). Both the intermediate and the low quality variants are own brand products, where by own brand products we will understand those products sold under the supermarket brand name. The intermediate quality variant is the high-quality own brand product (e.g. Tesco Baked Beans), which is the result of the evolution of the first own brand products introduced in the UK supermarkets. At the moment the products of this variant can be considered as very similar in quality to the Branded Products. The high quality own brand products compete with the branded products for those consumers in the upper medium segment of the consumer distribution that are willing to exchange the brand name for a price discount buying a product of very similar quality. The lowest quality variant is the low quality own brand product.

UK supermarket chains introduced the low quality own brand products (e.g. Tesco Value Baked Beans) since the middle of the nineties as a reaction to the arrival in the UK of the continental discounters. These latter retailers offer a limited range of low quality products sold at very reduced price. Therefore, they supposed a new form of competition for the supermarket, specially for the lowest segment of the consumer distribution. Supermarket chains faced this competition launching the low quality own brand products: very basic products whose relevant dimension is the price.

The importance of the own brand products in food retailing sales is increasing year after year and in 1996 they represented no less than 36% of the total food retailing sales. For the four large supermarket chains own brand penetration is even higher and sales of these products account at least for the 47% of their total sales. This increasing importance of the own brand products impose the need of considering the supermarket as a multiquality firm and studying the implications of this multiquality nature over supermarkets patterns of price setting for each one of the quality variants. This is one of the main aims and novelties of this PhD dissertation, which starts in Chapter 2 with a brief description of the UK food-retailing system.

Throughout this PhD dissertation we will assume that the utility that a consumer obtains from buying a product depends not only on the quality variant purchased but also on the supermarket in which the product is purchased. These differences in utility are explained by the characteristics of the products that are intrinsic to the supermarket in which they are sold. Therefore, in the UK supermarkets products are differentiated in two dimensions: on the one hand, the quality variant to which they belong gives them the vertical attribute; on the other hand (as we will explain in the next chapters) the supermarket characteristics of the products confer them their horizontal attribute. As a consequence, a product of a given quality variant sold at a given supermarket does not compete only with other products of the same quality variant sold at other supermarkets but also with products belonging to different quality variants sold at the same and other supermarkets.

With the aim of introducing the modelling of multiproduct competition in markets in which variants are differentiated both vertically and horizontally, we present in Chapter 3 a survey of the more recent literature about the topic. In this survey, we provide a framework to compare the different models analysing multiproduct competition when variants are differentiated both horizontally and vertically. Additionally, we explore the relationships between these models and the discrete choice models of product differentiation widely used in the last years to empirically model markets in which the relevant alternatives of consumption are differentiated in more than one dimension. Although the work in this PhD dissertation is mainly empirical, this survey provides the fundamental keys to interpret the results later obtained.

Chapters 4 and 5 are devoted to the analysis of supermarket price setting for the different quality variants they sell. In Chapter 4, we analyse price competition and price dispersion for each one of the quality variants just taking into account the price effects between supermarket-differentiated variants of the same quality. The results of the empirical analysis in this chapter suggest that whereas differences in the degree of between-supermarket price dispersion across quality variants are cost driven, between-supermarket price competition is less intense for the quality variant with greater possibilities of supermarket product differentiation, the high quality own brand products. In Chapter 5, we build an econometric model to take into account both the effects of competition between variants of the same quality and variants of different quality over supermarket price setting. The empirical results obtained in this paper confirm those obtained in Chapter 4: between supermarket competition is less intense for the quality variant with greater possibilities of supermarket product differentiation, the high quality own brand products.

The confirmation of these results suggests a new explanation of the higher profits enjoyed by the UK supermarkets in comparison with their continental counterparts. The traditional factors used to explain this phenomenon are more advanced supply management systems and the existence of high property costs acting as barriers to entry. However, we think that the joint consideration of the lower intensity of price *competition* for the high quality own brand products and the fact that the UK market share of this variant is the highest one in the EU provides an additional explanation to this phenomenon.

All the empirical analysis in this PhD dissertation was performed using a panel of micro level price data. These prices were directly taken in three adjacent supermarkets located in the south of Coventry, which correspond to three of the four chains with largest market share in the UK: Tesco, Sainsbury and Safeway. It would have been interesting to include in the analysis an Asda store but the closest Asda is located in the north of Coventry, an area quite different from a socioeconomic point of view.

During the period in which the price data was collected, Tesco started offering the *Unbeatable Value* low price guarantce (LPG). Having price data both for the periods before and after the start of the low price guarantee, as well as for products included and not included in the LPG, gave us the invaluable opportunity to test empirically the predictions of the theoretical models about LPGs. This analysis is the object of Chapter 6.

Whereas the theoretical literature about low-price guarantees is extensive, to the best of our knowledge only Hess and Gerstner [1991] analyse empirically the effects of a particular LPG in food retailing. They analysed a price-matching guarantee and, conclude that it served the supermarkets to tacitly collude to rise prices to supra-competitive levels. Therefore, their analysis supports both the line of analysis started by Salop (that related LPGs with collusive episodes), as well as Sargent's [1993] and

Edlin's [1997] antitrust claims.

Tesco's *Unbeatable Value* offers to refund double the difference and so is a price-beating guarantee. Both Hviid and Shaffer [1994] and Corts [1995] call the attention on the differential effects of price-beating guarantees: when they are introduced in the space of possible strategies the incentive to compete is restored and price matching guarantees loose their ability to raise prices to supracompetitive levels. Whereas most of the literature about LPGs assumes that activating the LPGs is costless, Hviid and Shaffer [1998,1999] theoretically analyse the effects of LPGs when activating the LPG has a cost (hassle costs): LPGs will be activated only when the reward from activating them is larger than the cost of doing it. Therefore, if this condition is not accomplished LPGs should not have any effect over prices. Our analysis suggest that in general in food-retailing the costs of activating overweight the rewards and so guarantees will be activated only occasionally. However, Tesco's Unbeatable Value did have an effect over supermarket prices and this was a reduction of the prices of the products included in the LPG with respect to the prices of the products not included. Further analysis and the consideration of the supermarket as multiproduct firm led us to relate this LPG with a loss-leaders strategy. Moreover, the decreasing price trend observed recommends to carefully analysing each LPG before claiming antitrust action.

Supermarkets face not only the competition of other supermarkets offering the same level of service quality, but also the competition of other food retailers offering a lower level of service quality, the discounters. We devote Chapter 7 of this PhD dissertation to analyse the influence of service quality over the patterns of price competition between Tesco, Sainsbury and Kwik Save in an area of the south of Coventry. The first two are supermarkets offering a homogeneous level of "high" service quality. In contrast, Kwik Save (the largest UK discounter) offers a "low" level of service quality (by comparison with the supermarkets). In the first part of Chapter 7, we present a theoretical model controlling both for the effects of locational asymmetries and differences in service quality over supermarket price setting. In the second part, we analyse if the effects of Tesco LPG depend upon retailer service quality levels. The results of both analyses reveal service quality differentials as a determinant element segmenting the market and suggest that supermarkets and discounters are possibly part of two different relevant markets.

Finally, I would like to note that each one of the chapters was initially thought as a self contained paper. This implies that some tables and definitions are included in more than one chapter[1]. The objective of maintaining this structure has been to ease the independent reading of each one of the chapters.

[1]When these repetitions happen they are indicated.

Chapter 2

Food Retailing in the UK

Abstract

The objective of this chapter is to carry out a brief description of the UK food retailing system. We start describing the recent transformations that have lead to the dominance of a group of four large supermarket chains (Tesco, Sainsbury, Asda and Safeway). Second we carry out a vertical characterization of the quality variants (branded products vs. own brands) sold by large supermarket chains. Third, we present a brief discussion about retailers' buying power. Finally, we characterise other players in UK food retailing: soft discounters, hard discounters and buying groups.

2.1 Market structure characteristics and evolution

2.1.1 The structure

Food retailing is the most important single component of UK retail sales, covering in 1997 46.9% of the total market. The 90s have witnessed a terrific change in its structure and organization that has been even labelled as a revolution; this has shifted the market from being a rather unsophisticated, non-concentrated one, into being highly technological, sophisticated and concentrated. As we will see, the dominant player has become the large supermarket/hypermarket chains, selling a variety of food and non-food products, and offering a variety of additional services to the customers.

The whole market can be divided between three main kinds of players:

1. large multiples stores (supermarkets, superstores and hypermarkets);

2. smaller multiple stores (symbol/buying groups and convenience stores) and discounters;

3. independent retailers and specialist outlets;

Table 2.1: Turnover by food retailers by type of outlets, 1992-1997 (Pounds millions)

	1992	1993	1994	1995	1996	1997	change (%) 1992-97
Supermarkets	25,252	24,050	22,655	20,660	21,482	22,728	-10
Hypermarkets	22,401	24,491	25,823	26,920	27,991	28,943	29
Cooperatives	5,404	4,933	4,727	3,834	3,672	3,598	-33.40
Discounters	6,368	5,645	4,160	4,662	4,953	4,749	-25
Indep. retailers	3,878	3,497	3,394	3,138	3,183	2,941	-24
C-stores	4,551	4,625	5,352	5,947	6,139	6,740	48
Symbol/Buying Groups	2,181	2,608	1,850	1,951	2,381	2,068	-5.20
Off licences	1,776	1,990	2,077	2,049	2,723	2,639	48.60
Specialists	4,004	3,641	3,455	3,051	2,826	2,651	-33.80
Total	75,815	75,480	73,503	72,212	75,350	77,057	

Source: Euromonitor/ONS/trade estimates, 1998. Cooperatives include also some non-food specialists. The category "specialists" includes: dairymen, butchers, poulterers, fishmongers, greengrocers, fruiterers, bread and flour confectioners.

As we can see from tables 2.1 and 2.2, the large multiples chains of supermarkets and hypermarkets (which in the UK belong to the same owners) dominate the market with a 67.1% of total food turnover, a 12.7% increase over the period, whereas all other players, in particular the small independent retailers, have suffered a continuous decrease in their market share.

Table 2.2: Market shares evolution 1992-1997

	1992	1993	1994	1995	1996	1997
Large multiples	62.9	64.3	66	65.9	65.6	67.1
Smaller multiples	16	16.1	16.2	16.2	16.2	16.1
Discounters	8.4	7.5	5.7	6.5	6.6	6.2
Indep. retailers	10.4	9.4	9.3	8.6	8	7.3
Off licenses	2.3	2.6	2.8	2.8	3.6	3.4
Total	100	100	100	100	100	100

Source: Euromonitor/ONS/trade estimates, 1998.

A more detailed situation is offered by Table 2.3. This shows that the multiples dominance is actually the dominance of a group of four supermarket chains which together cover 67.5% of the whole market: Tesco (23.6%), Sainsbury (19.6%), Asda (13.5%) and Safeway (10.8%).

Table 2.3: Grocery market shares (sales in value) 1993-1997

	1993	1994	1995	1996	1997	% Change 1993-1997
Tesco	18.7	19.3	21.8	22.5	23.6	26.20
J Sainsbury	21.6	22	21.1	20.7	19.6	-9.26
Asda	10.5	10.9	11.7	12.8	13.5	28.57
Safeway	9.1	9.2	9.6	10.3	10.8	18.68
TOP 4	59.9	61.4	64.2	66.3	67.5	12.69
Kwik Save	7.2	6.9	6.6	6.5	5.8	-19.44
Somerfield	4.6	4.8	4.5	4.5	4.5	-2.17
Wm Morrison	3.3	3.6	4	4.2	4	21.21
Iceland	3.3	3.4	3.2	2.9	3	-9.09
Waitrose	1.5	1.4	1.6	1.6	1.6	6.67
Netto	0.4	0.6	0.7	0.8	0.9	125.00
TOP10	80.2	82.1	84.8	86.8	87.3	8.85
Aldi	0.2	0.3	0.8	0.9	0.8	300.00
Lidl	-	-	0.3	0.5	0.6	100.00[1]
Other mult.	5.4	4.9	2.9	2	2.7	-50.00
Co-ops	7.3	6.6	6.3	5.5	5	-31.51
Symbols	1.6	1.3	1.1	1	0.8	-50.00
Other indep.	5.3	4.8	3.8	3.3	2.8	-47.17
Total	100	100	100	100	100	

Source: Taylor Nelson Sofres/ Mintel , 1998; [1]% change (1995-97)

Price wars between the major players, as a means to gaining market share, characterised the first half of the 90s, and helped keeping the level of prices on food well below the average RPI. This was also a response to the appearance in the UK of the European hard discounters and their low-price policy, that triggered also the spread of low-quality own brands[1] by the major supermarkets.

The price wars stop around 1995, and are replaced by a different policy, aimed at keeping customers and building their loyalty, consistently also with a perceived change

[1] We characterise low and high-quality own brand products in section 2.

in consumers tastes, that, once out of the recession, stop giving the highest priority to low prices: notwithstanding the forecasts, the discounters do not get much of a market share (see table 2.2).

2.1.2 The reasons

The main reasons that lead to the dominance of large retailers can be summarised in the following.

1. Cost advantages: sunk costs and economies of scale and scope

Food retailing becomes a large scale activity much more sophisticated and technologically advanced than before. The cost advantages include:

1. floor space economies of scope and product proliferation: larger stores can pile and sell many more products, consistently with the preference of consumers for one-stop shopping and bulk buying.

2. Between 1992 and 1997, the average sales area in supermarkets and hypermarkets increased by 5.8% and 21% respectively (see Table 2.4).

Table 2.4: Average Sales Area (square meters)

	1992	1993	1994	1995	1996	1997
Supermarkets	1653	1638	1580	1606	1665	1749
Hypermarkets	3815	3974	3821	3955	4268	4616

Source: Retail Monitor International, June 1998

3. cost advantages from the existence of buying power (see section 3 in this chapter);

4. economies of scale in logistics and distribution: distribution activities change a lot for the big retailers, and are one of the main causes of their higher levels of efficiency. Wholesaling and distribution are internalised, and the retailer controls them directly. The suppliers now transport all their merchandises

to the central wholesaler who then allocates them to its outlets. The new transport trucks, with fridge and freezer capacity, make it possible to transport in a single journey a lot of different items to each outlet, reducing the number of journeys and therefore reducing costs. The adoption of EPoS (electronic points of sale), EFTPoS (electronic funds transfer systems) and electronic scanners greatly improves the efficiency of distribution and stocking activities, as needs can be communicated almost in real time to the wholesaler and then to the supplier.

As an example of the rate of penetration of new technologies in food retailing, we can see in Table 2.5, that the number of food-outlets with electronic scanners increased fivefold between 1990 and 1997.

Table 2.5: Number of food-outlets with electronic scanners in period 1990-1997

	Scanning Stores	% growth year-on-year
1990	1506	
1991	1811	20.3
1992	2681	48.0
1193	3700	38.0
1994	4954	33.9
1995	5729	15.6
1996	6683	16.7
1997	7462	11.7

Source: Retailer Monitor International, August 1998

2. Legal advantages

At the beginning of the nineties it was relatively easy to obtain planning permission to build out-of-town large stores, which are cheaper than the high street ones and enjoy a large space for car parking. The recent changes in the law that makes it virtually impossible to obtain the permission are obviously an strategic advantage for the incumbents. There is also evidence that some of the major chains in the past bought these large, cheaper sites in excess with respect to their needs, and might now enjoy a first mover advantage by not renting them, or renting them at very high prices.

The Sunday Trading Act of 1994 abolishes most of the restrictions on Sunday opening; late-night opening (with a few stores trying even a 24-hours shift) and Sunday opening become the rule for the large multiples which enjoy a larger, more elastic staff; this makes competition for other, smaller kinds of retailers even more difficult. The abolishment of the restrictions on alcohol sales on Sunday to supermarkets gives them a further advantage over specialist outlets (off-licences).

3. Strategic advantages.

Strategic advantages are all the advantages related to consumer loyalty, reputation and advertising that all in effect restrict the residual demand for a potential entrant.

The four major multiples are now investing a lot in consumers loyalty, through the use of loyalty cards (see table 2.6) and the spread of their own brand products. Loyalty cards can give an advantage not only if they build loyalty to the store, but also because they are providing the retailer with a huge detailed information on consumers tastes and changing preferences.

Table 2.6: Loyalty card owners, 1997

	Total Consumers (in millions)	%consumers
Tesco	9	78
Sainsbury	7	72
Safeway	5	80
Asda[1]	0.5	34
Somerfield	3	43

Source: Retail monitor international, 1998; [1] on trial in 18 stores

4. Social changes

From the beginning of the eighties there is an increasing trend among the UK consumers towards one-stop shopping and bulk shopping. This in turn is due to a variety of social changes, among which the increase in the number of women working, in the levels of car ownership and of women driving, in the ownership of fridges and freezers. As a response to these new needs and as competition for customer loyalty grew, supermarket chains start offering services like car parking and petrol stations, as well as complimentary bus services; on their own or via franchising agreements with other independent chains they offer photo printing services, pharmacies, dry-cleaning and newsagents.

Since the middle of the nineties, changes in customers' tastes and needs, as well as the attempt at differentiation because of possible market saturation has led to heavy investment in consumer loyalty through growth of own-brands products and launch of loyalty card schemes.

The end of the nineties has witnessed the introduction of several additional services by the major retailer chains. They have moved into banking and insurance, and have started introducing home shopping.

In addition, they increase the amount of non-food items (27% of their total turnover in 1997) including books, music and clothes.

2.1.3 The trends

All the above factors explain the trend towards greater concentration during the decade. They worked and still work as barriers to entry, so that the only source of competition for the dominant retailers could come from mergers between smaller, already existing retailers. This, together with the increasing saturation of the market, justifies the general belief that it will concentrate further rather than expand, with the large multiple stores increasing their shares at a rate between 5% and 7% annually[2], covering up to 80% of the market by the end of the century. This will happen via mergers between the existing players (for example the announced merger between Kwik Save and Somer-

[2] Key Note 1997.

field), whereas mergers between the major chains have to be ruled out, as they are looked at unfavourably by both the Government and the MMC. This, together with the increasing difficulty in obtaining planning permissions to build new sites especially out-of-town, translates into the trend of the major chains to focus back on their high street locations (like the Tesco Metro stores for Tesco) and to expand their capacity via buy outs.

2.1.4 Legal and institutional interventions

A few legal interventions have heavily contributed to modifying the structure of the food retailing market during the decade, though we might say that the main role has been played by a general policy of non intervention, especially under the conservative government.

The OFT has started an investigation in the summer 1998 as the big four chains, who have almost quadrupled their profit margins over the last 10 years, are suspected to be charging too high prices to the customers. An international comparison (Financial Times, 8-98) has shown that prices charged by British leading supermarkets are between 35%-40% higher than the prices in Europe and USA. Even though the strength of the pound has made price of (food) imports much cheaper, and prices of food at the farm gate and at the factories have decreased, in 1998, respectively by a 7.2% and 1.1%, prices at supermarkets have increased by 0.6%. Their dominant position on the market has made them very strong against the suppliers, and there starts to be some evidence that they might be abusing their buying power at the expenses of the manufacturers but not at the advantage of the consumers. An earlier OFT investigation in 1997, following a complaint of the National Association of Master Bakers (NAMB), had concluded in favour of the supermarkets, ruling out predatory pricing on their side. The problem is, apparently, far from being resolved.

2.1.5 Effects on the consumers

If consumers have benefited from this change in structure, the benefits are of two main kinds.

1. These changes reflected their changing needs: they can now do most of their weekly shopping in the same place, which they can easily reach by car; they enjoy a wider variety of products, a quicker and more efficient service (shorter queues, credit cards, efficient stocking and distribution of the products to all the stores), longer opening hours and, increasingly, home service

2. The technological advances, together with the competition for market shares between supermarkets and with the discounters, have helped to keep prices low, both via price wars and the introduction of own-brand products. This last point though is now controversial, as was mentioned before and will be discussed more in detail later.

However, it is necessary to remember some drawbacks:

1. The expansion of large food retailers has brought both a reduction in the number of brands available and a reduction in possible consumer choice about the place to shop. Along with the introduction of own label products, the supermarkets have delisted second brands, limiting consumer alternative to the leader brand in the market and the own brand product.

2. The expansion of large food retailers has lead to the closure of small retail business that cannot match supermarket price offers and so to a reduction of the shopping alternatives available.

2.2 Branded Products vs. Own-Brand Products

Own brands are very important in the UK retailing. England was the first country to introduce own label[3] products, in the 70s, and has been the leader in their development and diffusion for two decades. Although, own-brands products market share for the whole food retailing was estimated between 37% and 39% for 1996 (depending on the source, see Table 2.7) its importance varies widely both across products classes and retailers formats. As it is possible to observe in Table 2.8, own-brand penetration is notably high for the chilled foods, a category for which supermarkets are leaders in development and introduction of new varieties. However, in general we can say that own brand product penetration is high in categories such us bakery, kitchen towels or aluminium foils in which quality is easy to evaluate, and possibilities of differentiation and levels of advertising low. In contrast, own brand penetration is particularly low in categories like toiletries for which quality is difficult to determine ex-ante, taste play an important role in the buying decision and possibilities of product differentiation greater[4].

Table 2.7: Estimated own brand shares of total retail sales

	1990	1991	1992	1993	1994	1995	1996
Own Brand Share	24.1	25.7	27.8	31.3	32	34.1	36.7

Source: KeyNote, 1996

Own-brand penetration also varies with retailer format. On the one hand, the highest own brand shares (see Table 2.8) correspond to the major supermarkets chains (Sainsbury, Tesco and Safeway) with highly developed own-brand products programmes. On the other hand, the lowest own-brand market share corresponds to Kwik Save that

[3]We will use indistinctly the own brands and own-labels names to refer to products sold under the supermarket brand name.

[4]Some examples of low own brand penetration: 9.2% for deodorants, 8.0% for toothpaste or only 1.9% for cold treatments. A curious case is pet food, a survey carried out by MAPS discovered that consumers were more willing to try a new own brand when they were the consumers of the product than when the final consumer were their pets.

Table 2.8: Market Shares of Own Label in UK by Category, 1995

	Chilled Products	Dry Grocery	Household Goods	Pet Food & Care	Toiletries	Total
Asda	66.2	33.4	34.9	19.3	19.6	47.3
Co-op	60.2	24.0	23.3	5.0	13.9	39.2
Kwik Save	23.6	12.1	17.4	4.7	3.5	17.0
Morrisons	71.4	17.4	17.1	6.7	3.2	49.5
Safeway	73.7	35.7	40.4	14.1	16.2	54.2
Sainsbury	80.1	51.1	48.5	26.7	25.4	65.6
Somerfield	75.1	28.1	34.7	11.2	13.8	50.4
Tesco	76.3	38.5	41.9	18.6	23.7	55.1
Discounters	33.8	15.7	21.9	7.1	8.1	25.7

Source: Nielsen, 1996

operates a reduced line of "No Frills" own brand products and specializes in the sales of branded products at discounted prices.

2.2.1 Vertical characterization of the quality variants in the UK large supermarkets chains

In all the major UK supermarkets we can find both branded products (BPs)[5] and own-brand products (OBPs) determining the quality rank offered by the supermarket.

The BP, sold under the manufacturer brand name, is the quality variant that initially created the product space. The BPs are sustained by intense manufacturer advertising and product development, and provided with identical specifications to all the supermarket chains.

The own brand products, sold under the retailer brand name, cover a wide range of products and can be divided in two categories: high quality (HQ) and low quality own brand products (LQ)[6]. HQs were the first to be introduced, more than twenty years ago, with the aim of competing directly with the branded products. Their quality level has been improving over the decade and is now considered (by consumers) very

[5] Also called National Brands.

[6] Using Corstjens and Corstjens [1995] terminology, HQs would be Type-I own brands and LQs would be Type-II own brands.

close, if not identical, to the quality level of the branded products, so that they can be used to compete with the latter for those consumers located in the upper and medium segment of the consumer distribution that are willing to exchange the brand name for a price discount. The cost advantage enjoyed by the supermarket as a multiproduct firm (economies of scale and product development, etc.) allows it to offer a product of very similar objective quality at a lower price. In addition from the point of view of the supermarket, the HQs enjoy a series of advantages with respect to the BP:

1. higher profit margins than the BP, usually 20-30% higher.
2. possibility of using them to create a reputation of quality and loyalty to the supermarket (Mills, 1995, Cortsjens *et al*, 1997).
3. possibility of using an umbrella brand to advertise all them.

In the supermarkets, these products are located on the shelves very close to the BPs, and tend to mimic very closely the packaging and presentation of the BPs.

With respect to the LQs, their origin is much more recent, and their introduction can be related to the arrival in the UK of the Continental discounters, that offer products of a lower quality at a lower price. The development of this type of retailers implied a new form of competition for the supermarkets, because the segment of more price conscious consumers might prefer to buy at the discounter even at the risk of a lower quality. The aim and characteristics of these products are therefore different: they are basic products, of lower quality level, with basic packaging (with the aim of reducing the cost), and a name that suggests their competitive approach (Tesco Value, Sainsbury Essentials, Safeway Savers). In order to compete for the lowest segment of the market, they are offered at a very low price.

In Table 2.9, we show the proportion of high and low quality own brand sales in total own brand product sales for the four largest supermarket chains and Kwik Save.

Table 2.9: Proportion of high and low quality own labels (over total own brand sales), 1996

	HQ	LQ
Tesco	91.5	8.5
Sainsbury	97.6	2.4
Safeway	88.6	11.4
Asda	91.0	9.0
Kwik Save	0	100

Source: Marketing Week 28th June 1996

The difference between the shares of HQs and LQs is to some extent conditioned by two factors: shares are calculated over sales in value and LQs are much cheaper than HQs; rank availability[7] is smaller for the LQs. As we will explain later Kwik Save does not have a range of high-quality own brand products.

2.2.2 Some effects of the own-brand product phenomenon

Overall, the share of own brand products has been steadily increasing in the nineties, as we saw in Table 2.7. An important consequence of this increasing importance has been the disappearance of second brands from the supermarkets, i.e. those secondary brands of products who used to be a cheaper alternative to branded goods were squeezed between the own labels and the brands. For most of their manufacturers the only chance of survival was then to start producing for the supermarkets own label.

Moreover, in many product spaces now the only branded product sold by the supermarket is the brand leader, so that competition within the supermarket between branded products has lost importance in favour of the competition with the own brand products.

If the own brand market keeps growing, as it tends to, then this might seriously reduce consumers choice as well as increase supermarkets profit margins.

As it has been suggested for other countries, also UK supermarket chains set very

[7]The number of LQ lines is smaller than the number of HQ lines.

Table 2.10: Retailer gross margins (in percentage of sales), 1993

	Own label	Brand leader
Baked beans	18	2
Soft drinks	26	26
Household detergents	20	6
Paper products	26	6
Cigarettes	10	8

Source: Independent Grocer/PLMA 1993

high margins on own brands. The most recently available information (for 1993) is provided in Table 2.10.

2.2.3 The manufacturers

As the importance of own brands increased and their role changed, more and more brand manufacturers started producing for own labels. Names include Unilever and Nestle' (two of the main manufacturers in the UK), PepsiCo, Danone, McCain, Campbell, Allied Lyons and others, among which, recently, also Heinz. Not all manufacturers agree to produce for own labels, as some of them, like Kellog's, Coca Cola or Gillette, consider it prejudicial to their (quality) reputation. The list of those who agree is getting longer every year, though.

The relationship between producers of branded goods and retailers has become more complicated now that the former have started producing for the latter's own label as well as their branded product. There is evidence that in some cases their production deals can be used as negotiation tools for example for the stocking of other branded goods by the same manufacturer, so the relationship is mutually beneficial. However this is not always the case, as evidenced by the growing number of claims and complaints by manufacturers, and by the very foundation of a special association to protect their rights, the British Producers and Brand Owners Group, or BDPOG. Apart from the copy-right claims, against the copy-cats produced by the supermarkets, manufacturers have complained for example about the reduction or the quality of shelving space offered by the supermarkets. Another point that has to be noticed about this relationship is that brand producers involvement in the production of own labels entails the sharing of some cost information with the retailers. The latter can therefore use this information in the negotiation of the price of branded goods.

The possibility of retailers exerting buying-power in the manufacturer-large supermarket chains relationship has been an issue of great public concern in the last years and we will give it closer attention in section 2.3.

2.3 Manufacturer-large supermarket chains bargaining: retailers buying power

Consistently with their size and dominant position on the market, the "big four" have been shown to enjoy by themselves significant buying power with the manufacturers. This buying power has manifested itself not only positively, as a way of increasing efficiency by reducing costs, thus passing over to consumers in terms of lower prices and/or higher quality; it has also assumed extortionary forms, increasing the burden on the manufacturers at the advantage of the retailers, in terms of higher profits, therefore reducing social welfare. As it can be expected, whether buying power is going to be socially beneficial or detrimental, will depend crucially on whether it serves as a means of increasing efficiency and thus reduce costs in the interest of the final consumer, or as a means of increasing the power of the dominant firms and reducing competition in retailing[8].

As a reaction to the increasing power of the dominant retailers chains, smaller retailers have started joining up in buying groups and symbol groups, as will be discussed

[8]For a detailed analysis of the manufacturer-retailer bargaining and its possibles consequences see Dobson et al. [1998].

in Section 4 of this chapter.

2.3.1 Evidence of retailing buying power

There is growing evidence that the major supermarket chains abuse their dominant position and engage in such practices, at their only advantage, i.e. with the aim of increasing their market power by reducing competition, and increasing profits. As the major retailers are operating nationally or even internationally, the manufacturer often does not have much of an alternative than accepting the imposed conditions. More specifically, claims have been made by some manufacturers of the use of the following procedures:

1. conditional purchase behaviour, like exclusivity contracts for example to fight the competition coming from the discounters, or refusal to purchase, delisting or refusal to stock;
2. use of "minimum supply levels" to rule out supply to other retailers;
3. imposition of extortionary prices, in order to reduce costs and/or promote discounts in store;
4. use of slotting allowances.

At this point is relevant to make reference to the direct information provided by interviews with a supermarket manager and a representative of an association of food producers[9].

In general, supermarkets do not deny that they engage in such practices, as they know that their competitors are going to use them anyway, and that would leave them out of the game in terms of competitiveness. Among the practices that entail an abuse of buying power there are:

[9]This interviews were carried out as part of a study about retailing buying power carried out by Dobson Consulting.

1. The international imposition of discounts: supermarkets that operate in more than one country impose to the supplier the most favourable contractual conditions everywhere; for example, that was the case for Heinz USA, that was forced to supply to Shaws (a retailer owned by Sainsbury) in the USA at the same conditions as those offered by Heinz Europe.

2. Imposition of the packaging characteristics of the product, even when these are against the interest of the supplier (for example, they increase its transportation costs); this power extends to an almost complete determination of all the characteristics of the product with the manufacturers of own brand products. Although theoretically they are independent firms, supermarkets are said to behave as if they were the very owners;

3. Imposition of discounts: request of special discounts to the suppliers to copy the special offers proposed by another supermarket (even when the promotion was not related to any supplier discount); price cuts for special offers (like three for two) whose burden stays with the manufacturer and remains like that even when the special promotion is over; lower costs that do not translate anymore into lower prices to the consumers, but in higher profits for the retailer;

4. Use of "advice" letters as not to sell to particular retailers; this was for example the case of the discounter Aldi, whose entrance in the market was hindered in this way.

Triggered by the unjustified price increases in retail shops, and the huge increase in their profit levels (net profits in the UK supermarkets, averaging 6%, double those of the supermarkets in the continent[10]), parallel to the increasing degree of concentration,

[10]The Economist, 6-2-99.

the OFT has announced an investigation on the matter.

2.4 Other food retailers

Beside supermarket chains other players in the UK food retailing are soft discounters, hard discounters and buying groups.

Soft discounters

UK owned soft discounters, as Kwik Save, are characterised by smaller size than supermarket/superstores both in sales area and range of products[11]. Kwik Save´s range is integrated by branded products sold at discount and a limited range of low-quality own brand products sold under the "No Frills" name. A clear difference between Kwik Save and the large supermarkets chain is the level of service quality. The supermarkets offer a nice shopping atmosphere with wide aisles, tidy shelves and big number of check-out lines to assure short queuing times and convenience. In contrast, in Kwik Save aisles are narrower, products are just piled up on the shelves, the number of check-outs is small and the queues are frequent, etc. Supermarkets accept all major debit and credit cards whilst Kwik Save only accepts some of them. Supermarkets offer loyalty cards with accumulable points that later on will be transformed in monetary discounts and the possibility of using it in the own supermarket petrol station.

Hard or Continental Discounters

Owned by continental companies, hard discounters are located in cheap sites and give a carefully studied image of low price outlets. Hard discounters such as Aldi or Netto sell a limited and frequently discontinued line of low-quality own brand products that rarely includes branded products at very competitive prices. In the price strategy of hard discounters service quality is not a concern, products are piled up inside its own

[11] Whereas the average size of a superstore belonging to a large supermarket chain is over 25000 sq. feet, the larget Kwik Save outlet ares about 12000 sq. feet.

transportation boxes, no credit or debit cards are accepted and check out availability reduced[12].

We can observe in Table 2.11 the market shares that correspond both to hard and soft discounters in total retail food sales between 1992-1997.

Table 2.11: Discounters' Share of Total Food Retail Sales

	1992	1993	1994	1995	1996	1997
Hard Discounters	0.5	0.7	1.3	1.8	1.9	2.1
Soft Discounters	7.9	6.8	4.4	4.7	4.7	4.1

Source: Retail Monitor International, June 1998

We can observe two opposite trends for soft and hard discounters. Whereas hard discounter more than multiply by four their market share, soft discounters market share in 1997 is less than half of what it was in 1992. Soft discounters market share has been squeezed between the larger more efficient Continental owned stores and the competition of supermarket chains, which appear to be offering better quality products at comparable prices and the possibility of the desired one-stop shopping.

Buying Groups

With the increase in market concentration over the decade and the increasingly dominant position of the four chains of supermarkets, joining a buying or a symbol group became basically the only chance for survival of smaller retailers. This has proved true, as increased efficiency of the groups and their members has made them more successful specially during the recession.

Both buying and symbol groups give their members the advantage of enhancing economies of scale in purchasing; in the case of symbol groups this corporate identity goes beyond the purchasing activity, and extends to marketing support for retailing. Members operate under a symbol group facia, and are subject to disciplines as regards

[12]In Aldi check outs do no have scanners and products do not have price labels. Prices are the same for many products and check out clercks know these prices by heart .

unity of style and coherent product offering, though retaining their financial autonomy. A very recent variant of the symbol group is the development of the new logo facias, where the traders sign a three-year agreement to purchase a given value of stock in exchange of marketing services and preferential prices on shopfittings and equipment.

Buying groups differ from symbol groups because their members operate autonomously and are united only with respect to the purchasing activity. Membership is relatively fluid and requires to satisfy certain conditions of operational performance which vary across the groups consistently with their particular aims.

Table 2.12: Buying/Symbol Gropus Share of Total Food Retail Sales

	1992	1993	1994	1995	1996	1997
Buying/Symbol Groups	2.9	3.5	2.5	2.7	3.2	2.7

Source: Retail Monitor International, June 1998

We can see in Table 2.12 that buying /symbol groups represented only 2.7% of the total retail sales in 1997. Between 1992 and 1997 this market share fell in only 0.2 percentage points. Very likely, this evolution is the result of two opposite effect: on the one hand, the continuous influx of independent grocers into these associations and on the other hand the increasing importance of supermarket chains.

Chapter 3

Multiproduct Firms and Product Differentiation: a survey

Abstract

We start the survey by reviewing the implications of horizontal and vertical product differentiation on market structure under the assumption of single-product firms. Then, we analyse the main results of the multiproduct firm models, both when variants are assumed to be differentiated in vertical attributes only and when variants are assumed to be differentiated in two dimensions (vertical and horizontal). Finally, we review the empirical literature about discrete-choice models of product differentiation.

3.1 Introduction

In recent years the study of models of multiproduct competition with product differentiated variants has become an important field both for the theoretical and empirical industrial organization. This survey tries to explain firms' product range and pricing decisions using models in which variants are differentiated in one or more dimensions. The literature that is of potential relevance to a survey of this field is extensive. Hence, most of the times we explicitly review those models that we have consider essential for the general argument pursued: briefly expose the possibilities of modelling multiproduct competition under different product differentiation assumptions.

In order to give an intuition to understand more complex models, we start the survey by the "finiteness property" of the models of vertical product differentiation. The aim is to stress the different effects on market structure of the assumptions of horizontal and vertical product differentiation. In the second part of the introductory section, we first present a model of single product competition in which goods are differentiated both horizontally and vertically (two-dimensional product differentiation) and, then we present a reconsideration of the "finiteness property" with two-dimensional product differentiation.

We start the analysis of multiproduct competition by a brief review of a model in which variants are differentiated only by vertical characteristics. Then, we start the analysis of multiproduct competition when goods are differentiated in two dimensions (vertical and horizontal dimensions). Most of the attention is focused on these models with the aim of using them as a reference for the empirical analysis of supermarket competition carried out in later chapters. As we already explained in Chapter 2, UK supermarket offer three variants of different quality (vertical attribute), from higher to lower quality: BPs, HQs and LQs. Besides, we consider that the supermarket in which the variant is sold confers it a differential horizontal attribute. Therefore, UK supermarket competition is a clear example of a market in which variants of a given quality compete both with variants of the same quality and variants of different qualities sold at other supermarkets.

In recent years, the most interesting empirical approach to oligopolistic models of product differentiation is the discrete-choice models of product differentiation. Hence, we devote the last part of this survey to review this models with the aim of using the empirical results obtained in this models as modelling suggestions.

3.2 Price competition and product differentiation: single product firms

It is a standard result in models analysing markets with horizontally differentiated products that in free-entry equilibrium the number of firms increase without bound when the size of the fixed setup costs tends to zero or the size of the market becomes very large. Additionally, the limiting price approaches the marginal cost[1].

However, in markets in which products are vertically differentiated (only), as long as consumers' willingness to pay for quality grows faster than the unit variables costs of providing this quality, the number of firms in the market is independent of both the size of the market and fixed costs. In the free-entry equilibrium of these models, the number of firms in the market will never be greater than a maximum determined by the income distribution. Thus, price will be above marginal costs and the firm will get positive profits. In order to illustrate these phenomenon usually referred as "finiteness property", we will follow Shaked and Sutton [1982, 1983]. First, we present the general framework of the model and then we analyse the particular case of a single product duopoly selling vertically differentiated products.

Let us assume that n products of different quality produced by n single-product firms are available for sale. If we denote quality by q we can sort the products in increasing order of quality: $q_1 < q_2 < ... < q_n$ with prices for each one of the quality variants $p_1 < p_2 < ... < p_n$. As the finiteness property is a property of the price equilibrium we consider qualities as given and focus on the Nash equilibrium in prices[2]. All consumers have the same tastes but differ in income. Consumers' incomes (θ) are assumed to be uniformly distributed with density s over $[a, b]$ with $a > 0$. Consumers either choose to consume one unit of one of the available qualities or instead consume none. Utility from consuming the variant of quality k is supposed to be of the specific form[3]:

[1]For an analysis of the different effects of horizontal and vertical product differentiation on market structure see Sutton [1986]. For extensive reviews of product differentiation: Eaton and Lipsey [1989], Tirole [1988, ch2], Ireland [1987], Waterson [1989] and Beath and Katsoulacos [1991].

[2]In general Shaked and Sutton consider a two-stage competitive game. In Stage 1, firms choose quality and in Stage 2 prices (Bertrand competition).

[3]Here we use Mussa and Rosen [1978] specification of preferences instead of Shaked and Sutton [1982] specification. The reason is that the papers considering both horizontal and vertical product differentiation reviewed later use this function to specify the vertical product differentiation component.

$$U(\theta, k) = \theta q_k - p_k, \qquad k = 1, ..., n \tag{3.1}$$

and the utility from consuming nothing:

$$U(\theta, 0) = \theta q_0 \tag{3.2}$$

A consumer with income θ_k will be indifferent between buying variants of quality k and $k-1$ if

$$\begin{array}{l} U(\theta_k, k) = U(\theta_k, k-1) \\ \text{i.e. } \theta_k q_k - p_k = \theta_k q_{k-1} - p_{k-1} \end{array} \tag{3.3}$$

We can rearrange (3.3) as

$$\theta_k = r_k(p_k - p_{k-1}) \tag{3.4}$$

where $r_k = 1/q_k - q_{k-1}$. Thus, given prices, those consumers with an income greater than θ_k will to buy the variant k and those consumer with an income lower than θ_k will buy the variant $k-1$. By repeating this operation for every pair of adjacent qualities, we can partition the distribution the consumers into income bands such that every one within a specific income band buys a certain quality. The higher the income band the higher the quality. We can use this income-splitting property to obtain the demands for each one of the quality variants, starting with the highest, n ,

$$\begin{array}{l} x_n = s(b - \theta_n) \\ x_{n-1} = s(\theta_n - \theta_{n-1}) \\ \\ x_1 = s(\theta_2 - a) \end{array} \tag{3.5}$$

By substituting (3.4) into each one of the demands of (3.5) it is possible to observe that the demand of each one of the quality variants depends on its own price and quality

Other applications for markets in which products are vertically diferentiated using this specification can be found for example in Tirole [1988; ch7] and Moorthy [1988].

but also on prices and qualities of its lower and upper quality neighbours.

With respect to the costs, it is assumed that fixed costs depend upon quality and that unit variable costs are independent of quality, i.e. all the burden of quality improvements is placed on fixed costs.

$$C_k = cx_k + F(q_k) \tag{3.6}$$

Furthermore, it is assumed that the range of the income distribution is such that $2a < b < 4a$. If, without loss of generality we set $c = 0$, the revenues of the firms producing the variant of quality q_n and the variant of quality q_1 are, respectively

$$sR_n = sp_n(b - \theta_n) \tag{3.7}$$

and

$$sR_1 = \begin{cases} sp_1(\theta_2 - a), \ \theta_1 \leq a \\ sp_1(\theta_2 - \theta_1), \ \theta_1 > a \end{cases} \tag{3.8}$$

where s can be understood as a measure of the size of the economy. The first order condition of profit maximization for the firm producing the variant of quality q_k (given qualities) is given by $\partial R_k/\partial p_k$. Therefore, for the firms producing the variants of quality q_n and q_{n-1} these are respectively,

$$\frac{\partial R_n}{\partial p_n} = b - 2\theta_n - r_n p_{n-1} = 0 \tag{3.9}$$

$$\frac{\partial R_{n-1}}{\partial p_{n-1}} = \theta_n - 2\theta_{n-1} - r_n p_{n-1} - r_{n-1} p_{n-2} = 0 \text{ if } \theta_{n-1} \geq a \tag{3.10}$$

$$\frac{\partial R_{n-1}}{\partial p_{n-1}} = \theta_n - \theta_{n-1} - p_{n-1} r_n = 0 \text{ if } \theta_{n-1} < a \tag{3.11}$$

Using (3.9) and (3.10) Shaked and Sutton [1982] establish that if $4a > b > 2a$ only two firms stay in the market[4]. As $p_k > 0$ and $r_k > 0$, FOCs (3.9) and (3.10) require respectively that $b > 2\theta_n$ and $\theta_n > 2\theta_{n-1}$ which implies $b > 4\theta_{n-1}$. Since by assumption we consider $b < 4a$, this implies that $\theta_{n-1} < a$, i.e. at most two firms have positive market shares at the Nash equilibrium in prices. Thus, the number of firms in the market is independent of both the size of the market and the size of the fixed costs and depends only upon the wideness of the income distribution.

The Nash equilibrium in prices in this model is characterised by working out the best-reactions functions of the two duopolists. Given the direct relationship income-price (through the marginal consumer conditions) we can study the reaction functions in the space (θ_1, θ_2)[Shaked and Sutton, 1982]. Accordingly, three possible areas where we can find a Nash equilibrium can arise depending on the values of $v = \dfrac{q_2 - q_0}{q_2 - q_1}$. If $v \geq (b+a)/3a$ the Nash equilibrium prices are $p_1 = \dfrac{b-2a}{3(v-1)r_1}$, $p_2 = \dfrac{2b-a}{3r_2}$. If $(b-a)/3a \leq v < (b+a)/3a$ then Nash equilibrium prices are $p_1 = \dfrac{a}{r_1}$, $p_2 = \dfrac{b+a(v-1)}{2r_2}$. In both cases the market is covered (i.e. all the consumers buy one or the other good). Region III ($v < (b-a)/3a$) is not possible because of our assumption $2a < b < 4a$.

Both equilibria involve two established firms producing different qualities (the quality decision has not been made explicit here) at a price which in general implies supra-normal profit but which not attracts entry. In a model of *pure* vertical product differentiation the existence of sunk costs (even very small) implies that no firm will enter the market producing one of the already available quality variants. If entry happens Bertrand competition will drive prices equal to unit variable costs and fixed sunk costs will be not covered.

[4]In general Anderson, de Palma and Thisse [1992, ch. 8] show that the necessary condition for n products to have positive market shares is $b > 2^{n-1}a$.

3.2.1 Two-dimensional models of product differentiation

Actually, most of the products that we usually purchase and use embody both horizontal and vertical product characteristics. We can combine this two characteristics in the following utility function:

$$v_i = r + \theta q_i - z\,|\delta - l_i| - p_i \tag{3.12}$$

where r is the basic willingness to pay for the product. Each consumer type is defined by its willingness to pay for quality (θ) and its parameter for horizontal specification (δ). A variant can be specified as (q_i, l_i). The indirect utility function (3.12) is additively separable in the horizontal and vertical characteristics. The underlying assumption behind this additivity is the independency of the two characteristics.

Neven and Thisse [1990][5] analyse duopoly product selection using (3.12). They assume quadratic transportation costs, $z\,|\delta - l_i| = z(\delta - l_i)^2$. Consumers are uniformly distributed over $[0, \theta_M] \times [0, L]$. Qualities q_1,q_2 are chosen from $[q_m, q_M]$ and locations from $[0, L]$. Without loss of generality, it is assumed that $q_2 > q_1$ and $l_2 > l_1$. Production costs are assumed zero.

Firms decision process is modelled as two stage game: in the first stage firms choose simultaneously product characteristics; in the second stage firms choose prices. Depending on the two variants it is possible to distinguish two regimes: the horizontal dominance regime characterize those situations in which variants are closer vertically than horizontally ($2zL(l_2 - l_1) > \theta_M(q_2 - q_1)$); the vertical dominance regime is characterized for the opposite situations, variants are closer horizontally than vertically.

[5] For other works in which single product firms compete in more than one-dimensional space see: Vandenbosch and Weinberg [1995] for a two-dimensional vertical product differentiation model and Degryse [1996] for the application of a two-dimensional model of horizontal/vertical product differentiation to study the interaction between remote access (vertical attribute) and location (horizontal attribute) as determinants of the market equilibrium in the banking sector.

Let us start by briefly commenting the properties of the price equilibrium, Neven and Thisse show that, *"when firm 1 improves upon its position (higher $q_1 < q_2$ or more central location $l_1 < l_2$) along the dominated characteristic, its equilibrium price generally increases despite the fact that variants are getting closer"*. In contrast to the one-dimensional models of horizontal or vertical product differentiation prices do not necessarily fall when variants get closer[6]. The cause of this result is that variants are sufficiently separated by the dominant characteristic. However, when variants get closer in the dominant characteristic, the results of the one dimensional model hold and prices fall.

With respect to the equilibrium variant specifications, two configuration appear as equilibria depending on the preference intensity in vertical dimension relative to the preference intensity in horizontal dimension. If preference intensity in vertical dimension is large enough (relative to preference intensity in horizontal dimension) then vertical differentiation is maximum and horizontal differentiation is minimum, $(q_1^*, l_1^*) = (q_m, L/2)$ and $(q_2^*, l_2^*) = (q_M, L/2)$. If the opposite is true, then the equilibrium configuration involves maximum horizontal product differentiation and minimum vertical product differentiation, $(q_1^*, l_1^*) = (q_M, 0)$ and $(q_2^*, l_2^*) = (q_M, L)$. Whereas, in one-dimensional model of vertical/horizontal product differentiation the equilibrium implies maximum product differentiation, in this model the maximum product differentiation configuration ($(q_1^*, l_1^*) = (q_m, 0)$; $(q_2^*, l_2^*) = (q_M, L)$) never arises. This results uncovers that interplay between horizontal and vertical characteristics (even under the assumption of additive preferences) has important effects in the firms' product selection process.

[6]See for example the prices resulting from the Nash equilibrium in prices of the vertical product differentiation model.

Reconsidering the finiteness property in two-dimensional models of product differentiation

The finiteness property of the models of vertical product differentiation ceases to exist when the horizontal dimension is introduced. Assume that consumer preferences are given by (3.12). Independently of the number of firms in the market an entrant can make positive profits by introducing a new variant with quality equal to the quality ranked first for all consumers and horizontal specification different from that of the already established firms. Since this new variant will be strictly preferred by the nearby consumers, the entrant will capture a positive market share selling at price over unit costs of production. The limiting result is that all firms will choose the same quality specification but different locations.

Notwithstanding, Shaked and Sutton [1987][7] suggest the existence of some kind of finiteness property in two dimensional models (vertical-horizontal) of product differentiation when fixed costs depend of quality. They show that in a free entry equilibrium, at least one firm has a market share bounded away from zero, even if the market gets arbitrarily large.

Firms costs are decomposed in quality-dependent fixed costs, $K(q)$, and quality-dependent unit costs of production, $c(q)$. Shaked and Sutton make three more assumptions about the costs:

$$c'(q) < \theta_M \qquad \text{for all } q \in [0, \infty[\tag{3.13}$$

$$0 < \frac{\partial \log K(q)}{\partial q} \leq \beta \qquad \text{for all } q \in [0, \infty[\tag{3.14}$$

[7] In order to use the same specification of indirect utility function that we will use when analysing multiproduct competition we follow chapter 8 of Anderson, de Palma and Thisse [1992] to review Shaked and Sutton [1987].

$$c(q) < r \text{ for all} \qquad q \in [0, \infty[\tag{3.15}$$

where marginal costs and fixed costs are assumed to be continuously differentiable with respect to q, and β is a constant. The first two conditions ensure that the burden of quality improvement is placed on fixed cost rather than in marginal costs, but fixed cost do not grow too fast with quality. The third condition ensures that unit costs of production are lower than income for all the qualities.

The objective is to show that in free entry equilibrium at least a firm will have a strictly positive market share ($\mu > 0$). The proof is carried out by contradiction. Assume a free entry equilibrium at which all firms have positive market shares smaller than an arbitrary $\varepsilon > 0$ that is independent of size of the market, s. Since price cannot be higher than income, the maximum possible revenue is given by $s\varepsilon r$, therefore fixed cost must be less than $s\varepsilon r$. What we need to show is that there are strictly positive values for Δ, m, μ such that if a firm enters the market producing a variant of quality $(q^+ + \Delta)$ (where q^+ is the highest quality available in the market) at an arbitrary location l in $[0, L]$ and incurring in a fixed cost $K(q^+ + \Delta)$, it can get a market share μs selling at a price $c(q^+ + \Delta) + m$. Thus, the entrant would make positive profits contradicting the original the assumption of free entry equilibrium.

The utility for a consumer of type (θ, δ) from consuming the variant of quality $(q^+ + \Delta)$ (the variant offered by the new entrant) is

$$V_{(q^+ + \Delta)} = r - [c(q^+ + \Delta) + m] + \theta\left(q^+ + \Delta\right) - z\left|\delta - l\right|$$

and the higher utility that a consumer can obtain from consuming any of the other variants available in the market is

$$V_{q^+} = r - c(q^+) + \theta\left(q^+\right)$$

Substraction of V_{q^+} from $V_{(q^++\Delta)}$ results in the left-hand side of condition (3.16)[8]. This condition implies that there exists a positive fraction μ of consumers for whom

$$[\theta - \max c'(q)]\,\Delta - m - z(L) > 0 \tag{3.16}$$

strictly holds. These fraction μ of consumers strictly prefer the variant offered by the new entrant at price $c(q^+ + \Delta) + m$ to any other variant offered at marginal cost. Thus, the entrant sells at least $s\mu$ units at a markup of m. Consider a value of ε such that

$$\varepsilon < \frac{\mu m}{r e^{\beta\Delta}} \tag{3.17}$$

Conditional on market shares smaller than ε and prices less or equal to r, the maximum revenue that firms can obtain is $s\varepsilon r$. In equilibrium,

$$s\varepsilon r \geq K(q^+) \tag{3.18}$$

With $p = r$ the revenue for the entrant is $s\mu r$, and integration of (3.14) implies

$$K(q^+ + \Delta) \leq e^{\beta\Delta} K(q^+)$$

and so given that

$$\begin{aligned} s\mu r - K(q^+ + \Delta) &\geq s\mu r - e^{\beta\Delta} K(q^+) \\ &\geq s\mu r - e^{\beta\Delta} s\varepsilon r \qquad \text{from (3.18)} \\ &> s\mu r - s\mu m > 0 \qquad \text{from (3.17)} \end{aligned}$$

$\pi_e > 0$ and entry will happen. Therefore, we cannot find a free entry equilibrium if we find that none of the firms have a market share $\varepsilon > 0$. In a free entry equilibrium at

[8] Where $\Delta > 0$ is large enough and m is small enough.

least one of the firms must have a market share bounded away from zero independently of the size of the market. From this, we can conclude that even when horizontal product differentiation is allowed, the presence of vertical attributes implies a minimum degree of concentration in the market.

3.3 Multiproduct competition in a model of vertical product differentiation with endogenous quality range decision

Champsaur and Rochet [1989] extend the single-product firm models of vertical product differentiation presented in section 3.2 to allow for multiproduct competition. Restricting their attention to the demand side (in the costs side no economies of scope are allowed and production activities of the firm are fully additive) they analyse quality range and price decisions in the multiproduct duopoly. They consider a two-stage noncooperative game in which firms take first the quality decision and then the price decision. They highlight that the quality range decision in the first step is influenced by two opposite effects. On the one hand, in order to discriminate among consumers with different characteristics, firms would like to offer a broad range of qualities (as in the monopoly situation). On the other hand, price competition lowers the profits of a firm when it offers qualities close to those of its rivals and so firms have an incentive to differentiate their products from those of their rivals. They show that for intermediate quality ranges the second of the effects dominates the first and that in the Nash equilibrium of the quality game in which firms make positive profits there is a quality gap between the product lines offered by the two firms. In this model, it is the assumption of price competition among homogeneous product that rules out head-to-head competition.

3.4 Multiproduct competition in two-dimensional models of product differentiation

The next step is to study models of multiproduct competition in which products are differentiated in two dimensions: quality and horizontal attributes[9]. We propose here a general framework to analyse Katz [1984], Gilbert and Matutes [1993] and Canoy and Peitz [1997]. In Katz [1984] the firms' product line decision is taken as given and firms choose simultaneously prices and qualities of the products in their product lines. However, in Gilbert and Matutes [1993] and Canoy and Peitz [1997] qualities are taken as given and firm choose product line (niche or proliferation) and prices. These last two papers analyse firm entry decisions using sequential games. Table 3.1 summarizes the main assumptions and results of these papers.

Let us start by providing a common benchmark for the three papers with respect to the assumptions about firms and consumers.

Firms

Consider a market in which two firms can produce more than one variant of a good. In this market variants are differentiated in two dimensions: quality and horizontal characteristics. It is assumed that there are two goods: a low-quality (good 1) and a high-quality (good 2). Lets us call V_i the space of possible production choices and R_i the realized choice of the firm i. Firm i sets prices p_{ij}, $j \in R_i$ such that it maximizes:

$$\pi_i = \sum_{j \in R_i} [p_{ij} - c(q_j)].MS_{ij} - K_{R_i}$$

[9] An important line of analysis of multiproduct competition not explicitely considered here is the models assuming horizontal product differentiation only. Within this line we can distinguish between those papers that take firm range decision as given and those papers that analyse the firm range decision. In the first line we consider specially relevant the analysis of interlaced-product competition versus head-to-head competition carried out by Klemperer [1992]. Those papers assuming that each firm produce a given range of products have the limitation of presupposing a particular equilibrium solution to the product range, i.e. the product line selection is consider as exogenous. Within the horizontal product differentiation literature papers considering endogenous rank selection are for example Shaked and Sutton [1990], Dobson and Waterson [1996] and Lal and Matutes [1989].

where MS_{ij} is the market share of the variant of quality j produced by firm i and $c(q_j)$ the unit cost of production of this variant (with $c'(q_j) > 0$). As regards the fixed cost of production K the assumptions differ across papers: Katz [1984] does not introduce any fixed costs, Canoy and Peitz [1997] assume weak economies of scale and Gilbert and Matutes [1993] strict economies of scale.

Customers

Each consumer buys one unit of one of the variants and none of the other variants. His indirect utility function is given by:

$$v_{ij} = r + \theta q_j - z\left|\delta - l_i\right| - p_{ij} \tag{3.19}$$

where r is the basic willingness to pay for the product. Each consumer type its defined by its willingness to pay for quality (θ) and its parameter for horizontal specification (δ). In all the three papers it is assumed that consumers' preference for horizontal specification is distributed in the interval [0, L] with density d. Whereas in Gilbert and Matutes [1993][10] and Canoy and Peitz [1997] is assumed that at each location δ, consumers' willingness to pay for quality is uniformly distributed over $[0, \bar{\theta}]$, Katz [1984] assumes a finite number of θ-types in the market (here, we will assume two: high θ and low θ-types). z usually interpreted as transportation cost could be interpreted here as a measure of the intensity of the consumer's firm preference.

A consumer located at δ with a willingness to pay for quality θ will buy the product j from firm i if:

$$(j,i) = \arg\ \max\left[r + \theta q_j - z\left|\delta - l_i\right| - p_{ij}\right]$$

All the three papers assume maximum differentiation. In Katz [1984] and Gilbert and Matutes [1993] the firms (describing the horizontal characteristic of the variant)

[10] Actually, Gilbert and Matutes [1993] do not make any assumption about the shape of the distribution, we make the assumption here to make comparisons with the other two models.

are located in the end points of the linear segment of L length, and in Canoy and Peitz [1997] variants are located in the corner points of a symmetric triangle.

3.4.1 A model with homogeneous brand preferences

Gilbert and Matutes [1993] present two different models. In the first of them, two duopolists compete in a one-stage game in which they set the prices for all the possible variants. The second model is a three-stage sequential game in which the firms can make credible commitments of not producing one or more products.

They set the quality of the low-quality variant to zero ($q_1 = 0$) and that of the high-quality variant to 1 ($q_2 = 1$). In their model z does not vary with θ and it is assumed to be equal to one. The density of consumers in each location δ is assumed to be equal to $\frac{N}{L}$. Therefore, their indirect utility function takes the following form:

$$v_{ij} = r + \theta q_j - |\delta - l_i| - p_{ij}$$

Then, using this utility function and by means of the condition defining the customer indifferent between any two particular variants they obtain the sales regions (markets shares) for each one of the variants.

They assume that each one of the firms has a cost function

$$C_i(x_{i1}, x_{i2}) = c(q_1)x_{i1} + c(q_2)x_{i2} + F = c_1 x_{i1} + c_2 x_{i2} + F$$

where x_{ij} denote the sales of quality variant j by firm i. This function is assumed to show strict economies of scope. The cost advantage of the low-quality over the high quality variant is defined as $D = c_2 - c_1$.

Let us consider first the one-stage game in which the two firms set simultaneously the price for the low-quality and high-quality variants and firms have no ability to precommit to their product offerings. Gilbert and Matutes show that in a symmetric Nash equilibrium the profits of firm 1 are

$$\pi_1 = \frac{N}{L}\left[(p_{11}-c_1)\,t_1\theta_1 + (p_{12}-c_2)\,t_2(1-\theta_1)\right]$$

and the profit of firm 2 are

$$\pi_2 = \frac{N}{L}\left[(p_{21}-c_1)\,(L-t_1)\,\theta_1 + (p_{22}-c_2)\,(L-t_2)\,(1-\theta_1)\right]$$

where:

$$t_1 = \frac{p_{21}-p_{11}+L}{2}$$
$$t_2 = \frac{p_{22}-p_{12}+L}{2}$$
$$\theta_1 = p_{12}-p_{11}$$

The equilibrium prices obtained from solving the system of FOCs resulting from the maximization problems of firm 1 and 2 are: $p_{11} = p_{21} = L + c_1$ and $p_{12} = p_{22} = L + c_2$. Therefore in the symmetric equilibrium: both firms set the same prices, the mark-up is the same for each one of the products ($m_{11} = m_{12} = L$ and $m_{21} = m_{22} = L$), this mark-up is the same that in the single product competition and profits are independent of the number of variants produced[11]. In equilibrium mark-ups are independent of consumer tastes for quality. Although firms are not better off by offering the product line than by offering a single product, this symmetric Nash equilibrium in pure strategies involves both firms producing the product line (q_1 and q_2). This is because if one firm is producing just one variant, for any product choice of the other firm, this firm could introduce a second variant with the same mark-up that would generate additional sales with no loss of profits from the consumers that switch from one variant to the other. The sales of the new variant come from consumer switch from the variant that the firm was already producing and from consumer switch from the variant of the same

[11]This result contrast with the higher mark-ups for the high-quality variant obtained in the analysis of vertical product differentiated-only models by Mussa and Rosen [1978] and Moorthy [1988].

The equilibrium price when each firm sells only the same quality variant is $p = c + L$. It is assumed that $0 < D \leq \bar{\theta}$ and that therefore in an efficient equilibrium both variants would be produced.

quality produced by the other firm. Consumer switch between variants produced by the firm has no cost for the firm and the additional sales to consumers previously buying form the rival represent additional profits[12]. Therefore, in a one-stage game of product-choice and pricing and without possible commitments to product choices, firms introduce the maximum number of product variants but they do not benefit from the production of more goods.

They model product commitment as a three-stage sequential game in which firms can commit to withhold one or more quality variants from his production possibilities set. The stages of this game are as follows: in the Stage 1 firm 1 takes the necessary actions to produce 1,2 or the product line; in Stage 2 firm 2 takes the same decision with full information about the actions taken for firm 1; in Stage 3 firms choose prices simultaneously and can decide whether or not drop one or more quality variants from their actual production. Two specifications of this sequential game are analysed. In the first specification firms 1 and 2 incur in the sunk cost of entry before Stage 1. In the second specification, in order to analyse the possibility of entry in an industry with an established incumbent, it is assumed that firm 1 incurs in the sunk cost of entry at Stage 1 and firm 2 at Stage 2 before choosing their products. In both specifications, the choice of niche or product line strategy depends on the degree of firm-specific differentiation, we will focus on the analysis of the second one that we consider more interesting. For small firm-specific differentiation (L) (relative to vertical differentiation ($\bar{\theta}$)) incumbent (firm 1) optimal strategy is specializing in one of the quality variants and allowing entry to occur in the other. In the limit when $L \to 0$ firms profits are zero for the quality variant they both sell, so in Stage 1 firm 1 will commit to produce only one of the quality variants, and knowing that, in Stage 2 firm 2 will

[12] Given that in this symmetric Nash equilibrium both firms produce the product line if the introduction of any new product involves any overhead cost the firms are worse off as multiproduct firms than as single product firms.

choose the other quality variant. For large firm-specific differentiation entry happens and both firms produce both quality variants. For intermediate values of firm-specific differentiation the incumbent chooses the product line as a defensive strategy even if conditional to entry both firms would be better off if the incumbent would choose a niche strategy. The incumbent is choosing the product line strategy in order to avoid product proliferation by the entrant. If the incumbent choose a niche strategy then the entrant will choose a product line strategy and the incumbent will be worse off than by having chosen a product line strategy. This strategy deters entry when the level of profits when both firms produce the product line is lower than the fixed costs of entry. Even though entry would be profitable under specialization by both firms, for the incumbent product line is a dominant strategy. Gilbert and Matutes [1993] find an exception to the general result of Judd [1985][13] about the inability of multiproduct firms to deter entry by product proliferation. In this model, when firms are able to precommit to a given product choice and the level of firm specific differentiation is sufficiently large, product proliferation is a credible strategy to deter entry.

3.4.2 A model of separate quality submarkets

Katz [1984] assumes that the purchasing decision of the consumer can be broken into two stages. First, for each firm the consumer chooses her preferred quality variant. In the second stage, after having calculated the optimal quality variant of each one the firms, the consumer chooses the firm whose optimal quality variant yields the higher surplus. Therefore, in the first stage the quality variants of a given firm compete against one another. In the second stage the products of a firm compete against the products of the other firms.

[13] Whilst, Schmalensee [1978] and Eaton and Lipsey [1979] suggested that product proliferation could be used as an strategy to deter entry, Judd [1985] shows that multiproduct firms are specially vulnerable to entry. Entry does not affect only the profits of the variant facing direct competition by the entrant but also the profits obtained by the variants neighbouring it.

In this model firms choose price and qualities simultaneously with quantities determined by consumer demand. Before analysing multiproduct competition he analyses the two polar cases of vertical product differentiation only and horizontal product differentiation only. By assuming that $r \geq 0$ and $z = 0$ in (3.19) for both the high-θ and low-θ consumers he analyses the quality and pricing decision of a multiproduct monopolist. In Appendix A we show the two main results of this analysis. First, discrimination between consumers that differ in their willingness to pay for quality leads to the monopolist providing suboptimal quality (below the social optimum) to the low-θ consumers[14]. Second, the monopolist's price-cost margins are greater for the high-quality than for the low-quality variant. The multiquality monopolist discriminates against the high-θ consumers.

In order to analyse the horizontal product differentiation case in isolation, the existence of some exogenous mechanism that allows each of the firms to prevent a given θ_j-type from consuming any other variant that the variant of quality θ_j is assumed. This assumption allows the market to be divided into two independent submarkets, one for each one of the two θ-types considered. The analysis is restricted to symmetric equilibria ($p_{1j} = p_{2j}$ and $q_{1j} = q_{2j}$ for $j = 1, 2$) and two further assumptions are made: all the θ_i-type have the same intensity of firm preference ($\theta_2 > \theta_1 \Rightarrow z_2 > z_1$); there are N_j θ_j-consumers uniformly distributed in the interval [0,L] with L=1. Given the assumption of the exogenous allocation mechanism, firms do not need to set q_1 lower than the efficient quality for low-θ consumers to discriminate between high and low θ-type consumers. Thus, qualities will be set at the efficient level in the two submarkets (q_1^e, q_2^e)[15]. The analysis of each one of these independent submarkets is identical to the

[14]In general the multiquality monopolist provides suboptimal quality to all the θ-types but the highest θ-type.

[15]For the θ_i-type consumer the efficient level of quality is the q_j^e that maximizes $\theta_j q - c(q)$ and therefore $\theta_j = c'(q_j^e)$.

analysis of the standard linear-city model of horizontal product differentiation assuming transportation costs equal to z_j. This analysis reveals that the higher the intensity of consumer's firm preference (z_j) the greater the market power of each one of the firms, competition less intense and consequently the higher the price-cost margin.

Thus, both the analysis of the price and quality setting for the multiquality monopolist and for the horizontally differentiated only submarkets suggest that firms' price-cost margins will be higher for the high-quality variant than for the low quality variant[16]. This entails that firms will be specially concerned about possible downwards switching of high-θ consumers from consumption of the high-quality variant to consumption of the low-quality variant. Katz shows that in any symmetric equilibrium this possibility of downwards switching results in firms serving qualities (q_j) that are lower or equal than the optimal levels of quality and it has two additional effects over the pattern of competition across variants. On the one hand price competition for the low-quality variant may be blunted by strong firm differentiation in the high-quality variant. If prices (p_1, p_2) and efficient qualities (q_1^e, q_2^e) that result in the equilibrium of the model with an exogenous types-allocation mechanism violate the quality discrimination requirements needed in absence of this exogenous mechanism and it is not true that the high-θ do not prefer the low-quality good, then firms to prevent switching must either increase the surplus that the high-θ consumers obtain from the high-quality variant or decrease the surplus that they obtain from the consumption of the low-quality variant. As reducing the price of the high-quality variant would reduce the profits of the variant, firms will opt for increasing the price of the low-quality variant. Therefore, it is likely that competition between product line firms engaged in quality discrimination will be softer than between single product firms. The result is that price-cost margins for the

[16] This result contrast with the equal price-cost margin result obtained in Gilbert and Matutes [1993] presented before.

low-quality variant will be higher when firms engaged in quality discrimination than when there exists an exogenous allocative mechanism that makes it unnecessary[17].

On the other hand if the low-quality segment of the market is sufficiently large, firms will compete for sales in this segment even though this competition may involve a reduction of the prices for the high quality variants. The presence of low-θ consumers confers a positive externality to high-θ consumers.

3.4.3 A model with heterogeneous brand-preferences and quality determined horizontal differentiation

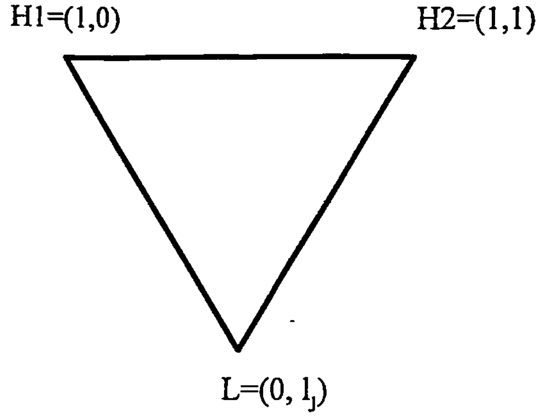
Canoy and Peitz [1997] propose a differentiation triangle to analyse the trade-off between strategic (nature of resulting price competition and possibilities of entry deterrence) and cost factors to explain firms' product choice between niche and product line strategies. They assume that variants are positioned in the corner points of a symmetric triangle and that firms $i = 1, 2, 3$ can choose their product from the following product set $V_i = \{0, (L_i), (H_i), (L_i, H_i)\}$. In order to limit the first-mover advantage of incumbent 1 it is assumed that firms cannot produce the two high-quality variants.

As in Gilbert and Matutes [1993] they set the quality of low-quality variants equal to 0 and the quality of the high-quality variant equal to 1. However, whereas in Gilbert and Matutes [1993] the horizontal characteristic is independent of the quality level they make the horizontal characteristic depend upon the quality level by assuming that the low-quality variant cannot be horizontally differentiated from any other variant of the same quality. Each one of the variants is described by two numbers $q_j, l_j \in [0, 1]$ and so variant L is described as $(0,l_j)$, H_1 as $(1, 0)$ and H_2 as $(1,1)$.

With respect to the customers, they assume the willingness to pay for quality (θ) to be uniformly distributed in the interval $[0, 1]$ and that customers with willingness

[17] The presence of high-θ consumers may be a negative externality for low-θ consumers because the surplus they obtained from the consumption of the low-quality variant can result reduced.

Figure 3.1: The Differentiation Triangle



to pay for quality θ are uniformly distributed in the interval $[0, 1]$. As in Katz [1984], they assume that intensity of consumer's firm preference (z) is increasing in θ and so they make $z = \theta q_j$ in (3.19).

They propose a sequential game similar to the three-stage sequential game proposed by Gilbert and Matutes [1993] in which an additional intermediate stage is added to allow for the possibility of entry of a third firm. In Stage 1, incumbent 1 develops $\{L\}$, $\{H_1\}$, $\{L, H_1\}$, or $\{0\}$ and incurs in the associated fixed costs; in Stage 2, incumbent 2 develops $\{L\}$, $\{H_2\}$, $\{L, H_2\}$, or $\{0\}$ and incurs the associated fixed costs; in Stage 3 the potential entrant (firm 3) develops $\{L\}$, $\{H_1\}, \{H_2\}, \{L, H_1\}, \{L, H_2\}$ or $\{0\}$ and incurs the associated fixed costs; finally at Stage 4, firms set prices simultaneously (at this stage fixed costs are sunk).

In the model, for a particular combination p_L, p_{H1}, p_{H2} such that all market shares are positive, only customers of one particular type are indifferent between the three variants that are offered. Therefore, by identifying the conditions characterising the customer type that is indifferent between any two variants it is possible to calculate the market shares that correspond to each one of the variants.

Canoy and Peitz follow two steps to find the perfect equilibrium in the game. In the first they show that only four scenarios such that all corner points are occupied are candidate to subgame perfect equilibrium and using numerical methods calculate the prices, market shares and profits before deduction of fixed costs that correspond to each one of them. In the second step, assuming that fixed costs are sufficiently small for all the corners to be occupied in equilibrium, they show that there exists a unique subgame perfect equilibrium that is characterised by a scenario and associated price equilibrium. Which of the scenarios constitute the equilibrium depends on the interaction between costs (economies of scope) and strategic (pricing and product choice as an entry deterrence instrument) factors. In order to understand this interaction they distinguish between the motivations of each one of the firms to develop a product line or niche strategy. On the one hand, incumbent 1 will choose to produce the vertical product line or a single variant with basis on the costs structure (the first mover advantage allows to guarantee himself profits at least as high as the profits of incumbent 2). Therefore, if economies of scale are very strong incumbent 1 will choose the product line. If the production of the low-quality variant is very favorable the incumbent 1 chooses a niche strategy producing only the low-quality variant and the resulting market structure is a three-firms oligopoly. Otherwise, incumbent 1 follows a niche strategy with the high-quality variant. On the other hand, the choice of incumbent 2 is restricted by the choice of the incumbent 1. If incumbent 1 develops the product line, incumbent 2 choose the only option in the market and choose a high-quality niche. However, if incumbent 1 chooses a high-quality niche strategy, incumbent 2 will choose between niche and product line strategies with basis in entry deterrence principles (whereas brand proliferation is an entry deterrence strategy for incumbent 2 it is not for incumbent 1). With respect the predictions about prices, they show that the firm producing the vertical product line sets a higher price for its high-quality variant

Table 3.1: Summary I

	Framework		
Firms/ Variants	Two Firms LQ(q_1)/HQ(q_2)		
Relevant Parameters	θ: willingness to pay for quality z : strength of brand preference L : firm (horizontal) differentiation $\bar{\theta}$: maximum willigness to pay for quality		
	Katz [1984]	Gilbert and Matutes [1993]	Canoy and Peitz [1997]
Assumptions about distribution of θ	Two θ-types$\rightarrow$ (θ_2, θ_1) $\theta_2 > \theta_1$	θ uniformly distributed [0,$\bar{\theta}$]	[0,1]
Assump. brand preferences Horizontal characteristic	$\theta_2 > \theta_1 \rightarrow z_2 > z_1$ Independent of quality	$z = 1$ for all θ Independent of quality	z=θq_i Depends upon quality
	Vertical Product Diff. Only	One stage price setting game	Sequential Game
Results	- $m_1 > m_2$ (m: price cost margin) - $q_2 = q_2^e$ and $q_1 < q_1^e$ Horizontal Product Diff. Only	Two firms produce the product line $m_1 = m_2$ Sequential Game	* Incumbent 1 (I1) product line decision based on cost structure: - Strong economies of scope$\rightarrow$ product line - Very favorable L_1 $\rightarrow$resulting market structure: three firms oligopoly - Otherwise$\rightarrow$ H_1 * Incumbent 2 product line decision: importance of strategic motives - If I1 product line$\rightarrow$ H_2 - If I1 H_1 then niche or product line on the basis of entry deterrance principles * Price of the H is higher for the firm that developes the product line
	- $m_1 > m_2$ $\downarrow$ $\downarrow$ Combining: - $m_1 > m_2$ - $q_2 = q_2^e$ and $q_1 < q_1^e$	- small L/θ $\rightarrow$incumbent niche and entrant niche - large $L/\bar{\theta}$ $\rightarrow$incumbent product line and entrant product line - intermediate $L/\bar{\theta}$ $\rightarrow$ incumbent product line strategy to deter entry (pre-emption strategy)	

than the firm that follows a niche strategy. The reason is that in this way a firm try to relax competition between the two quality variants produced.

3.5 Discrete choice models of product differentiation

From Bresnahan [1987][18] a main stream in the empirical analysis of oligopoly models with product differentiation has been the joint analysis of a demand function and a supply relationship using discrete-choice models of product differentiation[19]. Major works in this area are Berry [1994] that establish the theoretical benchmark for the treatment of not observed product characteristics and Berry, Levinsohn and Pakes [1995a][20] that carries out an equilibrium analysis of the automobile industry in the US. In this paper, BLP empirically implement the theoretical framework proposed by Berry [1994] when carrying out the joint estimations of demand and supply relationships. Hence, we devote this section to the analysis of the framework proposed by Berry [1994] with some references to BLP.

3.5.1 A benchmark for the estimation of discrete choice models of product differentiation

On the basis of Berry [1994] in this section we carry out a brief description of the models used in the empirical analysis of discrete choice models of product differentiation. The objective of these models is the joint estimation of supply and demand equations in markets with product differentiation. With respect to the general framework of these models: on the demand side, consumers' utility depends both on product characteristics

[18] Whereas most of the analysis using dicrete-choice models of product differentiation are *non-address* models (all the products are in competition with all others), Bresnahan [1997] that uses a discrete-choice model with vertically differentiated products is an *address* model (each product compete just with its neighbours).

[19] For an extensive revision of the discrete-choice models of product differentiation Anderson, de Palma and Thisse [1992].

[20] From now on this paper will be referred as BLP.

and on consumers characteristics and demand of each product is obtained as the result of the aggregation over all the consumers that prefer this product to all the other products; on the supply side, firms are modelled as price setting oligopolists and the existence of a Nash equilibrium in prices is assumed. The characteristics of the products are taken as given.

We start our analysis by the demand side of the problem. The utility of consumer i for product j depends both on a vector of unobserved (by the econometrician) individual characteristics (v_i) and on a vector of characteristics of the product,

$$u_{ij} = U(x_j, \xi_j, p_j, v_i; \theta)$$

where p_j is the price of the product j, x_j is the vector of observed product characteristics, ξ_j is a vector of unobserved (by the econometrician) product characteristics, and θ is the vector of parameters determining the distribution of consumer characteristics.

Let us assume that this utility function is additively separable in a term (δ_j) that depends exclusively of the characteristics of the products and in an individual specific term (v_{ij}) that for the moment, we consider as resulting from the interaction of consumer and product characteristics,

$$u_{ij} = \delta_j(x_j, p_j, \xi_j) + v_{ij} \qquad \text{for } j = 0, 1, ..., J \tag{3.20}$$

$j = 1, ..., J$ represent the purchase of competing differentiated products, and $j = 0$ the outside option, i.e. the consumer does not purchase any of the products available in the market. The term δ_j can be interpreted as the mean utility that consumers obtain from the purchase of product j. Furthermore, if we assume a linear specification for δ_j, we can express the mean utility level for product j as:

$$\delta_j = x_j\beta - \alpha p_j + \xi_j \tag{3.21}$$

Each consumer purchases one unit of the good that gives him the higher utility, $\{u_{ij} \geq u_{ir}$ for $j = 0, 1, ...r\}$. If we define the set of unobservable taste parameters, v_{ij}, that result in the purchase of product j as $A_j(\delta) = \{v_i/\delta_j + v_{ij} > \delta_r + v_{ir}; \forall r \neq j\}$, the market share of firm j is given by the probability that v_i falls into the region A_j. Given the distribution of consumer preferences over the product characteristics, $F(\cdot)$, the discrete choice market share of product j is[21]:

$$s_j(\delta(x, p, \xi), x; \theta) = \int_{A_j(\delta)} f(v, x)\, dv \tag{3.22}$$

If the number of consumers in the market is equal to M, the demand of product j is given by:

$$q_j = M s_j(x, \xi, p; \theta)$$

Let us consider the following demand equation relating observed market shares (S_j) to the market shares predicted by the model (s_j),

$$S_j = s_j(x, p, \xi; \theta) \tag{3.23}$$

Unobservable product characteristics are expected to be correlated with prices and this makes price endogenous. The traditional solution to the problem of endogenous prices (when prices and unobserved characteristics enter in a linear fashion in the demand equation) is the use of instrumental variables. However, from (3.22) is possible to observe that unobserved product characteristics enter (3.23) in a non-linear fashion what prevents the application of this approach. Berry [1994] solves this problem by using a transformation so that market shares are linear in unobserved product characteristics. Just for a matter of simplicity, let us start assuming that the distribution of consumer

[21] In other words, the discrete-choice model market share for product j can be calculated as the probability of purchase of product j given the distribution of consumer preferences over the product characteristics.

unobservables (v_{ij}) is known (by the econometrician) so market shares depend only on mean utility levels

$$S_j = s_j(\delta) \qquad \text{for } j = 1, ..., n \tag{3.24}$$

Using the fact that at the true values of δ the above equation must hold exactly, if it is possible to obtain closed form solution for the integral in (3.22) we can invert (3.24) to obtain the vector $\delta = s^{-1}(S)$. Thus, the vector of mean utility levels is uniquely determined by the vector of observed market shares. From (3.21), at the true values of the parameters (β, α) the demand equation is

$$\delta_j(S) = x_j\beta - \alpha p_j + \xi_j \tag{3.25}$$

If in (3.25) we consider ξ_j as an unobserved error term, we can obtain the unknown parameters (β, α) by instrumental variable regression of $\delta_j(S)$ on (x_j, p_j).

An alternative to assume that the distribution of consumer unobservables is known is to assume that the density of v_{ij} is unknown and depends on a vector of unknown parameters (σ) to be estimated. With this assumption, the market share function and the implied mean utility levels depend also on σ, $S = s(\delta, \sigma)$. As above, inverting this last equation we can obtain the demand equation as

$$\delta(S, \sigma) = x_j\beta - \alpha p_j + \xi_j$$

We can still make use of instrumental variables to estimate the above equation. Now, we have an additional parameter to estimate, σ.

Different assumptions about the consumers' preferences lead to different specification of the utility function and as a consequence to different demand specifications and patterns of substitution. The simplest one is the assumption of homogeneous preferences across consumers. Under this assumption the utility function (3.20) takes the form

$$u_{ij} = x_j\beta - \alpha p_j + \xi_j + \varepsilon_{ij}$$

where ξ_j can be understood as the mean of consumer's valuation of an unobserved product characteristic and ε_{ij} that represents the distribution of consumer preferences about this mean is assumed to be independently and identically distributed across consumer and products with zero mean. Furthermore, if we assume that ε_{ij} follows a extreme value distribution and normalize the utility of the outside good to zero, the probability of purchase of product j (market share of the product j) is

$$s_j(\delta) = \frac{e^{\delta_j}}{1 + \sum_{j=1}^{n} e^{\delta_j}} \qquad \text{for all } j = 0, 1, ...n \tag{3.26}$$

and from (3.26) we can obtain the following linear model in price and product characteristics[22]

$$\ln(S_j) - \ln(S_0) = \delta = x_j\beta - \alpha p_j + \xi_j \tag{3.27}$$

Therefore, if we consider ξ_j as an error term we can estimate by instrumental variables the structural form demand parameters (β, α).

The main problem with this simple logit specification is that it does not allow the interaction of consumer and product characteristics. Products are just differentiated by mean utility levels (δ_j) and so, market shares and own and cross price elasticities are determined exclusively by them. The result is unreasonable patterns of substitution: in the logit model substitution effects are the same independently of the degree of similarity between product characteristics[23].

[22] The transformation requires to weight for the outside option and to take logs.

[23] In the logit model the general expresion for the cross price elasticity is given by $\eta_{jr} = \frac{ds_j}{dp_r}\frac{p_r}{s_j} =$

A possible solution to the problems shown by the logit model is to remove our assumption of homogeneous consumer preferences and allow for heterogeneous consumer preferences. In discrete-choice models, we can generate heterogeneous preferences by interacting consumer and product characteristics. A first possibility is the use of nested logit models that although in a restricted way allow consumer tastes to be correlated across products. In the nested logit models, prior to the estimation products are grouped in sets of products of similar characteristics and it is imposed a higher correlation for the products within the same set than for product belonging to different sets[24]. Thus, the utility of consumer i from buying product j that belongs to group g is:

$$u_{ij} = \delta_j + \zeta_{ig} + (1-\sigma)\epsilon_{ij} \tag{3.28}$$

For consumer i , the variable ζ is common to all products in g and has a distribution that depends on σ. The parameter σ $(0 \leq \sigma < 1)$ can be interpreted as a substitution parameter. The perturbations (ϵ_{ij}) that (as in the logit model) follows a maximum value distribution are assumed correlated for products belonging to the same set but uncorrelated for products belonging to different sets. In this nested logit model the probability of purchase of product j (market share of good j) is given by:

$$s_j(\delta,\sigma) = \frac{e^{\frac{\delta_j}{1-\sigma}}}{D_g^{\sigma}\left[\sum_g D_g^{(1-\sigma)}\right]} \qquad D_g = \sum_{j \in J_g} e^{\frac{\delta_j}{1-\sigma}} \tag{3.29}$$

This market share of product j $(j \in J_g)$ can be expressed as the product of the share of product j within group g (conditioned share) and the share of group (g) over the total of products (marginal share), i.e.

$\alpha p_r s_r$, and so a change in the price of the Ford Fiesta will have the same effect over the market shares of the Ford Scorpio and Fiat Punto.

[24] $G+1$ exhaustive and mutually exclusive sets, $g = 0, 1, ...G$. The outside good is assumed to be the only product in group 0.

$$s_j = \bar{s}_{j/g} \cdot \bar{s}_g \tag{3.30}$$

where:

$$\bar{s}_{j/g}(\delta, \sigma) = \frac{e^{\frac{\delta_j}{1-\sigma}}}{D_g} \qquad \text{for } j \in g \tag{3.31}$$

$$\bar{s}_g(\delta, \sigma) = \frac{D_g^{(1-\sigma)}}{\left[\sum_g D_g^{(1-\sigma)}\right]} \qquad \text{for } g = 0, 1, ..., G \tag{3.32}$$

If we normalize the mean utility level the outside good to zero, then $D_0 = 1$ and

$$s_0(\delta, \sigma) = \frac{1}{\sum_g D_g^{(1-\sigma)}} \tag{3.33}$$

Using (3.31), (3.32) and (3.33), and after rearranging (3.30), we can obtain the linear model used for the estimation of the parameters of the model (β, α, σ).

$$\ln(S_j) - \ln(S_0) = x_j\beta - \alpha p_j + \sigma \ln\left(\bar{S}_{j/g}\right) + \xi_j \tag{3.34}$$

The estimating equation of the nested logit includes an endogenous extra term on the market share of the model with respect to the group of products to which model j belongs. Estimation of the parameters (α, β, σ) can by obtained by linear instrumental variables regression.

In contrast to the simple logit model, the nested logit model generates reasonable patterns of substitution. Cross price elasticities between products belonging to the same set (with similar characteristics) are greater than between products belonging to different sets (with more heterogeneous characteristics).

If we think of quality as the criterion used to group the products, the parallelism between the nested logit model and the models of vertical-horizontal product differentiation presented in the previous sections are obvious. Those models could be thought as nested logit models with two groups: a low and high-quality group.

The main limitation of the nested logit is that correlation patterns between products and consumer characteristics depend on grouping of products carried out previously to the estimation and therefore it is imposing some a priori patterns of substitution. The random coefficients model proposed by BLP that allows for full interaction between consumer and product characteristics solves this problem and obtains sensible patterns of substitution at the cost of a substantial complication in the calculation of the market share equation (3.22). In their model the vector of consumer taste parameters, β, for observed characteristic k is model as:

$$\beta_{ik} = \beta_k + \sigma_k \zeta_{ik} \qquad \text{for } k = 1, ..., K \tag{3.35}$$

where β_k is the mean of the taste parameter for characteristic k and ζ_{ik} is assumed to have an identically and independently distributed standard normal distribution.. Thus, the utility function can be expressed as:

$$u_{ij} = x_j \beta - \alpha p_j + \xi_j + v_{ij} = \delta_j + v_{ij} \tag{3.36}$$

and $v_{ij} = \sum_{k=1}^{K} \sigma_k x_{jk} \zeta_{ik} + \epsilon_{ij}$ with ϵ_{ij} independently and identically distributed across consumers and products.

The main drawback of the random coefficient models is that the market share equation (3.22) is difficult to calculate and usually it is necessary to use simulation procedures.

Until now we have considered just the analysis of the demand-side of the economy, therefore the next step will be to consider the supply side of the economy. Let us consider a market with N firms each one of them producing just one product. In order to simplify, we can assume that fixed cost are equal to zero, and that marginal costs are independent of output levels and linear in a vector of cost characteristics. Furthermore it is assumed that costs characteristics can be decomposed in observed product characteristics (w_j) and unobserved (by the econometrician) product characteristics (ω_j)[25]. Given these assumptions the cost function takes the following form

$$c_j = w_j\gamma + \omega_j \tag{3.37}$$

and profits of firm j are

$$\Pi_j = (p_j - c_j)Ms_j(x, p, \xi; \theta) \tag{3.38}$$

If following Caplin and Nalebuff [1991] it is assumed that a pure strategy Nash equilibrium exist for this pricing game, the price set by firm j must satisfy the following first order condition

$$[p_j - c_j]\left[\frac{\partial s_j(x, p, \xi; \theta)}{\partial p_j}\right] + s_j(x, p, \xi; \theta) = 0$$

that after rearranging can be expressed as:

$$p_j = c_j + \frac{s_j}{|\partial s_j/\partial p_j|} = w_j\gamma + \frac{s_j}{|\partial s_j/\partial p_j|} + \omega_j \tag{3.39}$$

From (3.21) and (3.22), $\partial s_j/\partial p_j = -\alpha\partial s_j/\partial\delta_j$, and so (3.39) can be rewritten as a function of $\partial s_j/\partial\delta_j$. Given the vector δ obtained from the inverse market share function, $\delta = s^{-1}(S)$, it is possible to obtain $\partial s_j/\partial\delta_j$ by analytical or numerical differentiation of the market share evaluated at the adequate value of δ. Therefore, δ_j and $\partial s_j/\partial\delta_j$ can be treated as known transformations of the data and (3.39) can be rewritten as,

[25] In general it is expected x_j to be part of w_j and ξ_j to be correlated with ω_j.

$$p_j = w_j\gamma + \frac{1}{\alpha}\left[S_j/(\partial s_j/\partial\delta_j)\right] + \omega_j \tag{3.40}$$

We can now study the pricing equation (3.40) for the three models considered above: logit, nested logit and random coefficients model. For the logit model, from (3.26) $\partial s_j/\partial\delta_j = S_j(1-S_j)$ and so using (3.40) the pricing equation for the logit model is given by

$$p_j = w_j\gamma + \frac{1}{\alpha}\left(\frac{1}{(1-S_j)}\right) + \omega_j \tag{3.41}$$

where the parameters to estimate are (γ, α). The logit joint estimation problem is given by (3.27) and (3.41).

For the nested logit model, from (3.29)

$$\frac{\partial s_j}{\partial\delta_j} = \frac{1}{(1-\sigma)}S_j[1-\sigma\bar{S}_{j/g}-(1-\sigma)S_j]$$

and so using the pricing equation, the estimation equation for the nested logit model is given by

$$p_j = w_j\gamma + \left[\frac{(1-\sigma)}{\alpha}\Big/\left[1-\sigma\bar{S}_{j/g}-(1-\sigma)S_j\right]\right] + \omega_j \tag{3.42}$$

where the parameters to estimate are α, γ, σ. Therefore, the estimating equations for the joint nested logit estimation are given by (3.34) and (3.42).

Whereas, both for the logit and the nested logit specifications with an analytical solution for δ_j there exists also an analytical solution for $\partial s_j/\partial\delta_j$, for the full random effects model it is needed the use of numerical differentiation[26].

[26]For an extension of the supply equation to the case of multiproduct firms see BLP.

Table 3.2: Summary II

	Logit	Nested Logit	Full Random Coefficien
Consumer Preferences	Homogeneous	Heterogeneous	Heterogeneous
Advantages	Simplicity of estimation	Reasonable patterns of substitution	Reasonable Patterns of substitution
Inconvenients	Unreasonable patterns of substitution	Patterns of substitution determined by a priori grouping	No analytical solution for the market share function

3.6 Concluding Remarks: Learning from the empirical results

The main shortcoming of the discrete choice models described is that they take as starting point a equilibrium situation without considering product range decisions explaining this equilibrium. Keeping it in mind, the aim of this section is to use the empirical results obtained in recent empirical work to suggest the direction that future theoretical modelling on competition in markets in which products are differentiated both vertically and horizontally should follow. For their relevance in the recent empirical work, we will focus our attention on the results obtained when analysing the car market. The car industry is a good example of a market in which horizontally differentiated variants of a given quality compete with horizontally differentiated variants of the same quality and with variants of another quality.The most important application of discrete choice models of product differentiation to the car market is BLP. BLP in their study of the US automobile market propose a model with heterogeneous consumer preferences using a full random coefficients model to interact consumer and products characteristics. Goldberg [1995], also for the US automobile market, uses nested logit models to capture consumer sequential choice characterising the car purchase decision. Her analysis focuses on the study of the effects of a voluntary export restraint and exchange rate pass-through. Verboven [1996] uses a two-level nested logit model to study the causes of international price discrimination in the European automobile market. First cars are grouped by segments and then by country of origin with the aim of explicitly modelling the national segmentation of the European automobile market[27]. Common results of these three papers relevant for our aim are:

1. own price elasticities are decreasing with quality
2. cross price elasticities are decreasing with quality
3. mark-ups are increasing in quality

One possible explanation for the observed quality-dependence of price elasticities and mark-ups is that in general customers' preference for diversity is more intense for the high than for the low quality products, i.e. whereas the purchasing decision of a consumer buying the low-quality variant will be mainly determined by the price, the horizontal characteristics of the variant play a relevant role to determine the purchasing decision of a consumer buying the high–quality variant. Hence, the possibilities of horizontal product differentiation will be directly related with quality.

It would be desirable that the theoretical models described in section 3.4 (in which variants are both vertically and horizontally differentiated) would incorporate these features with the aim of generating results matching with the observed facts.

Let us consider a model with two firms that produce two variants of a good: a high and a low quality variant. The quality of the high and the low quality variants are the same in the two firms. The horizontal characteristic of the variant is given by the firm selling it. Likely, the easiest way of catching the relationship between horizontal product differentiation and quality is to assume that variants are located in the four

[27] Other applications of discrete choice models of product differentiation are: Barry, Levinsohn and Pakes [1995b] study of the effect of a voluntary export restraints placed on exports of automobiles from Japan to the US (May,1991) over the US automobile industry and welfare; Berry, Grilli and Lopez de Silanes [1992] analysis of the possible effect on the automobile industry of a free trade agreement between Mexico and the US; Berry, Spiller and Carnall [1996] analysis airline competition

corners of a trapezoid. The low-quality variants would be located in the corners of the short side and the high-quality variants in the corners of the long side. Among the three papers reviewed in section 3.4, only Canoy and Peitz [1997] considers this possibility. However, they take this possibility to the limit: it is assumed that the low quality variant cannot be horizontally differentiated of a variant of the same quality and so that only one firm can produce the low quality variant in equilibrium. Although, this assumption probably simplifies the analysis, it prevents to carry out predictions about cross price elasticities within the low quality variant.

A possible way of including in the model that consumers' preference for diversity is increasing in consumers' willingness to pay for quality (θ) is to make the parameter representing consumers' intensity of firm preference (z) depend on consumers' willingness to pay for quality such as in Katz [1988] and Canoy and Peitz [1997]. Katz that considers a discrete distribution for θ establish a one to one relationship between θ and z; i.e. if $\theta_2 > \theta_1$ then $z_2 > z_1$. This assumption contributes in his model to generate lower price elasticities and higher mark-ups for the high-quality variant. However, the main problem of Katz [1988] is that assumes that there are as many products as consumer types and actually the products are less than consumer types. Canoy and Peitz [1997] solve this problem assuming a continuous distribution of consumer types and making z an increasing function of θ. Gilbert and Matutes [1994] locate the low-quality variants at the same horizontal distance that the high-quality variants and assume a constant z that does not vary with θ. The result of these assumptions is that in the symmetric equilibrium mark-ups are independent of quality.

Therefore, it seems that of the three models considered in section 3.4, the more realistic one is Canoy and Peitz [1997]. However, the introduction of the elements described before complicates the model and closed form solutions cannot be worked out; the authors have to use numerical methods to solve the problem.

In this PhD dissertation we do not try to develop a theoretical model including three quality variants with different possibilities of horizontal product differentiation. The reason is that we believe that most of the framework of Canoy and Peitz [1997] match with our ideas about the modelling of multiproduct competition in presence of product differentiation.

Along the next four chapters of this PhD dissertation we will empirically analyse using a sample of prices, the pricing decisions of supermarkets selling three quality variants. These variants are differentiated both vertically and horizontally. The vertical dimension is given by the different quality of the three variants sold by each supermarket. The horizontal dimension is given by the characteristics of the supermarket selling the variants. Furthermore, as in the models described above in our empirical investigation of the multiquality supermarkets pricing decision we consider that a variant of a given quality sold by a supermarket competes both with variants of the same quality sold at other supermarkets and with variants of different quality sold at the same and other supermarkets.

We carry out this analysis using a sample of product prices that was directly taken in three adjacent supermarkets in the south of Coventry. The ideal framework to model empirically multiquality supermarkets competition would be the discrete choice models of product differentiation as described in the former section. However, the unavailability of data about quantities prevents this approach. The absence of data about quantities also prevents to test the models of vertical-horizontal product differentiation described in section 3.4. Therefore, in the next Chapters, we will use our price data to empirically analyse the implications of:

1. supermarket multiproduct nature

2. different possibilities of horizontal product differentiation for each one of the quality variants

   over supermarket price setting

Whenever it is possible along the next chapters we will describe the implications of the vertical and horizontal characteristics of our products over the patterns of supermarkets price competition using as benchmark the models described here.

3.7 Appendix

A: The monopolist price-quality decision

In this Appendix we solve analytically the efficient and multiproduct monopolist price-quality problems for the case of a vertical product differentiation only model as the one described by Katz [1984]

Let us assume that each consumer buys one unit of the variant and none of the others. His indirect utility function is given by :

$$v_j = \theta_j q_j - p_j \text{ for } j = 0, 1, ...n$$

where $q_j = 0 = p_j$ denotes the outside option.

As in Katz [1984], it is assumed a discrete distribution for consumer willingness to pay for quality: there are only two types of consumers with willingness to pay for quality, θ_1 and θ_2, with $\theta_2 > \theta_1$. Let N_j denote the number of consumer with willingness to pay for quality θ_j. It is also assumed that firms offer only two products q_1 and q_2, with $q_2 > q_1$.

In order to capture the idea of marginal cost increasing with quality, the marginal cost of producing a good of quality q_j is $C(q_j) = \alpha q_j^2$. This is the simplest specification capturing the idea of marginal costs increasing with quality[28].

Efficient Solution

The efficient quality for the θ_j-consumer is the quality that maximizes the total surplus from serving her, i.e. the quality that maximizes the difference between her willingness to pay for quality, $\theta_j q$, and the marginal cost of providing this quality, $c(q) = \alpha q^2$. (TS=CS+PS; CS=$\theta_j q - p_j$; $PS = p_j - c(q)$; $TS = \theta_j q - c(q)$). Therefore, it is the quality that maximize consumer θ_j surplus under marginal-cost pricing.

[28]This quadratic specification of the marginal costs is also used in Moorthy [1988].

The efficient qualities in an industry with two products are given by the solution to

$$\max_{q1,q2} \sum_{j=1}^{2} [N_j(\theta_j q_j - \alpha q_j^2)]$$

These efficient qualities are $q_j^e = \frac{\theta_j}{2\alpha}$ and the associated prices $p_j^e = \frac{\theta_j^2}{4\alpha}$. Another interesting characteristic of the efficient solution is that consumer surplus is greater for the θ_2-consumers ($CS_2 = \frac{1}{4}\frac{\theta_2^2}{\alpha}$) than for the θ_1-consumers ($CS_1 = \frac{1}{4}\frac{\theta_1^2}{\alpha}$), i.e. consumer surplus increase with willingness to pay for quality.

Monopolist Solution

Let us consider the price and quality decisions of a monopolist producing the two quality variants. The monopolist would like to charge to any consumer its reservation price but it cannot observe the willingness to pay for quality of any given consumer directly. In order to induce to the θ_1-type consumer to buy the quality variant q_1 and to the θ_2-type consumers to buy the quality variant q_2, the monopolist must set prices p_1 and p_2 satisfying the following conditions:

$$\theta_1 q_1 - p_1 = 0$$

$$\theta_2 q_2 - p_2 = \theta_2 q_1 - p_1$$

Therefore, the optimum quality choices for the multiproduct monopolist (q_1^m, q_2^m) are given by the solution to

$$\begin{array}{ll} \max_{q_1,q_2} \prod_m = N_1 (p_1 - \alpha q_1^2) + N_2 (p_2 - \alpha q_2^2) \\ s.t. \quad p_1 = \theta_1 q_1 \\ \qquad p_2 = \theta_2 (q_2 - q_1) + \theta_1 q_1 \end{array}$$

These optimum quality choices are $q_1^m = \frac{\theta_1}{2\alpha} - \frac{N_2(\theta_2 - \theta_1)}{2N_1\alpha}$ and $q_2^m = \frac{\theta_2}{2\alpha}$. Whereas the monopolist serves to the θ_2-type consumers with their efficient quality, the quality served to the θ_1-consumers is lower than the efficient one $\left(q_1^e = \frac{\theta_1}{2\alpha}\right)$. Equally, it is possible to prove that when the multiproduct monopolist produce n quality variant to serve n consumer types, it provides to all consumer types except the highest one with qualities lower than the efficient ones.

The prices that maximize profits of the multiproduct monopolist serving qualities q_1^m and q_2^m are

$$p_1^m = \frac{\theta_1(N_1\theta_1 + N_2(\theta_2 - \theta_1))}{2\alpha N_1}$$
$$p_2^m = \frac{1}{2\alpha N_1}\left[(N_1 + N_2)(\theta_2 - \theta_1)^2 - N_1 N_2 \theta_1\right]$$

The price-cost margins for each one of the quality variants are

$$\begin{aligned} PCM_1 &= p_1 - \alpha s_1^2 = \frac{1}{4\alpha N_1^2}\left[N_1^2\theta_1^2 - N_2^2(\theta_2 - \theta)_1\right] \\ PCM_2 &= p_2 - \alpha s_2^2 = \frac{1}{4\alpha N_1}\left[(N_1 + 2N_2)(\theta_2 - \theta_1)^2 + N_1\theta_1^2\right] \end{aligned}$$

and $d = PCM_2 - PCM_1 = \frac{1}{4\alpha N_1^2}(\theta_1 - \theta_2)^2 (N_1 + N_2)^2 > 0$. Therefore, the multiproduct monopolist obtains a higher price-cost margin for the high quality variant than for the low quality one. This is a consequence of the fact that higher quality variants serve higher quality types, and higher quality types (as we saw above) bring with them higher consumer surplus (see Moorthy, 1988).

Chapter 4

Price Competition and Price Dispersion in the UK Supermarkets[1]

Abstract

This chapter investigates using micro level price data the determinants of the differences in price dispersion and intensity of price competition across the three quality variants sold at the UK supermarkets: branded products, high quality own brand products and low quality own brand products. The results of the analysis confirm that intensity of price competition is greater for those quality variants with less possibilities of horizontal product differentiation: branded products and low quality own brand products. Therefore, we explore the role played by the High Quality Own Brand Products to explain the coexistence of tight between-supermarkets competition (as claimed by the supermarket managers) with high levels of profits.

4.1 Introduction

There has been in the recent years a recognition of the important economic implications of the own brand product phenomenon. Although, the own brand products (OBP) initially appeared in the supermarkets as a cheap alternative to the branded products (BP), in the UK the natural evolution of these original own brand products lead to

[1] I would like to thank to Jordi Jamandreu and seminar participants at the University of Warwick-Workshop of Industrial Economics, 24th EARIE Congress (Leuven) and XIII Jornadas of Economia Industrial for helpful coments. A preliminar version of this paper was awarded with the Young Economists' Essay Competition prize in the 24th EARIE Congress.

products of similar quality to the branded products with a slight price discount, that we will call high-quality own brand products (HQ). From the middle of the nineties and as a reaction to the arrival in the UK of the discounter formula, the supermarkets introduced a second own brand product variant, the low-quality own brand products (LQ). The importance of the own brand product variants in the UK supermarkets sales increases year after year and at the moment they represent no less than 36% of the supermarkets sales (the highest own brand product share in the EU).

The purpose of this chapter is to carry out a preliminary empirical approach to our data and investigate price dispersion and price competition among UK supermarkets chains with the novel feature of considering the supermarket as a multiquality firm. In this chapter we define price dispersion and price coordination indexes and analyse the causes of their differences across quality variants. However, it is in Chapter 5 that we present an econometric model of price competition between multiquality supermarkets.

We argue that the utility obtained by consuming a given product does not depends only on the quality variant but also on the supermarket in which the product is purchased[2]. This difference is explained by the characteristics of the product that are intrinsic to the supermarket in which it is sold. It is in this framework that we study between-supermarket differences in the degree of price dispersion and price competition across quality variants. As regards price dispersion we are interested in discriminating between cost-side and demand-side factors[3] as possible sources of the differences in the degree of between-supermarket price dispersion observed across quality variants. With respect to price competition we are interested in analysing the relationship between the possibilities of supermarket product differentiation and intensity of between-supermarket price competition across quality variants.

[2]Dobson and Waterson [1996] in a theoretical paper take a similar approach with two product variants and two firms, but they consider two products of the same quality.

[3]Possible differences in cross and own brand price elasticities across supermarkets.

Additionally, we also explore the role played by the own brand products to explain an important paradox in the UK food retailing system: while the managers of the supermarkets usually claim the existence of a tight price competition across supermarkets, the profits of the UK supermarkets are the highest in the EU [The Economist, 1995].

Particular novel features of this chapter include (i) consideration of the supermarket as a multiproduct-multiquality retailer, (ii) use of a micro level data set of prices directly taken in three superstores in the south of Coventry that correspond to three of the four supermarket chains with largest market share in the UK (Tesco, Sainsbury and Safeway) and (iii) use of non-parametric tests for all the statistical analysis to avoid possible problems that can arise if the samples do not satisfy the distributional assumptions of the parametric tests[4].

The results of the empirical analysis suggest that whereas differences in the degree of between-supermarket price dispersion across quality variants are cost driven, between-supermarket price competition is less intense for the quality variant with greater possibilities of supermarket product differentiation, the HQ. The joint consideration of this last result and the fact that the market share of the HQs in the UK is greater than in any other EU country offers a new explanation of the higher profits of the UK supermarkets in comparison with their continental counterparts.

The chapter is organized as follows. A brief characterization of the UK retailing system is offered in section 2. Section 3 describes the data used in the analysis. Section 4 includes an analysis of between-supermarket price dispersion. Section 5 deals with the analysis of between-supermarket price competition. Finally the conclusions are presented in section 6.

[4] Even if the samples do not satisfy the distributional assumptions of the parametric tests, the non-parametric tests used here are still valid.

4.2 Brief characterization of quality variants and outlets

4.2.1 Characterization of the quality variants in a UK supermarket

As explained in Chapter 2, all the major UK supermarkets chains offer three quality variants for a big range of products: a brand product variant (BP) and two own brand products variants (OBP). These are the high quality own brand product variant (HQ) and the low quality own brand product variant (LQ).

We argue that the utility provided by the consumption of a given good does not depend only on the quality of the good but also on the supermarket providing the good. If we assume quality equivalence within quality variants across supermarkets[5], other supermarket characteristics[6] of the product are the only factor left to explain the differences in the utility obtained when consuming a product of the same quality variant at different supermarkets. These supermarkets characteristics include: level of service quality provided by the supermarket, physic characteristics of the product intrinsic to the supermarket other than quality, and location of the supermarket. Whereas the last two of these characteristics can be considered as horizontal attributes of the product, the level of service quality is definitely a vertical attribute. By service quality we understand the characteristics of the shopping environment and services provided by the supermarket when selling the products such as loyalty cards, assistance when packaging, etc. Shopping environment and services provided by the large UK supermarket chains in their superstores can be considered as homogeneous. Most of these superstores are located out of town with large parking areas. All of them offer a large

[5]For example, we assume that Tesco HQ Baked Beans are quality equivalent to Sainsbury HQ Baked beans and to Safeway HQ baked beans. When introducing the characteristics of each one of the quality variants we argue about the reasons behind this assumption.

[6]From now on, when talking about supermarkets characteristics of a product, we will refer to the characteristics of the products intrinsic to the supermarket it is sold other than quality.

range of food and non food products in a nice shopping environment and with wide opening hours. Services provided do not vary from one large chain to the other: all of them offer loyalty cards and associated discounts, accept debit and credit cards, they are involved in charities, etc. Furthermore, we should take into account that any new service provided by one of the supermarkets that successfully attracts shoppers can be quickly copied by the other supermarkets and the only final effect will be an increase in costs for all competitors and/or increase of consumer surplus [Corstjens *et al*, 1995][7]. Therefore, we should agree that for the large UK supermarket chains the possibilities of differentiating their products from those of other supermarket chains by means of service quality are limited[8]. However, we think that the supermarket can differentiate their products by means of the introduction of elements of horizontal product differentiation, and that supermarket possibilities of introducing elements of horizontal product differentiation (others than location) vary across quality variants.

The BPs are supported by intense manufacturer advertising and product development and provided with identical specifications to all the supermarkets, therefore supermarket differentiation for this quality variant is restricted to service quality and location. As we explained above, we consider the level of service as virtually homogeneous across supermarkets chains. Hence, the only possibility of supermarket differentiation for the products of the BP variant is given by the supermarket location.

As explained in Chapter 2, the quality level of HQs has been improving over the last years and now is considered very close, if not identical, to the quality of the BPs. The supermarket uses the HQs to compete against the BPs for those consumers located in the upper and medium segment of the consumer distribution that are willing to

[7]Example of this phenomenon in the recent times is the extension of the opening hours or the clerck assistence to pack the shopping.

[8]However, we will see in Chapter 7 that level of service quality is a key element in the differentiation between supermarkets and discounters.

exchange the brand name for a price discount.

An important consequence of the increasing importance of the HQs in the UK is that the supermarkets have de-stocked second brands. In most of the product spaces analyzed in this paper the only branded product sold at the supermarket is the brand leader. Therefore, competition within the supermarket between branded products has lost importance in favour of the competition between BPs and HQs. The HQs manufactured by own brand manufacturers[9] to the requisites of the supermarkets are the quality variant that allows for more supermarket differentiation. For the HQs the supermarkets have the possibility of introducing elements of horizontal product differentiation by means for example of advertising, taste, packaging, etc. i.e. we can find Heinz Baked Beans in all the supermarkets but Tesco Baked Beans with its particular packaging colours and taste only at Tesco.

The own aim of the LQs is limiting their possibilities of supermarket differentiation. The LQs are very basic products introduced to face the competition of continental discounters for the lowest segment of the consumer distribution. The relevant competition dimension is the price and so any product refinement that could contribute to differentiate the product is avoided in order to get the lowest possible price. The result is products that are very similar across supermarkets even in packaging and names (Essentials, Value, Savers). Unlike, the HQ variant whose package tries to mimic that of the BPs, the packaging of the LQs is basic with the aim of reducing production costs, signalling its "cheap" attribute and avoid confusions with the HQ variant.

In order to understand better the differences in the possibilities of introducing elements of horizontal product differentiation for the two categories of own brand products we can appeal to the asymmetric consumer distribution noted by Katz [1984] and

[9] The own brand product manufacturer can be a firm that produces exclusively own brand products or alternatively a production division of a BP manufacturer.

Canoy and Peitz [1997]. While the upper segment of the consumers distribution is concerned about the horizontal attributes of the products, the lower one is concerned mainly about the prices. Offering the lowest possible price hampers the introduction of supermarket product differentiation attributes.

As regards the assumption of quality equivalence within quality variant across supermarkets, BPs are necessarily identical across supermarkets. Supermarkets' competition for the LQs is focused on price, the need to reduce costs to adjust price leads to the supermarkets to offer products that as we noted before are extremely similar even in their basic packaging. With respect to the HQs, during the eighties Sainsbury's HQs were recognised as products of higher quality than Tesco's or Safeway's HQs, however in the last years Tesco and Safeway have replicated Sainsbury's high quality approach moving upwards the quality perceptions of their HQs [Cortsjens *et al*, 1995; KeyNote, 1997].

Another important factor that distinguishes BPs and OBPs is the process of formation of their wholesale price. As in Giulietti [1996] we think that supermarket wholesale prices respond to a model of bilateral bargaining involving a vertical relationship between the upstream supplier and the downstream supermarket. The final wholesale price will be the result of the relative bargaining power of manufacturer and retailer. In general we can think of the UK food retailing system as a retailer-led system [Cotterill, 1997][10], and hence the large supermarket chains considered in the analysis enjoy an advantageous position in their bargaining process with the manufacturers. Notwithstanding, the supermarket bargaining strength varies across quality variants.

In the bargaining process determining the BP wholesale prices, the retailers interact with powerful producers[11] (Kellogs, Coca-Cola, etc.) leaders of the retailing food sys-

[10]The UK retailing system is characterized by Cotterill as if "relatively few very large market share supermarket retail firms serve as marketing channel captains in the food system".

[11]The analysis as BP producers considers only the leaders in their respective product categories.

tem in other countries (e.g. the USA). Even though size, information about consumers needs and tastes, and marketing of own brand products with very similar characteristics (HQ variant) confer to the supermarkets a substantial bargaining power, this is limited by the impossibility of de-listing the BPs. Removing the BP variants from the supermarket shelves would involve losing the segment of brand-loyal consumers that would look for these products at other supermarkets. As no differences are expected in the bargaining power of the three supermarkets considered in this analysis (three of the four supermarkets with the highest market share in the UK), we expect very similar BP wholesale prices for all these supermarkets except for special deals offered by the BP manufacturer to a subset of supermarkets related with occasional product promotions.

As regards the own brand products, retailers control most of the bargaining power. Most of the times the OBP wholesale price results from a bidding competition among producers to supply a product tailored to the supermarkets specifications. Among the bids the supermarket will choose the one that meets its requirements (quality, conditions of delivery, adoption of particular technologies...) and offers the lowest price [Dobson, 1997]. Furthermore, the supermarket usually requires an exclusive supply agreement with the own brand product manufacturer. OBP wholesale prices are expected to differ across supermarkets because they are set via different supply contracts, with different conditions and mostly with different manufacturers. Moreover, whereas for the BPs the timing of change of wholesale prices is expected to be homogeneous across supermarkets, this timing for the OBPs is linked to a supplying contract with specific start and duration.

4.2.2 Characterization of the outlet structure in the analysis

The analysis considers three of the four supermarkets chains with highest market share in UK. Listed from the largest to the smallest they are: Tesco (23.6%)[12], Sainsbury (19.6%) and Safeway (10.8%).

These supermarkets have highly developed lines of both high quality and low quality own brand products. Sainsbury is the retailer in which the own brand products have the largest share of the sales (Table 4.1). The proportion of sales HQ/LQ in the own brand products sales of these three supermarkets are shown in Table 4.2. When analysing the small share represented by the LQ sales over the total own brand sales it should be taken into account that on the one hand these products are much cheaper than the HQs and sales are calculated in value; and on the other hand that the LQ range of products is smaller than the HQ range of products.

Table 4.1: Own Label Sales in Major Supermarkets (% in value)

	SAFEWAY	SAINSBURY	TESCO
1995	54.2	65.6	55.1

Source: Nielsen 1996.

Table 4.2: Proportion HQ-LQ own brand products (% over total own brand sales in value). March-96

	HQ	LQ
SAFEWAY	88.6	11.4
SAINSBURY	97.6	2.4
TESCO	91.5	8.5

Source: Marketing Week , 28th June 1996

It is also relevant for further analysis to note the high profits enjoyed by the UK supermarkets in comparison with their continental counterpart. The Economist (6-2-99) reports that net profits margins of British supermarkets (averaging 6%) are double those of the supermarkets in the continent. In Table 4.3, we provide the only data

[12]Market Shares in 1997.

about net profit margins we have been able to gather. The traditional factors used to explain this phenomenon are: more advanced supply management system, proactive store development programs, exploitation of scanner data [Wrigley, 1997] and the existence of high property costs that act as barriers to entry [The Economist, 1995].

Table 4.3: Profit Margins-Net Profit after tax in per cent (1994)

	1994
Carrefour	1.3
Promodes	0.8
Casino	0.8
Sainsbury	5.2
Tesco	4.8
Safeway	4.8

Source: Keynote 1996

4.3 The data

The data used in this analysis are micro level data about prices that were taken directly in three selected superstores in the south of Coventry: Tesco, Sainsbury and Safeway. There is no other superstore belonging to these chains or any other chain geographically located closer to any one of them. Asda, the third biggest supermarket chain in the UK, with a market share (13.5%), was not included in the analysis because it has no superstore in the south of Coventry. The closest Asda superstore is located more than five miles away from these supermarkets, in the north of the city (Walsgrave triangle), an area which is quite different from a socioeconomic point of view. Although it is known that price levels can differ across geographical areas depending upon socioeconomic variables, in general we expect that the patterns of price competition among supermarkets will be similar to the patterns found in the area under study.

The data set comprises 27 price observations for each one of the products taken from November 1995 to March 1997. Prices have been taken every two weeks but for the Christmas periods. For each one of the products considered the price of the BP, the HQ and LQ variants were taken.

Table 4.4: Distances between supermarkets (miles)

	Distance(miles)
TESCO-SAFEWAY	2.8
TESCO-SAINSBURY	1.4
SAFEWAY-SAINSBURY	1.5

In order to select the products to include in the sample the following criteria have been used:

- a BP, a HQ and a LQ should be available in the three supermarkets considered. The BP considered is the brand leader of its product space ;

- most of them should be present in the shopping basket of the representative English consumer;

- given that usually the LQ is available in only one package size, this size was chosen for the analysis.

If more than one price for a product was shown on the shelves the lowest one has been used for the analysis because this is the price at which the product is available for the consumers.

The list of the products used in the analysis is included in the Appendix F.

4.4 An analysis of supermarket price dispersion

In imperfectly competitive markets price dispersion can arise either from heterogeneities in own and cross-price elasticities among firms or from cost asymmetries. Previous research about price dispersion in the supermarkets sector has focused exclusively on the analysis of price dispersion for the branded products[13] [Giulietti and Waterson, 1997

[13] Among others:

and Walsh and Whelan, 1999[14]]. When analysing price dispersion for multiquality retailers as the UK supermarkets, we should keep in mind differences in characteristics across quality variants that can have an influence in price dispersion as: possibilities of supermarket-differentiation for each one of the quality variants and differences in the process of formation of the wholesale price for BPs and OBPs.

In order to carry out the price dispersion analysis we use as analytical tool the Degree of Price Dispersion Index (DPDI)[15]. We define the Degree of Price Dispersion between supermarkets J and K for product i in fortnight t as:

$$DPD_{it}^{J-K} = \begin{cases} 1 - \frac{p_{it}^{K}}{p_{it}^{J}} \text{ if } p_{it}^{J} \geq p_{it}^{K} \\ \\ 1 - \frac{p_{it}^{J}}{p_{it}^{K}} \text{ if } p_{it}^{K} > p_{it}^{J} \end{cases}$$

where:

p_{it}^{J} : is the price of product i in fortnight t at supermarket J.

t =1,...,27 fortnightly taken observations and i = 1,...,46 products

The Degree of Price Dispersion index between supermarkets J and K for product i is defined as:

$$\mathbf{DPDI}_{i}^{J-K} = \frac{1}{27}\sum_{t=1}^{27} DPD_{it}^{J-K}$$

We calculate this index for each one of the products and for each one of the supermarket pairs (TE-SA, TE-SF and SA-SF). The results is three series of **DPDIs** for

Shepard [1991] studies price dispersion in the context of gasoline stations considering full and self service pumps as two different quality variants. However, her analysis considers the fact of being a single or multiple service station as the main source of price dispersion across gasoline stations. Possible causes of price dispersion for a given quality varians across gasoline stations serving both quality variants are not analysed.

Borenstein and Rose [1994] study of the price dispersion in the US airline industry is involved with the study of intra-carrier and no inter-carries price dispersion.

[14]They extend Holmes [1989] model to the case of heterogeneous costs and heterogeneous own and cross price elasticities, to analyse price dispersion in the Irish Independent Grocery Sector.

[15]The characteristics of this index are explained in Appendix C.

each one of the three quality variants considered in the analysis. For example the series $\mathbf{DPDI}^{TE-SA}_{HQ}$ would contain $\mathbf{DPDI}^{TE-SA}_{i,HQ}$ for i=1,...,46.

We start the price dispersion analysis by checking if differences in price dispersion across quality variants are caused either by cost or demand asymmetries (section 4.4.1), then we analyse for each supermarket j of the sample and for each quality variant, if there is any difference in the degree of price dispersion of this supermarket with the other two supermarkets of the sample (section 4.4.2). Evidence in favour of a similar level of price dispersion across supermarket pairs would signal no differences in the degree of asymmetries across supermarket pairs.

4.4.1 Between-supermarket price dispersion across quality variants

The aim of this section is to disentangle if price dispersion is either based on asymmetries in costs or on asymmetries in demand (own and cross price elasticities heterogeneities). Hence, we should start by analysing the impact of these two possible sources of price dispersion over each one of the quality variants considered in the analysis:

1. Asymmetries in demand. If we assume quality equivalence of quality variants across supermarkets, differences in own and cross-price elasticities can be only originated by differences in the supermarket attributes of the product. As HQ is the quality variant with the greater possibilities of supermarket differentiation, it is also the variant for which differences in own and cross-price elasticities should be greater. Hence, if price dispersion across supermarkets is driven by differences in cross price elasticities, price dispersion should be greater for HQs than for BPs or LQs,

$$\mathbf{DPDI}^{J-K}_{HQ} > \mathbf{DPDI}^{J-K}_{BP}$$
$$\mathbf{DPDI}^{J-K}_{HQ} > \mathbf{DPDI}^{J-K}_{LQ}$$

2. Cost asymmetries. Because the BP supplier is the same for all the supermarkets it was argued in section 4.2.1 that differences in the BP wholesale price across supermarkets should be very small and caused for special deals offered by the BP producer at a subset of the supermarkets considered in the analysis. However, the OBP supplier can vary across supermarket and so the existence of asymmetries in costs across supermarkets is more likely for the two OBP quality variants sold at the supermarket. Therefore, greater price dispersion for the HQs and LQs should be interpreted as evidence in favour of cost asymmetries driven price dispersion.

$$\mathbf{DPDI}_{HQ}^{J-K} > \mathbf{DPDI}_{BP}^{J-K}$$
$$\mathbf{DPDI}_{LQ}^{J-K} > \mathbf{DPDI}_{BP}^{J-K}$$

Both under the hypothesis of demand-asymmetries driven price dispersion and under the hypothesis of cost-asymmetries driven price dispersions, it should be true that the degree of price dispersion is higher for the HQs than for the BPs. Hence, a prior step to the discrimination between hypothesis should be to check this common prediction. We carry out this verification by means of a battery of one-sided Wilconxon tests for Matched Pair Observations [16] for which the alternative hypothesis is just the common prediction to both hypothesis (**Test I**):

H_0: *On average, there is no difference between* $\mathbf{DPDI}_{HQ}^{J-K}$ *and* $\mathbf{DPDI}_{BP}^{J-K}$.

H_1: *On average,* $\mathbf{DPDI}_{HQ}^{J-K}$ *is greater than* $\mathbf{DPDI}_{BP}^{J-K}$.

Observation of Table 4.5 reveals that the null hypothesis of no differences between the average level of **DPDI** for the BPs and the HQs is rejected for all the three supermarket pairs (TE-SA, SA-SF, TE-SF). Thus, the results of the tests confirm the common prediction of both hypothesis about price dispersion: on average, $\mathbf{DPDI}_{HQ}^{J-K} > \mathbf{DPDI}_{BP}^{J-K}$

[16]The Wilconxon Test is described in Appendix C.

Table 4.5: Wilconxon Test for Differences in Price Dispersion across Quality Variants

Test I	BP-HQ	T	CV 5%*	CSS	One/Two-Sided
	TE-SA	171	389	46	One-Sided
	TE-SF	130	389	46	One-Sided
	SA-SF	94	389	46	One-Sided
Test II	**HQ-LQ**				
	TE-SA	507	371	45	One-Sided
	TE-SF	398	371	45	One-Sided
	SA-SF	455	389	46	One-Sided
Test III	**BP-LQ**				
	TE-SA	204	371	45	One-Sided
	TE-SF	275	389	46	One-Sided
	SA-SF	295	389	46	One-Sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV5\%$.
Corrected Sample Size (CSS)= Sample size − Number of Zero Differences

In order to discriminate between the two hypotheses presented above, we can use a sequence of two one-sided Wilconxon tests based on the comparison of the predictions of these two hypotheses about the degree of price dispersion for each one of the quality variants. The first one of these tests compares the degree of price dispersion of the two OBP variants: HQ and LQ (**Test II**). The null hypothesis of this test is based on the cost-asymmetries hypothesis, this hypothesis does not establish any a priori difference in the degree of price dispersion between the two own-brand product variants (H_0 : *On average, there is no difference between* $\mathbf{DPDI}_{HQ}^{J-K}$ and $\mathbf{DPDI}_{LQ}^{J-K}$). The alternative hypothesis is based on the demand-asymmetries hypothesis. This hypothesis predicts that price dispersion should be higher for the own-brand product variant with greater possibilities of horizontal product differentiation: the HQ (H_1 : *On average,* $\mathbf{DPDI}_{HQ}^{J-K}$ *is higher than* $\mathbf{DPDI}_{LQ}^{J-K}$). The results of **Test II** (Table 4.5) imply not to reject the null hypothesis for each one of the supermarket pairs. Therefore, they are evidence in favour of the cost-asymmetries hypothesis.

The second one of the tests compares the degree of price dispersion of BP and LQ (**Test III**). The null hypothesis of this test is based on the demand-asymmetries hypothesis. This hypothesis does not establish any a priori difference in the degree of price dispersion of the two quality variants with low possibilities of supermarket product differentiation: BP and LQ (H_0 : *On average, there is no difference between* $\mathbf{DPDI}_{LQ}^{J-K}$ *and* $\mathbf{DPDI}_{BP}^{J-K}$). The alternative hypothesis is based on the cost-asymmetries hypothesis that expects price dispersion to be higher for the own-brand product variant (H_1 : *On average,* $\mathbf{DPDI}_{LQ}^{J-K}$ *is higher than* $\mathbf{DPDI}_{BP}^{J-K}$). As it is possible to observe in Table 4.5, the results of the tests for each one of the supermarket pairs (rejection of the null hypothesis) confirm the prediction of the cost-driven hypothesis: on average, $\mathbf{DPDI}_{LQ}^{J-K} > \mathbf{DPDI}_{BP}^{J-K}$

Hence, the results of **Tests I, II** and **III** are evidence in favour of the cost asymmetries hypothesis. Price dispersion is greater for the OBP variants than for the BP variant. This empirical result is just identical to the prediction of the cost-asymmetries hypothesis. Consequently, we should conclude that the main explanatory factor of the degree of price dispersion is the extent of cost asymmetries across supermarkets for each one of these quality variants.

4.4.2 Analysis between-supermarket price dispersion

Once we have detected that the main cause of differences in price dispersion across quality variants is the extent of cost-asymmetries between the supermarkets, in this section, we analyse for each supermarket J of the sample and for each quality variant, if there is any difference in the degree of price dispersion of this supermarket with the other two supermarkets of the sample. We perform this analysis by using a two-sided[17] Wilconxon test for Pair Matched Observations with the following null and alternative hypotheses:

H_0 : *On average, there is no difference in* $\mathbf{DPDI}_q^{J-K}$ *and* $\mathbf{DPDI}_q^{J-L}$ *(for* $J \neq K$

[17]Two-sided because we do not have any a priori belief.

and $K \neq L$*)*

H_1 : *On average, there is a difference in* $\mathbf{DPDI}_q^{J-K}$ *and* $\mathbf{DPDI}_q^{J-L}$ *(for* $J \neq K$ *and* $K \neq L$*)*[18]

Table 4.6: Wilconxon Test for Differences in the Degree of Between-Supermarket Price Dispersion

BP	T	CV 5%*	CSS	One/Two-sided
TE-SA vs. TE-SF	511	343	45	Two-sided
TE-SA vs. SA-SF	385	294	42	Two-sided
TE-SF vs. SA-SF	373	310	43	Two-sided
HQ				
TE-SA vs. TE-SF	419	343	45	Two-sided
TE-SA vs. SA-SF	337	327	44	Two-sided
TE-SF vs. SA-SF	459	327	44	Two-sided
LQ				
TE-SA vs. TE-SF	390	327	44	Two-sided
TE-SA vs. SA-SF	480	343	45	Two-sided
TE-SF vs. SA-SF	407	310	43	Two-sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV$ 5%.
Corrected Sample Size (CSS)= Sample Size − Number of Zero Differences

The results of this battery of test shown in Table 4.6 always advice not to reject the null hypothesis. The degree of price dispersion among the supermarkets considered in the sample is homogeneous within each of the quality variants. Therefore, no difference in the degree of asymmetry across supermarket pairs is found. If we accept that price dispersion is mainly driven by cost asymmetries, the results of the test suggest homogeneity of cost asymmetries between supermarket pairs, e.g. for the HQs the degree of asymmetry in costs between Tesco and Sainsbury is no different from the degree of asymmetry between Tesco and Safeway.

[18]With this test, we could be testing for example if for the HQs there is no difference in the degree of price dispersion between the pairs TE-SA and TE-SF.

4.4.3 Disaggregated analysis of price dispersion

We can divide the products of the sample in six groups: canned products, groceries, household sundries, hygienic products, alcoholic products and soft drinks. Because the small size of the last two categories (one and two products respectively) does not allow any statistical inference, we exclude them from the disaggregated analysis.

We address this section to analyse whether we can detect different patterns of price dispersion within each one of the quality variants for the groups of products considered. In order to carry out this analysis, we use first a Kruskal-Walis test[19] to check if the data suggest differences in price dispersion for different groups of products. Then, if the Kruskal-Wallis test finds the existence of any difference we use a multiple comparisons technique (Dunn's technique)[20] to detect which groups are more different in degree of price dispersion.

As null and alternative hypotheses for the Kruskal-Wallis test we propose:

H_o: *Within a given quality variant and for a given supermarket pair, there is no difference in the average level of* **DPDI** *for the four groups of products considered, e.g. there is no difference in the average level of* $\mathbf{DPDI}_{HQ}^{TE-SA}$ *for the four groups of products*

H_1: *Within a given quality variant and for a given supermarket pair, there are some differences in the average level of* **DPDI** *for the four groups of products considered, e.g., there are some differences in the average level of* $\mathbf{DPDI}_{HQ}^{TE-SA}$ *for the four groups of products.*

and, as null and alternative hypotheses for the multiple comparisons test:

H_o: *Within a given quality variant and for a given supermarket pair, there is no*

[19] The Kruskal-Wallis is described in Appendix B.
[20] The Dunn´s Technique is described in Appendix B.

difference in the average level of **DPDI** *for groups i and j, e.g. there is no difference in the average level of* $\mathbf{DPDI}_{HQ}^{TE-SA}$ *for canned and grocery products*

H_1*: Within a given quality variant and for a given supermarket pair, there is some difference in the average level of* **DPDI** *for groups i and j, e.g., there is some difference in the average level of* $\mathbf{DPDI}_{HQ}^{TE-SA}$ *for canned and grocery products.*

The results of this analysis are shown in Figure 1 in Appendix E. In this Figure the groups of products have been ranked according to their mean rank. Star lines are drawn to join together groups of products that the multiple comparisons test have been unable to separate.

The analysis of the price data leads for the BP quality variant to reject the null hypothesis of no differences in the degree of price dispersion in two out of three pairwise comparisons (Figure 1). In order to define common patterns we look for the similarities among the results of the tests carried out for each one of the pairwise comparisons:

1. for all the three comparisons the rank of groups of products from higher to lower degree of price dispersion is the same: hygienics, groceries, household and canned;
2. according to the multiple comparisons test there is no difference in the degree of price dispersion among: groceries, household and canned;
3. in the two comparisons in which Dunn's technique distinguish between groups of products price dispersion for hygienics is significantly higher than for the household and canned products.

These similarities among pairwise comparisons indicate that price dispersion is significantly greater for the hygienics group of products. Probably this is the group of products for which interpurchase time is longer and tastes more important in the buying decision (deodorant, shower gel, toothpaste, etc)[21]. Their lower frequency of purchase and smaller share in the family budget could imply that the consumer is not sensitive to small price differences among supermarkets. The supermarket could use this lower price sensitivity to set higher prices for some products in this group and obtain higher profits.

With respect to the HQ variant the null hypothesis of no difference in the degree of price dispersion is always rejected. It is still true in all three pairwise comparisons that the group for which price dispersion is higher is hygienics. However, this time the multiple comparisons test joins always in a single group hygienics with groceries, two groups of products with quite different characteristics. This location of groceries could be due to its heterogeneity as a group. We have included in this group products that differ both in their interpurchase time and in the consumer sensitivity to price differences (bread, tea or cornflakes vs. drinking chocolate or evaporated milk). The location of household products as the group with lower degree of price dispersion (alone or jointly with canned) is probably explained by the character of "frequently purchased" of all the products included in the group.

As regards to the LQs, the Kruskal-Wallis test always suggests the acceptance of the null hypothesis of no differences in average level of **DPDI**, i.e. no differences in price dispersion. We could always think that the very price sensitive consumers purchasing this quality variant products are equally concerned about small price differences across all the groups of products.

[21]We can consider these products closer to being credence goods rather than experience goods in which case supermarkets may differ in their reputation.

4.5 Analysis of the patterns of competition among supermarkets

When considering the supermarket as a multiquality-multiproduct firm it is important to analyse differences in intensity of between supermarket price competition for the different quality variants sold. If price competition is relatively less intense in a quality variant than in the others, and a supermarket fails to develope a range of products for this quality variant, this could result in lower profits.

As a proxy for the degree of between-supermarket price coordination we use the Dynamic Degree of Price Matching Index (**DDPMI**)[22]. We build this index in the following way:

Let be p_{it}^J the price set by supermarket J in fortnight t for product i. Where:

i = 1,...,46 products included in the sample and t = 1,...,27 fortnightly taken price observations

J = TE, SA, SF stores included in the sample.

then if we define:

$$g_{it}^J = \frac{p_{it}^J - p_{it-1}^J}{p_{it-1}^J}$$

the Dynamic Degree of Price Matching between stores J and H (for all $J \neq H$) for product i in fortnight t is calculated as:

$$DDPM_{it}^{J-H} = \begin{cases} 1 \text{ if } g_{it}^J = g_{it}^H = 0 \\ \\ \dfrac{g_{it}^J}{g_{it}^H} \text{ if } \left|g_{it}^H\right| \geq \left|g_{it}^J\right| \\ \\ \dfrac{g_{it}^H}{g_{it}^J} \text{ if } \left|g_{it}^J\right| > \left|g_{it}^H\right| \end{cases}$$

and the Dynamic Degree of Price Matching Index between supermarkets H and J for product i along the period of the sample as:

[22]The characteristics of this index are explained in Appendix C.

$$DDPMI_i^{J-H} = \frac{1}{26}\sum_{t=2}^{27} DDPM_{it}^{J-H}$$

We calculate a **DDPMI** for every product and every supermarket pair (TE-SA, TE-SF, SA-SF). The result is three series of **DDPMIs** for each one of the three quality variants considered in the analysis. For example, the $\mathbf{DDPMI}_{BP}^{TE-SF}$ would contain $\mathbf{DDPMI}_{BP,i}^{TE-SF}$ for $i = 1, ..., 46$.

4.5.1 Between-supermarket price competition across quality variants

By means of the **DDPMI** we catch the simultaneity in the pricing behaviour between supermarket pairs and the extent of this simultaneity when prices change. High values of this index for a given quality variant can be the result of both simultaneous movements in wholesale prices for all the three supermarkets translated into final prices, and of the recognition of an intense price competition between supermarkets for this quality variant. In order to discriminate between these two possible sources of between-supermarket price coordination, we can compare the predictions arising from the two possible sources of price coordination with the real patterns of price coordination for each one of the quality variants.

If price coordination is due to simultaneous movements of wholesale prices translated into final prices the quality variant that should show a greater degree of price coordination is the BP:

$$\mathbf{DDPMI}_{BP}^{J-K} > \mathbf{DDPMI}_{HQ}^{J-K}$$
$$\mathbf{DDPMI}_{BP}^{J-K} > \mathbf{DDPMI}_{LQ}^{J-K}$$

As explained in section 2 the supplier of the BP is the same for all the supermarkets and given the similar bargaining power across the supermarkets considered in the sample usually wholesale prices for this quality variant will not vary across supermarkets. As regards the OBP quality variants, their supplier usually varies across supermarkets and therefore wholesale prices for the OBP quality variants will differ most of the times across supermarkets. Notwithstanding, when studying price coordination we are interested not only in wholesale price levels but also in the timing of change of the wholesale price. There exists no a priori reason to think that the BP producers will not change simultaneously the wholesale price offered to the three supermarkets considered in the analysis. However, the existence of heterogeneous OBP suppliers across supermarkets makes much more unlikely the event of simultaneity in the changes of the wholesale price faced by the supermarkets for the products of the two own brand quality variants. Furthermore, supermarkets when negotiating the supplying conditions with the OBP producer use their greater bargaining power to establish the price over a period of time, and the OBP producer bears the risk of changes in the raw material prices.

If price coordination varies with intensity of price competition, we expect price competition to be more intense for those quality variants with less possibilities of supermarket product differentiation: BP and LQ. For the HQs, greater supermarket product differentiation reduces the degree of substitutability and allows to the supermarkets to exercise some power over their price in the market. Hence, between-supermarket price competition should be less intense for the HQ variant than for the variants with less possibilities of supermarket product differentiation: BP and LQ.

$$\mathbf{DDPMI}_{BP}^{J-K} > \mathbf{DDPMI}_{HQ}^{J-K}$$
$$\mathbf{DDPMI}_{LQ}^{J-K} > \mathbf{DDPMI}_{HQ}^{J-K}$$

Summing up, the **DDPMI** could be interpreted as an indicator of price competition if its average level is greater for the two extreme quality variants (BP and LQ) than for the intermediate quality variant (HQ). Nevertheless, if the average level of **DDPMI** is significantly greater for the BP quality variant that for the OBP quality variants then **DDPMI** should be interpreted as measuring price coordination due to simultaneity in cost changes.

Both hypotheses about the possible sources of between-supermarket price coordination predict that this should be higher for the BP than for HQ. Hence, any attempt to discriminate between these two sources of price coordination must include as a previous step the verification of this prediction. We examine it by means of a one-sided Wilconxon test for Pair Matched Observations (**Test IV**). The alternative hypothesis of this test is just the prediction we are checking:

H_0 : *On average, there is no difference between* $\mathbf{DDPMI}_{BP}^{J-H}$ *and* $\mathbf{DDPMI}_{HQ}^{J-H}$*, i.e. on average, there is no difference in the degree of price coordination between supermarkets J and H for BPs and HQs.*

H_1 : *On average,* $\mathbf{DDPMI}_{BP}^{J-H}$ *is greater than* $\mathbf{DDPMI}_{HQ}^{J-H}$*, i.e. on average, the degree of price coordination between supermarkets J and H for BPs is greater than for HQs.*

The results of the tests comparing the degree of price coordination for BP and HQ are shown in Table 4.7. Observation of this table reveals that on average the degree of price coordination is significantly greater for the BP than for the HQ except for the TE-SA pair and so the common prediction to both theories seems to be true except for this supermarket pair.

In order to discriminate between the two possible hypotheses explaining between-supermarket price coordination, we make use of a sequence of two one-sided Wilconxon test for Pair Matched observations. The null and alternative hypotheses of these tests arise from the comparison of the predictions of these two hypotheses about the degree of price coordination for each one of the quality variants.

Table 4.7: Wilconxon Test for Differences in Price Coordination across Quality Variants

Test IV	**BP-HQ**	T	CV 5%	CSS	One/Two Sided
	TE-SA	408	389	46	One-sided
	TE-SF	290.5	389	46	One-sided
	SA-SF	320	389	46	One-sided
Test V	**LQ-HQ**	T	CV 5%		
	TE-SA	335	336	43	One-sided
	TE-SF	317.5	389	46	One-sided
	SA-SF	351.5	389	46	One-sided
Test VI	**BP-LQ**	T	CV 5%		
	TE-SA	490.5	353	44	One-sided
	TE-SF	488	371	45	One-sided
	SA-SF	577	389	46	One-sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV$ 5%.
Corrected Sample Size = Sample Size − Number of Zero Differences

Thus, the first one of these tests compares the degree of between-supermarket price coordination of the two OBP variants (**Test V**). The null hypothesis of this test arises from the hypothesis that relates between-supermarket price coordination with simultaneous movements of the wholesale prices, this hypothesis does no establish any a priori difference in the degree of between-supermarket price coordination of the two own-brand product variants (H_0 :*On average, there is no difference between* $\mathbf{DDPMI}_{LQ}^{J-K}$ *and* $\mathbf{DDPMI}_{HQ}^{J-K}$). Likewise, the alternative hypothesis arises from the hypothesis that relates between-supermarket price coordination with intensity of price competition. Under this hypothesis, between-supermarket price coordination should be higher for the LQs than for the HQs (H_1 :*On average,* $\mathbf{DDPMI}_{LQ}^{J-K}$ *is higher than* $\mathbf{DDPMI}_{HQ}^{J-K}$). The results of this test lead to reject the null hypothesis for the three supermarket pairs considered (Table 4.7). On average $\mathbf{DDPMI}_{LQ}^{J-K}$ is higher than $\mathbf{DDPMI}_{HQ}^{J-K}$ and the prediction of the hypothesis that relates the degree of between-supermarket price coordination with intensity of price competition is confirmed.

The second one of the tests compares the degree of price coordination of BPs and

LQs (**Test VI**). The null hypothesis of this test is based on the hypothesis that relates between-supermarket price coordination with intensity of price competition, this hypothesis does not signal any difference in the degree of between-supermarket price coordination between the two variants with low possibilities of supermarket product differentiation: BP and LQ (H_0 : *On average, there is no difference between* $\mathbf{DDPMI}_{BP}^{J-K}$ *and* $\mathbf{DDPMI}_{LQ}^{J-K}$). The alternative hypothesis arises from the hypothesis that relates between-supermarket price coordination with simultaneous movement of the wholesale costs. This hypothesis predicts that price coordination should be higher for the BPs than for the LQs (H_1 : *On average,* $\mathbf{DDPMI}_{BP}^{J-K}$ *is greater than* $\mathbf{DDPMI}_{LQ}^{J-K}$). We can observe in Table 4.7 that the null hypotheses of **Test VI** is not rejected for any of the supermarket pairs. Hence, the results of this test are evidence in favour of the hypothesis relating price coordination with intensity of price competition.

The results of the sequence of test carried out suggest that on average price coordination is higher for BPs and LQs than for HQs. These results confirm the predictions of the hypothesis relating between-supermarket price coordination with intensity of price competition (except in **Test IV** for the pair TE-SA) and advice to interpret the **DDPMI** as an indicator of price competition. Higher levels of between-supermarket price coordination for a given quality variant are the result of higher price competition and not of a similar pattern of wholesale price variation across supermarkets. In general we can say that there exists a negative relationship between supermarket product differentiation possibilities for a given quality variant and between-supermarket price competition for this quality variant. Therefore, horizontal product differentiation can be used by the supermarket to relax price competition.

We can use these findings to explain the paradox "tight competition-high profits" presented in the introduction. We cannot neglect that UK supermarkets are facing tough price competition for those variants with less possibilities of horizontal product differentiation: BP and LQ. However, it is also true that price competition is significantly softer for the HQs, a variant that represents no less than 48% of the sales of the three supermarkets considered in the analysis (see Tables 4.1 and 4.2) and for which the gross profit margins are in average 20-30% higher than for the BPs [Hoch, 1996]. Whereas the main UK supermarkets have been successful in developing a whole range of HQs most of the continental supermarkets have failed in the attempt [Corstjens *et al*, 1995]. Therefore, the joint consideration of the greater HQ percentage over sales (see table 4.8) and the lower degree of competition for this variant is a key factor to explain the high profits enjoyed by the English supermarkets in comparison with their continental counterparts.

Table 4.8: Own Label Market Share (% in value), 1994.

Country	% in value	Country	% in value
UK	30	Belgium	17
Germany	25	Holland	16
France	21	Spain	8
Denmark	18	Italy	8

Source: The Economist,4th March 1995

4.5.2 Analysis of between supermarkets price competition

Once we have shown that the **DDPMI** should be interpreted as a proxy for the intensity of between-supermarket price competition, in this section we examine for each supermarket j and for each quality variant if there is any difference in the intensity of price competition of this supermarket with the other two supermarkets of the sample. We perform this analysis by using a two-sided Wilconxon Test for Matched Pair observations with the following null and alternative hypotheses:

H_0 : *On average, the level of* $\mathbf{DDPMI}_q^{J-H}$ *is similar to the level* $\mathbf{DDPMI}_q^{J-L}$ *(for* $J \neq H$ *and* $J \neq L$*), i.e. on average, there is no difference in the degree of price competition of supermarket* J *with supermarkets* K *and* L *for quality variant* q

H_1 : *On average, there is a difference between the level of* $\mathbf{DDPMI}_q^{J-H}$ *and the level of* $\mathbf{DDPMI}_q^{J-L}$ *(for* $J \neq H$ *and* $J \neq L$*), i.e. on average, there is a difference in the degree of price competition of supermarket J with supermarkets K and L for quality variant q.*

With this battery of test we are checking, for example, if we can say that there is no difference in the degree of competition of Tesco with Sainsbury and Safeway for each one of the quality variants considered.

Table 4.9: Wilconxon Test for Differences in the Degree of Between-Supermarket Competition

BP	T	CV 5%	CSS	One/Two-sided
TE-SA vs. TE-SF	397	310	43	Two-sided
TE-SA vs. SA-SF	342	264	40	Two-sided
TE-SF vs. SA-SF	324.5	294	42	Two-sided
HQ				
TE-SA vs. TE-SF	474.5	310	43	Two-sided
TE-SA vs. SA-SF	339.5	327	44	Two-sided
TE-SF vs. SA-SF	392.5	327	44	Two-sided
LQ				
TE-SA vs. TE-SF	384.5	310	43	Two-sided
TE-SA vs. SA-SF	288	294	42	Two-sided
TE-SF vs. SA-SF	227.5	264	40	Two-sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV$ 5%.
Corrected Sample Size (CSS)= Sample Size − Number of Zero differences

For the BPs, observation of Table 4.9 reveals that for each supermarket j there is no difference in the average level of $\mathbf{DDPMI}_{BP}^{J-K}$ and $\mathbf{DDPMI}_{BP}^{J-L}$. This is just signalling that the intensity of between-supermarket price competition is homogeneous among the three supermarkets considered. Except for location BPs are homogenous across supermarkets and so consumers perceive them. There is no a priori reason to think of the degree of supermarket/horizontal product differentiation for any supermarket pair as different from the degree of product differentiation for the other supermarket pairs. Therefore, the result of homogeneous price competition is not surprising. Even though, we think that the main determinant of **DDPMI** is intensity of price competition, we do not rule out the possible influence of the almost homogeneous wholesale price for the BPs across supermarkets to explain the homogeneity of the **DDPMI**.

As for the BPs, for the HQs the average level of $\mathbf{DDPMI}_{HQ}^{J-K}$ never differ from the average level of $\mathbf{DDPMI}_{HQ}^{J-L}$. Although, the greater possibilities of supermarket product differentiation of the HQ variant give to the supermarkets some market power when setting prices, price competition is still homogeneous across supermarkets for this quality variant.

The own nature of the LQs, as basic products, make them homogeneous products but in location and so we would expect the average level **DDPMI** to be similar across comparisons. However, the results of the tests involving the LQs are conditioned by Tesco's "Unbeatable Value". This is a low price guarantee offered by Tesco for a subset of the products included in the sample from fortnight 16 onwards. The effects of this low price guarantee can explain that on average $\mathbf{DDPMI}_{LQ}^{TE-SA}$ is greater than $\mathbf{DDPMI}_{LQ}^{SA-SF}$, and that on average $\mathbf{DDPMI}_{LQ}^{TE-SF}$ is greater than $\mathbf{DDPMI}_{LQ}^{SA-SF}$. The degree of price competition between Safeway and Sainsbury is less intense than the degree of competition of each of them with the LPG actor (Tesco). The results are indicating that Tesco's low-price guarantee is disciplining the market.

To sum up, we should say that degree of price competition among supermarkets is in general homogeneous for the BPs and HQs. Therefore, distance between products in terms of supermarket/horizontal product attributes are similar among products belonging to the same quality variant sold at different supermarkets. For the LQ the presence of a "low-price guarantee" is distorting the results and further analysis is needed[23].

[23] Twenty-two over the forty-six LQs of the sample are subject to the low price guarantee for twelve over the twenty seven fortnights of the sample. In order to check if the results are independent of the LPG in Appendix D we carried all the aggregated analysis using only the data for the fortnights

4.5.3 Disaggregated analysis of price competition

We devote this section to check whether it is possible within a given quality variant to find out different levels of between supermarket price competition for the groups of products considered in the analysis[24]. We perform this analysis in two steps:

1. Kruskal-Wallis test to check for differences in the average level of price competition for the different groups of products.

2. Multiple comparisons technique (Dunn's technique) to detect for which groups differences in average level of price competition are greater.

As null and alternative hypotheses for the Kruskal-Wallis test we propose:

H_0: *Within a given quality variant and for a given supermarket pair, there is no difference in the average level of* **DDPMI** *for the four groups of products considered, e.g. there is no difference in the average level of* $\mathbf{DDPMI}_{HQ}^{TE-SA}$ *for the four groups of products*

H_1: *Within a given quality variant and for a given supermarket pair, there are some differences in the average level of* **DDPMI** *for the four groups of products considered, e.g., there are some differences in the average level of* $\mathbf{DDPMI}_{HQ}^{TE-SA}$ *for the four groups of products*

and, as null and alternative hypothesis for the multiple comparisons test:

H_0: *Within a given quality variant and for a given supermarket pair , there is no difference in the average level of* **DDPMI** *for groups i and j, e.g., there is no difference in the average level of* $\mathbf{DDPMI}_{HQ}^{TE-SA}$ *for canned and grocery products*

before the start of the LPG.

[24]For the reasons explained in Section 4.4.3 for the disaggregated analysis we only use four of the six groups of products included in the sample: canned products, groceries, household sundries and hygienic product.

H_1: *Within a given quality variant and for a given supermarket pair, there is some difference in the average level of* **DDPMI** *for groups i and j, e.g., there is some difference in the average level of* $\mathbf{DDPMI}_{HQ}^{TE-SA}$ *for canned and grocery products.*

In Figure 2 (Appendix E) we have ranked the groups of products according to their mean rank. Star lines are drawn to join together groups of products whose average degree of price competition the multiple comparisons test have been unable to separate.

For the BPs, the Kruskal-Wallis test does not reject the null hypothesis of no difference in the average level of between-supermarket price coordination among groups for the TE-SA comparison. However, the null hypothesis of no differences in **DDPMI** is rejected for the other two pairwise supermarket comparisons (TE-SF and SA-SF). For these two last comparisons, the Dunn's procedure distinguish two groups with different average level of price competition: the group of low price competition is formed by hygienics and grocery and the group of high price competition is formed by canned and household. The only surprising fact about this classification is the presence of grocery in the group of low degree of price competition. However, it is likely that the heterogenous composition of this group of products, (as it was explained when analysing price dispersion) could explain this phenomenon.

As regards to the HQs, although the Kruskal-Wallis test leads to reject the null hypothesis only for the SA-SF comparison, it is true in all the three pairwise comparisons that the ranking of the groups from lower to higher degree of price competition is: hygienics, canned, groceries, and household. Nevertheless, the only clear conclusion obtained from the Dunn's procedure is that for the SA-SF pairwise comparison the average degree of price competition is greater for the household than for the other groups of products.

To sum up the results for the BPs and HQs suggest that hygienics is the group for which average degree of price competition is the lowest. For this group of products characterized by a longer interpurchase time, a high importance of the tastes in the purchasing decision and comparatively reduced importance in the family shopping budget, price competition seems to be weaker than for the other three groups of products analysed. As regards the LQs, the intensity of price competition seems to be homogeneous across groups of products (the null hypothesis of the Kruskal-Wallis test is never rejected). Price competition for the lowest quality variant does not depend on the group of products considered but to the attribute of essential products they are linked with.

4.6 Concluding Remarks

The empirical confirmation of heterogeneity in the degree of between-supermarket price dispersion and price competition across quality variants sheds light about the importance of considering the supermarket a multiquality firm and analysing its different patterns in the price setting for each one of the quality variants.

Our results indicate that differences in the degree of price dispersion across quality variants are mainly explained by cost-asymmetries. Price dispersion is greater for HQ and LQ variants. The existence of a common BP supplier for all the supermarkets while the OBP supplier varies across supermarkets can explain greater cost asymmetries in the OBP variants. As regards the disaggregated analysis of price dispersion within each one of the quality variants, both for BPs and HQs price dispersion seems to be directly related to the importance of other factors different from price in the buying decision. The more important are tastes in the buying decision (as for hygienics), the higher is price dispersion. Within the LQ variant, we do not find differences in price dispersion between groups of products; we could think that the very price sensitive

LQ variant purchasers are equally concerned about small price differences for all the groups.

Independently of differences in the process of formation of the wholesale price between BPs and OBPs, price competition is more intense for those quality variants with less possibilities of supermarket product differentiation, the BP and the LQ variants than for the HQ variant. The main results of our work confirm empirically the effectiveness of supermarket/horizontal product differentiation as an instrument to relax between-supermarket price competition.

We use this finding about heterogeneity of intensity of price competition across quality variants to explain the existence of the economic paradox "tight competition-high profits" in the UK food retailing system. Whereas it is true that the UK supermarkets are facing tight competition for those quality variants with less possibilities of supermarket product differentiation (BP and LQ), it is also true that competition is significantly softer for the HQ variant. The sales of this quality variant represent no less than 48% of the sales of the three supermarkets considered in the analysis and its gross profit margins are in average 20-30% higher than for the BP. Furthermore, the joint consideration of the greater market share of the HQs in the UK supermarkets and the lower intensity of price competition for this variant provides an innovative explanation of the high profits enjoyed by the UK supermarket in comparison with their continental counterparts.

With the aim of checking the predictions of this work, further research of between-supermarket competition should consider the influence of within-supermarket competition among quality variants on the supermarket price setting for each one of the quality variants. This is the task that we carry out in Chapter 5. It is in this chapter that we propose an empirical model to analyse between supermarket price competition.

4.7 Appendices

A: Variables description and Descriptive Statistics

Variable	Description	Observations	Mean	Standard Deviation
$DPDI_{BP}^{TE-SA}$	Degree of price dispersion TE-SA for BP	46	0.0259	0.0294
$DPDI_{BP}^{TE-SF}$	Degree of price dispersion TE-SF for BP	46	0.0271	0.0277
$DPDI_{BP}^{SA-SF}$	Degree of price dispersion SA-SF for BP	46	0.0294	0.0360
$DPDI_{HQ}^{TE-SA}$	Degree of price dispersion TE-SA for HQ	46	0.0609	0.0510
$DPDI_{HQ}^{TE-SF}$	Degree of price dispersion TE-SF for HQ	46	0.0687	0.0507
$DPDI_{HQ}^{SA-SF}$	Degree of price dispersion SA-SF for HQ	46	0.0693	0.0453
$DPDI_{LQ}^{TE-SA}$	Degree of price dispersion TE-SA for LQ	46	0.0664	0.0663
$DPDI_{LQ}^{TE-SF}$	Degree of price dispersion TE-SF for LQ	46	0.0545	0.0366
$DPDI_{LQ}^{SA-SF}$	Degree of price dispersion SA-SF for LQ	46	0.0634	0.0512
$DDPMI_{BP}^{TE-SA}$	Degree of price coordination TE-SA for BP	46	0.7165	0.1961
$DDPMI_{BP}^{TE-SF}$	Degree of price coordination TE-SF for BP	46	0.7326	0.1838
$DDPMI_{BP}^{SA-SF}$	Degree of price coordination SA-SF for BP	46	0.7081	0.1852
$DDPMI_{HQ}^{TE-SA}$	Degree of price coordination TE-SA for HQ	46	0.6594	0.1702
$DDPMI_{HQ}^{TE-SF}$	Degree of price coordination TE-SF for HQ	46	0.6562	0.1508
$DDPMI_{HQ}^{SA-SF}$	Degree of price coordination SA-SF for HQ	46	0.6264	0.1683
$DDPMI_{LQ}^{TE-SA}$	Degree of price coordination TE-SA for LQ	46	0.7204	0.1295
$DDPMI_{LQ}^{TE-SF}$	Degree of price coordination TE-SF for LQ	46	0.7392	0.1467
$DDPMI_{LQ}^{SA-SF}$	Degree of price coordination SA-SF for LQ	46	0.6935	0.1462

B: Description of Non-Parametric Tests

Wilconxon Test for Matched Pair Observations

This non-parametric test should be used to detect differences in average between two samples when each observation in one sample has some kind of natural link with an observation in the other sample. In our case, if we are detecting differences in average between $\mathbf{DPDI}_{HQ}^{TE-SA}$ and $\mathbf{DPDI}_{LQ}^{TE-SA}$, the price dispersion index that corresponds to the Baked Beans in the first series is matched with the index that corresponds to the same product in the second sample (and so with all the products).

The Wilconxon test is based in ranking the differences of each pair of observations and then summing the rank of the positive and negative differences. If H_1 is one-sided then the T statistic is given by that sum of ranks that is expected to be smaller if the H_1 were true. If H_1 is two sided then T is whichever of the sum of ranks that turned out to be smaller. If any of the differences between pairs of observations is zero we ignore them and reduce the sample size accordingly. A correction of the T is needed if any tied differences exists. Therefore, in each one of the tables referred to a Wilconxon test, we will state if H_1 is one-sided or two-sided and specify the corrected sample size that we obtain as the difference between the original sample size and the number of zero differences. We reject the null hypothesis of no difference on the average level of the variable under analysis for the matched samples considered if $T \leq$ *critical value.* A complete description of this test can be found in Neave and Worthington [1988]; the critical values of the test in Table D of the same book.

Kruskal–Wallis Test and Dunn's Technique

This non parametric test should be used to test for differences in average between more than two independent samples. For independence, we understand that the observations in any sample are not related to the observations in any other sample. In our case, we could be using the Kruskal-Wallis test to check if there is any difference in the average $\mathbf{DDPMI}_{HQ}^{TE-SA}$ of canned, household, groceries and hygienics groups of products.

The Kruskal-Wallis test ranks the observations corresponding to each one of the groups as belonging to a single sample, then compares each group mean rank with the mean of all the ranks. The H statistic can be obtained as:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} n_i (R_i - \bar{R})^2$$

where: R_i is the sum of the ranks for group $i\,(i = 1, ...k)$; n_i is the size of group i; $N = \sum_{i=1}^{k} n_i$ and $\bar{R} = (1 + 2 + ... + N)/N$. A correction of the statistic H is needed if there exist any tied observations. The null hypothesis of no difference in the average level of the variable under analysis for the groups is rejected if $H \geq \chi^2_{k-1}$. A full description of the test can be found in Neave and Worthington [1988].

Using as starting point the ranking of observations carried out in the Kruskal-Wallis test, the Dunn's technique compares the means of the ranks assigned to the groups. For all the pair of groups, i and j, Dunn's procedure defines the absolute difference $|D_{ij}| = \left|\frac{R_i}{n_i} - \frac{R_j}{n_j}\right|$. It is possible to show that the standard deviation of this difference under the H_0 of no difference between the two groups is $\sigma_{ij} = \sqrt{\frac{N(N+1)}{12} \cdot \left(\frac{1}{n_i} + \frac{1}{n_j}\right)}$ and the mean 0. As D_{ij} is approximately normally distributed $T_{ij} = \frac{D_{ij}}{\sigma_{ij}}$ has approximately the standard normal distribution. The H_0 of no difference in the average level of the variable under analysis for groups i and j is rejected if $|T_{ij}| \geq z$ where z is the percentage point that corresponds to the upper probability $\alpha/k\,(k-1)$ in the standard normal distribution. α is the significance level corresponding to a two-sided alternative hypothesis.

If we were carrying a single test, the probability would be $\frac{1}{2}\alpha$, however with the Dunn's procedure we are performing $\frac{1}{2}k(k-1)$ tests. In order to share out the risk equally between these tests the appropriate probability is $\frac{1}{2}\alpha/\frac{1}{2}k(k-1) = \alpha/k\,(k-1)$.

On the basis of this rule with $k = 4$, we choose an $\alpha = 30\%$. The z that corresponds to an upper probability $\alpha/k\,(k-1) = 0.025$ is 1.960. Therefore, we will reject the null hypothesis when $|T_{ij}| \geq 1.960$. Some correction of the standard deviation is needed in presence of tied observations. The full description of the test and the critical values can be found in Neave and Worthington [1988].

C: Price Dispersion and Price Coordination Indices

The Degree of Price Dispersion Index (DPDI)

We use as proxy for the degree of between-supermarkets price dispersion the **DPDI**. As explained in the main body of the paper, we define the Degree of Price Dispersion between supermarkets J and K for product i in fortnight t as:

$$DPD_{it}^{J-K} = \begin{cases} 1 - \dfrac{p_{it}^K}{p_{it}^J} \text{ if } p_{it}^J \geq p_{it}^K \\ \\ 1 - \dfrac{p_{it}^J}{p_{it}^K} \text{ if } p_{it}^K > p_{it}^J \end{cases}$$

where:

p_{it}^J : is the price of product i in fortnight t at supermarket J.

t =1,...,27 fortnightly taken observations and i = 1,...,46 products

The Degree of Price Dispersion index between supermarkets J and K for product i is defined as:

$$\mathbf{DPDI}_i^{J-K} = \frac{1}{27}\sum_{t=1}^{27} DPD_{it}^{J-K}$$

The properties of $\mathbf{DPDI}_i^{J-K}$, defined as a mean along the time of $\mathbf{DPD}_{it}^{J-K}$, are determined by the properties of $\mathbf{DPD}_{it}^{J-K}$, so we start by examining the properties of this index,

- If supermarkets J and K are setting the same price for product i in fortnight t then $\mathbf{DPD}_t^{J-K}$ takes value 0.

- The larger the difference between the prices set by supermarkets J and K for product i in fortnight t the smaller the ratio $\frac{p_{it}^K}{p_{it}^J}$ (we assume in this example that $p_{it}^J \geq p_{it}^K$) and the higher $\mathbf{DPD}_{it}^{J-K}$.

- By construction $\mathbf{DPD}_{it}^{J-K}$ cannot take negative values. In the ratio $\frac{p_{it}^K}{p_{it}^J}$, the higher price is always in the denominator and so it cannot be greater than 1.
- For strictly positive prices $\mathbf{DPD}_{it}^{J-K}$ is bounded away from 1 because $\frac{p_{it}^K}{p_{it}^J}$ is bounded away from zero.

Therefore, both $\mathbf{DPD}_{it}^{J-K}$ and $\mathbf{DPDI}_{i}^{J-K}$ take values in the interval [0,1[

The Dynamic Degree of Price Matching Index (DDPMI)

We use as proxy for the degree of between-supermarkets price coordination the **DDPMI**, we built this index in the following way,

Let be p_{it}^J the price set by supermarket J in fortnight t for product i. Where:

$i = 1,...,46$ products included in the sample and $t = 1,...,27$ fortnightly taken price observations

$J =$ TE, SA, SF stores included in the sample.

then if we define:

$$g_{it}^J = \frac{p_{it}^J - p_{it-1}^J}{p_{it-1}^J}$$

the Dynamic Degree of Price Matching between stores J and H (for all $J \neq H$) for product i in fortnight t is calculated as:

$$DDPM_{it}^{J-H} = \begin{cases} 1 \text{ if } g_{it}^J = g_{it}^H = 0 \\ \frac{g_{it}^J}{g_{it}^H} \text{ if } \left|g_{it}^H\right| \geq \left|g_{it}^J\right| \\ \frac{g_{it}^H}{g_{it}^J} \text{ if } \left|g_{it}^J\right| > \left|g_{it}^H\right| \end{cases}$$

and the Dynamic Degree of Price Matching Index between supermarkets H and J for product i along the period of the sample as:

$$DDPMI_i^{J-H} = \frac{1}{26}\sum_{t=2}^{27} DDPM_{it}^{J-H}$$

$\mathbf{DDPMI}_i^{J-H}$ can be defined as a mean along the time of $\mathbf{DDPM}_{it}^{J-H}$. Hence, from the properties of this last index we can infer directly the properties of the first index,

- If in a given fortnight t both supermarkets J and H increase (decrease) the price of product i, $\mathbf{DDPM}_{it}^{J-H}$ takes a positive value and contributes positively to $\mathbf{DDPMI}_i^{J-H}$. This positive value is just reflecting that simultaneous movements of the prices in the same direction at the two supermarkets are interpreted as signal of price coordination and so they should contribute positively to a price coordination index. In the limit, when the rate of growth of the prices is the same in the two supermarket the index takes value 1.

- If in a given fortnight t one of the supermarkets increases its price for product i while the other is decreasing it (or viceversa), $\mathbf{DDPM}_{it}^{J-H}$ takes a negative value and contributes negatively to $\mathbf{DDPMI}_i^{J-H}$. We are just catching the idea that divergent price movements should have a negative impact over a price co-ordination index. In the limit, when the rate of growth of the prices at the two supermarkets is the same but with opposite signs $\mathbf{DDPM}_{it}^{J-H}$ takes value -1.

- When neither supermarket J nor supermarket H change their prices $\mathbf{DDPM}_{it}^{J-H}$ takes value 1. The fact that no one of the supermarkets change the price contributes positively to the price coordination index.

Therefore, both $\mathbf{DDPM}_{it}^{J-H}$ and $\mathbf{DDPMI}_i^{J-H}$ take values in the interval [1,-1]. $\mathbf{DDPMI}_i^{J-H}$ have the desirable property of catching the simultaneity in the pricing behaviour between supermarket pairs and the extent of this simultaneity when prices change.

D: Pre-policy period analysis

In order to show that the results obtained in this paper do not depend of Tesco's LPG, in this appendix we replicate the aggregated analyses of price dispersion and price competition using only the data that corresponds to the fifteen fortnights before the start of Tesco's LPG. The numbering of the tables correspond to that of the main body of the paper and an *a* is added to distinguish them.

Table 4.5a: Wilconxon Test for Differences in the Price Dispersion across Quality Variants

Test I	**BP-HQ**	T	CV 5%*	CSS	One/Two-Sided
	TE-SA	199	389	46	One-Sided
	TE-SF	136	389	46	One-Sided
	SA-SF	128	389	46	One-Sided
Test II	**HQ-LQ**				
	TE-SA	548	353	44	One-Sided
	TE-SF	461	371	45	One-Sided
	SA-SF	540	389	46	One-Sided
Test III	**BP-LQ**				
	TE-SA	216	371	45	One-Sided
	TE-SF	274	389	46	One-Sided
	SA-SF	288	389	46	One-Sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV5\%$.
Corrected Sample Size (CSS)=Sample Size − Number of Zero Differences

The results obtained confirm that for the period before the start of the LPG:

$\mathbf{DPDI}_{HQ}^{J-K} > \mathbf{DPDI}_{BP}^{J-K}$

$\mathbf{DPDI}_{HQ}^{J-K} \approx \mathbf{DPDI}_{LQ}^{J-K}$

$\mathbf{DPDI}_{LQ}^{J-K} > \mathbf{DPDI}_{BP}^{J-K}$

Table 4.6a: Wilconxon Test for Differences in the Degree of Between-Supermarket Price Dispersion

BP	T	CV 5%*	CSS	One/Two-sided
TE-SA vs. TE-SF	396	279	41	Two-sided
TE-SA vs. SA-SF	346	249	39	Two-sided
TE-SF vs. SA-SF	280	249	39	Two-sided
HQ				
TE-SA vs. TE-SF	475	343	45	Two-sided
TE-SA vs. SA-SF	435	327	44	Two-sided
TE-SF vs. SA-SF	459	310	43	Two-sided
LQ				
TE-SA vs. TE-SF	247	279	41	Two-sided
TE-SF vs. SA-SF	378	294	42	Two-sided
TE-SF vs. SA-SF	315	249	39	Two-sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV$ 5%.
Corrected Sample Size(CSS) = Sample Size − Number of Zero Differences.

For the period before the start of the LPG it is true that:

$$\mathbf{DPDI}_J^{TE-SA} \approx \mathbf{DPDI}_J^{TE-SF} \text{ for } J=BP,HQ$$

$$\mathbf{DPDI}_J^{TE-SA} \approx \mathbf{DPDI}_J^{SA-SF} \text{ for } J=BP,HQ,LQ$$

$$\mathbf{DPDI}_J^{TE-SF} \approx \mathbf{DPDI}_J^{SA-SF} \text{ for } J=BP,HQ,LQ$$

The only difference with the full sample analysis is that in this case we reject the null hypothesis of $\mathbf{DPDI}_{LQ}^{TE-SA} \approx \mathbf{DPDI}_{LQ}^{TE-SF}$

Table 4.7a: Wilconxon Test for Differences in Price Coord. across Quality Variants

Test IV	**BP-HQ**	T	CV 5%	CSS	One/Two Sided
	TE-SA	338.5	371	45	One-sided
	TE-SF	265.5	389	46	One-sided
	SA-SF	287	371	45	One-sided
Test V	**LQ-HQ**	T	CV 5%		
	TE-SA	373	389	46	One-sided
	TE-SF	364.5	371	45	One-sided
	SA-SF	385	389	46	One-sided
Test VI	**BP-LQ**	T	CV 5%		
	TE-SA	407	336	43	One-sided
	TE-SF	474.5	371	45	One-sided
	SA-SF	458	371	45	One-sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV$ 5%.
Corrected Sample Size (CSS) = Sample Size − Number of Zero differences

As for the whole-period analysis in the period before the start of the LPG it is true that:

$\mathbf{DDPMI}_{BP}^{J-K} > \mathbf{DDPMI}_{HQ}^{J-K}$

$\mathbf{DDPMI}_{LQ}^{J-K} > \mathbf{DDPMI}_{HQ}^{J-K}$

$\mathbf{DDPMI}_{BP}^{J-K} \approx \mathbf{DDPMI}_{LQ}^{J-K}$

Table 4.9a: Wilconxon Test for Differences in the Degree of Between-Supermarket Competition

BP	T	CV 5%	CSS	One/Two-sided
TE-SA vs. TE-SF	336.5	264	40	Two-sided
TE-SA vs. SA-SF	289.5	208	36	Two-sided
TE-SF vs. SA-SF	274	249	39	Two-sided
HQ				
TE-SA vs. TE-SF	436	310	43	Two-sided
TE-SA vs. SA-SF	379.5	279	41	Two-sided
TE-SF vs. SA-SF	334.5	249	39	Two-sided
LQ				
TE-SA vs. TE-SF	339	279	41	Two-sided
TE-SA vs. SA-SF	384	279	41	Two-sided
TE-SF vs. SA-SF	267	235	38	Two-sided

*Critical Value at 5% significance level. Rejection of the H_0 if $T \leq CV$ 5%.
Corrected Sample Size (CSS) = Sample Size − Number of Zero Differences

In the period before the start of the LPG,

$\mathbf{DPDI}_{J}^{TE-SA} \approx \mathbf{DPDI}_{J}^{TE-SF}$ for J=BP,HQ,LQ

$\mathbf{DPDI}_{J}^{TE-SA} \approx \mathbf{DPDI}_{J}^{SA-SF}$ for J=BP,HQ,LQ

$\mathbf{DPDI}_{J}^{TE-SF} \approx \mathbf{DPDI}_{J}^{SA-SF}$ for J=BP,HQ,LQ

In the whole period analysis,

$\mathbf{DPDI}_{LQ}^{TE-SA} \approx \mathbf{DPDI}_{LQ}^{TE-SF}$

$\mathbf{DPDI}_{LQ}^{TE-SA} > \mathbf{DPDI}_{LQ}^{SA-SF}$

$\mathbf{DPDI}_{LQ}^{TE-SF} > \mathbf{DPDI}_{LQ}^{SA-SF}$

The fact that in the period before the start of the LPG the DDPMI for the LQs is similar for the three supermarket pairs confirms that the cause of the greater degree of price coordination of Sainsbury and Safeway with Tesco than between them in the whole period analysis is Tesco's LPG.

E: Figures Disaggregated Analysis

Figure 1: Disaggregated Analysis of Price Dispersion

←+ Price Dispersion	**- Price Dispersion →**

TE-SA BP H=5.7985

```
   HYGIENICS          GROCERIES          HOUSEHOLD          CANNED
*************************************************************************************

```

TE-SF BP H=8.4942*

```
   HYGIENICS          GROCERIES          HOUSEHOLD          CANNED
********************  *************************************************************
******************************************
```

SA-SF BP H=9.2947*

```
   HYGIENICS          GROCERIES          HOUSEHOLD          CANNED
********************  *************************************************************
******************************************
```

TE-SA HQ H=9.9281*

```
   HYGIENICS          GROCERIES          CANNED          HOUSEHOLD
*****************************************  ******************************************
***************************************************************
```

TE-SF HQ H=9.3003*

```
   HYGIENICS          GROCERIES          CANNED          HOUSEHOLD
*****************************************************************  *******************
```

SA-SF HQ H=13.0723*

```
   HYGIENICS          GROCERIES          CANNED          HOUSEHOLD
*****************************************  ******************************************
                     ******************************************
```

TE-SA LQ H=4.3963

```
   CANNED          HYGIENICS          HOUSEHOLD          GROCERIES
*************************************************************************************
```

TE-SF LQ H=1.9000

```
   HYGIENICS          CANNED          GROCERIES          HOUSEHOLD
*************************************************************************************
```

SA-SF LQ H=1.8560

```
   CANNED          HYGIENICS          GROCERIES          HOUSEHOLD
*************************************************************************************
```

* Significant at 5% level. Figures have been built using 30% level of significance for the Dunn´s Procedure. See Appendix B.

Figure 2: Disaggregated Analysis of Price Competition

←+ **Price Competition**	**- Price Competition →**

TE-SA BP H=6.0165
CANNED HOUSEHOLD GROCERIES HYGIENICS
****

TE-SF BP H=9.0503*
CANNED HOUSEHOLD GROCERIES HYGIENICS
** **

SA-SF BP H=10.4520*
CANNED HOUSEHOLD GROCERIES HYGIENICS
** **

TE-SA HQ H=4.7990
HOUSEHOLD GROCERIES CANNED HYGIENICS
****

TE-SF HQ H=3.3498
HOUSEHOLD GROCERIES CANNED HYGIENICS
****

SA-SF HQ H=8.3215*
HOUSEHOLD GROCERIES CANNED HYGIENICS
******************** ***

TE-SA LQ H=0.0687
HYGIENICS CANNED GROCERIES HOUSEHOLD
****

TE-SF LQ H=0.1905
HOUSEHOLD HYGIENICS CANNED GROCERIES
****

TE-SF LQ H=0.4903
CANNED GROCERIES HOUSEHOLD HYGIENICS
****

* Significant at 5% level. Figures have been built using 30% level of significance for the Dunn´s Procedure. See Appendix B.

F:List of Products in the sample

CANNED PRODUCTS (5)	Baked Beans in Tomato Sauce (Heinz 425 grs)
	Canned Peas (Hartley's Garden Peas)
	Canned Spaghetti (Heinz 200 grs)
	Canned Sweet Corn (Green Giant 340grs)
	Canned Tomatoes (Napolina Chopped Tomatoes 400grs)
HOUSEHOLD SUNDRIES (8)	Bleach (Domestos Bleach 2l)
	Conditioner (Lenor Ultra Plus Fabric Conditioner 2l)
	Kitchen Foil (Bacofoil 450mm x5m)
	Kitchen Towel (Andrex Kitchen Towel Twin Pack)
	Tissues (Ultra 90. Kleenex)
	Toilet Roll (Twin Andrex 4)
	Washing Powder (Ariel Future 2kgs)
	Washing Up Liquid (Fairy Excel Plus 500ml)
ALCOHOL PRODUCTS (1)	Beer (Heineken 330 ml)
GROCERIES (24)	Bread (Mighty White. 800 grs)
	Cat Food (Whiskas 400grs)
	Coffee (Nescafe 200grs)
	Cornflakes (Kellogs Cornflakes 500grs)
	Dog Food (Chum Original Large 400gr)
	Fish Fingers (10 Birds Eye)
	Flour (Homepride Flour 1,5kgs)
	Frozen Peas (Birds Eye 340 grs)
	Ice Cream (Walls Vanilla 750grs)
	Ketchup (Heinz 340grs)
	Margarine (Flora 500 grs)
	Mayonneise (Hellmans 400 grs)
	Oven Chips (McCain 1810 grs)
	Pasta Sauce (Dolmio Pasta sauce Original 475 grs)
	Peach Halves in Natural Juice (Del Monte 415 grs)
	Rice (Uncle Ben Long Grain Rice 1 kg)
	Salad Dressing (Heinz Salad Dressing 285 grs)
	Smoked Back (Danepack 8s)
	Spaghetti (Buitoni 500grs)
	Strawberry Jam (Robertson 454 grs)
	Tea (PG Tips 250 grs)
	Tuna in Oil (John West 200grs)
	Walkers Crisps (Variety Multipack. 6 packs)
	Yogourth (Muller Strawberry 200 grs)
SOFT DRINKS (2)	Coca-Cola (2 l)
	Orange Juice (Del Monte 1 L)
HYGIENIC PRODUCTS (6)	Deodorant (Sure 24 hours Apa 150 ml)
	Hair Shampoo (Timotei Herbs Shampoo 400grs)
	Sanitary towels (Always 16)
	Shower Gel (Imperial Leather 500ml)
	Soap (Dove 250 grs)
	Toothpaste (Colgate Total 100ml)

Chapter 5

Pricing Behaviour at the UK supermarkets: Does Quality Matter?[1]

Abstract

We use an econometric model of simultaneous equations with error components to analyse the influence of between supermarket and within supermarket competition to determine supermarket patterns of price setting for the different categories they sell: brand products, high quality own brand products and low quality own brand products. The use of panel data allows the multiproduct-multiquality nature of the supermarket to be taken into account. In addition, the use of EC3SLS estimator provides efficient and consistent estimations of the parameters representing between supermarket and within supermarket price competition. The results confirm that between supermarket price competition is more intense for those categories with less possibilities of supermarket product differentiation: brand products and low quality own brand products. On the basis of these differences in intensity of price competition across supermarkets, we provide an alternative explanation to the fact of higher profits of the UK supermarkets in comparison with their continental counterparts.

5.1 Introduction

As explained in previous chapters, the UK supermarkets offer to the consumer three quality variants for most of the products they sell. These are, listed from higher to lower quality: brand products (BP), high quality own brand products (HQ) and low quality own brand products (LQ). When setting the price of a given quality variant of

[1]We would like to thank to seminar participants at the University of Warwick Workshop of Industrial Economics, 25th EARIE conference (Copenhagen), XIV Jornadas de Economía Industrial and XXIII Simposio de Análisis Economico for helpful comments.

a product, supermarkets have to take into account not only the competition within the supermarket by variants of different quality but also the competition by variants sold at other supermarkets.

In Chapter 4, we analysed price setting for each one of the quality variants just taking into account the influence of the price setting by other supermarkets for the same quality variant. The aim of this chapter is to take also into account the influence in the price setting for each one of the quality variants of the price setting of the other quality variants sold within the supermarket.

We consider the price setting decision by the supermarket as the final stage of a multistage game. In the first stage of the game the supermarket takes the long run decision about the range of quality variants to sell and the specific quality of the variants. In the second stage the supermarket sets prices[2]. Most of the studies carried out about retailing ignore either between or within supermarket competition. Bliss [1988] deliberately does not consider the existence of own brand products and therefore the existence of different quality variants competing within the supermarket. However, the increasing market share of sales represented by the own brand products (around 36% of the total sales in value) makes it essential to consider within supermarket competition in the analysis of the supermarket price setting. Mills [1995] sets the conditions under which it is profitable for the supermarket to sell an own brand product in addition to the BP, but does so assuming it to be a multiproduct monopolist. Hence, he ignores the influence of the competition among supermarkets when the supermarket chooses quality and price sequentially. For the purpose of this paper, we consider just the second stage of the game, the pricing decision

We hypothesize that the consumers according to their willingness to pay for quality make an a priori decision about the quality variant to buy before going to the super-

[2]See Moorthy [1988] for an explanation of this multistage game.

market. However, the final quality variant bought will depend on the comparison in the supermarket of the prices of the different quality variants. As regards the consumers' decision about the store, we believe that the variables influencing this decision vary across consumers depending on the quality variant they are more likely to buy. As BPs are homogeneous across supermarkets, for those consumers whose shopping basket contains mostly BPs, location and supermarket average level of prices will be the main determinants of the store decision. Because of their character of very basic products the possibilities of supermarket differentiation for the LQs are very small. As a result, for those consumers whose shopping basket contains mostly LQs, location and average level of prices are again the main variables considered when choosing the supermarket. The HQs are the quality variant with greater possibilities of supermarket differentiation, hence those consumers whose shopping basket is mainly composed of HQ products will consider an additional choice variable: the supermarket-characteristics of the products[3].

Therefore, we assume that the supermarket will set prices for the three quality variants to maximize profits taking into account the competition by other supermarkets, i.e. the prices set by other supermarkets.

In this chapter, we build an econometric model that allows for control of both the effects of between and within supermarket competition on the price setting of the different quality variants considered. In addition, we analyse relevant points for supermarket pricing policies and competition issues such as:

- the relationship between product differentiation possibilities and price setting interdependence between supermarkets;

- the detection of supermarket price leadership for the different quality variants;

[3]While we can find Heinz Baked Beans at all the supermarket we only can find Sainsbury Baked Beans with its particular taste and packaging at Sainsbury.

- the interdependence between the price setting of the different quality variants within the supermarket;

- assessing the importance of direct and indirect between supermarket price effects, where we understand as indirect price effect those that take place through the within supermarket price readjustment;

In addition, we explore the role played by the differences in intensity of price competition across quality variants to explain the higher profits of the UK supermarkets with respect to their continental counterparts [The Economist, March, 1995].

The analysis is performed using a panel of micro level price data. These prices were directly taken in three adjacent supermarkets that correspond to three of the four chains with largest market share in the UK: Tesco, Sainsbury and Safeway. We obtain efficient and consistent estimations of the system of simultaneous equations characterising the supermarket behaviour by using an EC3SLS estimator. In addition the joint consideration of both structural and reduced form parameters of this system of equations allow us to control for both direct and indirect between supermarket price effects.

The empirical work detects the presence of price leadership by Tesco for the high quality own brand products. This fact is not surprising if we consider that in the last years Tesco has taken over Sainsbury's leadership in the sector. As expected, the results confirm the existence of an inverse relationship between supermarket product differentiation possibilities and supermarkets price interdependence. Price interdependence between supermarkets is higher for the categories with less scope for supermarket differentiation: branded products and low quality own brand products. Within supermarket, it is true for all the three supermarkets that the price setting of the intermediate quality (HQ) is affected more by the price setting of the higher quality (BP) than by the price setting of the lower quality (LQ). This is just reflecting the objective of the supermarkets when introducing the HQs: competing with the BPs.

The joint consideration of the high market share of the HQs and the comparative lower degree of between supermarket competition for this variant provides an additional explanation to the higher profits of the UK supermarkets in comparison with other EU supermarkets.

The rest of the chapter is organized as follows. Section 2 introduces the theoretical framework. Section 3 describes the data used in the analysis. Section 4 is devoted to the methodology. Section 5 deals with the analysis of the results. Finally the conclusions are presented in Section 6.

5.2 Theoretical Framework

A supermarket product faces both competition from variants of different quality sold at the same supermarket as well as competition from variants of the same and different quality sold at other supermarkets. In our study the first form of competition will be referred to as within supermarket competition. The idea is to model the competition that takes place within the supermarket between the quality variants they sell: BP, HQ and LQ, e.g. DelMonte Orange Juice vs. Sainsbury Orange Juice. The competition from variants sold at different supermarkets will be referred to as between supermarket competition. The between supermarket competition assumes quality equivalence of quality variants across supermarkets, e.g. the quality of the Tesco HQ Orange Juice is the same that the quality of Sainsbury HQ Orange Juice[4].

In order to set up an econometric model taking into account both the effects of within and between supermarket competition, we present first a model controlling just for the effects of within supermarket competition. Then we redefine this model

[4]The reasons behind this assumption were explained in Chapter 4.

to introduce the influence of between supermarket competition in supermarket price setting.

5.2.1 Within supermarket competition

In order to analyze within supermarket competition we can consider the supermarket as a multiproduct monopolist [Mills, 1995] selling three variants of the same product with perceived qualities $q_{BP} > q_{HQ} > q_{LQ}$ at prices $p_{BP} > p_{HQ} > p_{LQ}$. With the aim of simplifying the notation we make $q_{BP} = q_3, q_{HQ} = q_2$ and $q_{LQ} = q_1$.

Let us consider a continuum of consumers identical in tastes but differing in their willingness to pay for quality. Consumers' willingness to pay for quality (θ) is assumed to be uniformly distributed with density equal to 1 on [a,b]. The consumer makes indivisible and mutually exclusive purchases among the three goods sold at the supermarket. It means that the consumer buys either exactly one unit of the good or none. Utility from consuming a good of quality q_k is assumed to take the specific form [Gabszewicz et al, 1986] :

$$U_k = q_k(\theta_k - p_k)$$

the utility obtained for consuming nothing, U_0, is referred as $q_0\theta$.[5]

Let θ_k be the willingness to pay for quality such that the consumer with this particular willingness to pay for quality is indifferent between buying the good of quality k and the good of quality $k-1$

$$\theta_k = \frac{q_k}{q_k - q_{k-1}} p_k - \frac{q_{k-1}}{q_k - q_{k-1}} p_{k-1}$$

We can make use of this willingness to pay-splitting property (everyone within a specific willingness to pay band buys a given quality) to write demands for each one of the qualities as:

[5] U_0 can be interpreted as the utility of the outside option.

$D_{LQ} = \theta_2 - \theta_1$
$D_{HQ} = \theta_3 - \theta_2$
$D_{BP} = b - \theta_3$

The profits of the monopolist multiproduct supermarket are given by:

$$\pi_s = D_{LQ}(p_{LQ} - c_{LQ}) + D_{HQ}(p_{HQ} - c_{HQ}) + D_{BP}(p_{BP} - c_{BP})$$

and from the first order conditions that solve the maximization problem of the monopolist multiproduct supermarket we can derive the "within supermarket" best response functions. In these best response functions the price setting for each one of the qualities depends on the price setting for its quality neighbour/neighbours[6].

$$\frac{\partial \pi_s}{\partial p_{BP}} = 0;\ p_{BP} = \alpha_1 + \gamma_{11} p_{HQ}$$
$$\frac{\partial \pi_s}{\partial p_{BP}} = 0;\ p_{HQ} = \alpha_2 + \gamma_{21} p_{BP} + \gamma_{22} p_{LQ}$$
$$\frac{\partial \pi_s}{\partial p_{LQ}} = 0;\ p_{LQ} = \alpha_1 + \gamma_{31} p_{HQ}$$

The supermarkets carry out their price-quality space maximization by choosing price for the BP variant and quality and price for HQ and LQ variants. For the purpose of this analysis we will take the long run quality decision as given. The existence of brand loyal consumers force the supermarkets to keep in stock BPs. The role played by the HQs is to compete against the BPs for those consumers located in the upper and medium segment of the market that are willing to exchange the brand name for a

[6]The parameters have the following functional form:

$$\gamma_{11} = \frac{1}{2}\left(1 + \frac{q_2}{q_3}\right)$$

$$\gamma_{22} = \frac{1}{2}\left(1 + \frac{q_1 q_3 - q_2^2}{q_2(q_3 - q_1)}\right), \gamma_{21} = \frac{1}{2}\left(1 + \frac{q_2^2 - q_1 q_3}{q_2(q_3 - q_1)}\right)$$

$$\gamma_{31} = \frac{1}{2}\left(1 + \frac{q_1^2 - q_1 q_0}{q_1(q_2 - q_0)}\right)$$

price discount buying a product of very similar objective quality. The cost advantage enjoyed by the supermarket as a multiproduct firm (economies of scale in advertising and product development, umbrella branding, etc.) and its advantageous position in the bargaining process determining the OBP wholesale price allows it to offer a product of similar quality to the BP at lower price.

However, when introducing the LQ variant the main concern of the supermarkets was not quality but price. In order to fight back against the discounters for the lower and more price sensitive segment of the market, the supermarkets introduced a range of products of manifestly lower quality than BPs and HQs sold at a very low price. To avoid the risk of sales cannibalization between the two ranges of own brand products, the supermarkets from the beginning established a clear distinction in terms of quality packaging, advertising and brand name.

The different supermarket strategies when introducing each one of the two own-brand quality variants determine the distribution of qualities within the UK supermarket. The result is a distribution in which the quality of the intermediate quality (HQ) is closer to the quality of its upper quality neighbour (BP) than to the quality of its lower quality neighbour (LQ). This has two main implications for the within supermarket best response functions: on the one hand, HQ price setting should be more influenced by BP price setting than by LQ price setting (i.e. $\gamma_{21} > \gamma_{22}$); on the other hand, HQ price setting should influence more BP price setting than LQ price setting (i.e. $\gamma_{11} > \gamma_{31}$).

5.2.2 A model of within and between supermarket competition

The problem of considering just within supermarket competition is that we are ignoring the effect of the competition by other supermarkets on supermarket price setting.

Therefore, the next step will consist of defining an econometric model that allows for joint consideration of both forms of competition.

In order to define this model we assume that supermarket J when setting the prices for the three quality variants of product m at time t has perfect information about the prices at time $t-1$ for the three quality variants of product m at supermarkets H and K . Using this information and given qualities, supermarket J choose prices according to the following structural system of simultaneous equations:

$$\begin{aligned} p_{it}^{J_{BP}} &= \alpha_1^J + \gamma_{11}^J p_{it}^{J_{HQ}} + \beta_{11}^J p_{it-1}^{H_{BP}} + \beta_{12}^J p_{it-1}^{K_{BP}} \\ p_{it}^{J_{HQ}} &= \alpha_2^J + \gamma_{21}^J p_{it}^{J_{BP}} + \gamma_{22}^J p_{it}^{J_{LQ}} + \beta_{21}^J p_{it-1}^{H_{HQ}} + \beta_{22}^J p_{it-1}^{K_{HQ}} \\ p_{it}^{J_{LQ}} &= \alpha_3^J + \gamma_{31}^J p_{it}^{J_{HQ}} + \beta_{31}^J p_{it-1}^{H_{LQ}} + \beta_{32}^J p_{it-1}^{K_{LQ}} \end{aligned} \tag{5.1}$$

where:

J, H, K: supermarkets considered in the analysis ; $i = 1, ..., n$ products considered in the analysis ; $t = 1, ..., T$ number of periods considered in the analysis ; $p_{it}^{J_q}$:price of the variant of quality q of product i at supermarket J in period t.

We will consider as many systems of equations as supermarkets included in the analysis. In this case three.

In this structural system of simultaneous equations describing price setting behaviour we control for within supermarket competition by means of the within-supermarket best-response functions. In order to control for the effects of between-supermarkets competition we have added to the right-hand side of each one of the within-supermarket best-response functions the price effects of supermarket-differentiated variants of the same quality. For example, in the first of the equations we make the price of the BP at supermarket J in the period t to depend on the price of the BP at supermarkets H and K in the period *t-1*. As the horizontally differentiated variants of the same quality sold at different supermarkets are strategic complements we assume that the β's>0.

The structure of this model describing supermarket pricing behaviour is given by our assumptions about price effects between supermarket differentiated variants. We consider the price effects between supermarket differentiated variants of the same quality as direct price effects (e.g. $p_{it-1}^{H_{BP}}, p_{it-1}^{K_{BP}}$ have a direct price effect on $p_{it}^{J_{BP}}$) and include them in the right-hand side of the relevant within-supermarket best-response function. However, the price effects between supermarket differentiated variants of different quality are considered as indirect price effects and assumed to act through direct price effects. In order to illustrate this assumption we can use as example the effect of $p_{it-1}^{H_{BP}}$ on $p_{it}^{J_{HQ}}$: $p_{it-1}^{H_{BP}}$ affects $p_{it}^{J_{HQ}}$ through the within supermarket price readjustment that its direct price effect on $p_{it}^{J_{BP}}$ starts.

The total price effects between supermarket differentiated variants of the same quality (e.g. $p_{it-1}^{K_{BP}}$ on $p_{it}^{J_{BP}}$) are not just exhausted by the direct price effect caught the structural form coefficient. We must consider that the supermarket is selling more than one quality variant and account for the indirect price effect that takes place through the within supermarket price readjustment that any direct price effect starts.

The structural form coefficients gives us just direct price effects between supermarket-differentiated variants of the same quality without considering within supermarket price readjustment, e.g. the effect of $p_{it-1}^{H_q}$ over $p_{it}^{J_q}$ assuming the prices set by supermarket J for the other two quality variants are constant. Therefore, in order to assess properly both price effects between supermarket differentiated variants of the same quality and price effects between supermarket-differentiated variants of different quality we have to determine the reduced-form of the system.

$$\begin{aligned}
p_{it}^{J_{BP}} &= A_1 + \pi_{11}\mathbf{p}_{it-1}^{H_{BP}} + \pi_{12}\mathbf{p}_{it-1}^{K_{BP}} + \pi_{13}p_{it-1}^{H_{HQ}} + \pi_{14}p_{it-1}^{K_{HQ}} + \pi_{15}p_{it-1}^{H_{LQ}} + \pi_{16}p_{it-1}^{K_{LQ}} \\
p_{J_{it}}^{J_{HQ}} &= A_2 + \pi_{21}p_{it-1}^{H_{BP}} + \pi_{22}p_{it-1}^{K_{BP}} + \pi_{23}\mathbf{p}_{it-1}^{H_{HQ}} + \pi_{24}\mathbf{p}_{it-1}^{K_{HQ}} + \pi_{25}p_{it-1}^{H_{LQ}} + \pi_{26}p_{it-1}^{K_{LQ}} \\
p_{J_{it}}^{LQ} &= A_3 + \pi_{31}p_{it-1}^{H_{BP}} + \pi_{32}p_{it-1}^{K_{BP}} + \pi_{33}p_{it-1}^{H_{HQ}} + \pi_{34}p_{it-1}^{K_{HQ}} + \pi_{35}\mathbf{p}_{it-1}^{H_{LQ}} + \pi_{36}\mathbf{p}_{it-1}^{K_{LQ}}
\end{aligned} \tag{5.2}$$

In this reduced-form system[7], supermarket J prices at time t for each one of the quality variants are expressed as a function of the prices set by the other two supermarkets (H and K) at time *t-1* for each one of the three quality variants they sell. The highlighted parameter in this system correspond to total price effects (once within supermarket price readjustment has been allowed) between supermarket-differentiated variants of the same quality. The rest of parameters correspond to price effects between supermarket-differentiated variants of different quality that here are assumed indirect price effects.

We capture the multiproduct nature of the supermarket[8] by means of a panel data set of supermarket product prices[9].

Using this econometric model we are interested in exploring the following questions:

- detection of possible price leaderships in the price setting of each one of the three quality variants considered;

- analysing the effects of supermarket differentiation possibilities on the intensity of the price effects between supermarket-differentiated variants of the same quality;

- comparison of the intensity of between supermarket price effects for supermarket-differentiated variants of the same quality and supermarket-differentiated variants of different quality

- within supermarket: exploring the price relationships between the different quality variants sold by the supermarket;

[7] The existence of a reduced form of the model requires $1 - \gamma_{11}\gamma_{31} - \gamma_{22}\gamma_{31} \neq 0$. The expressions for the reduced form parameters can be seen in Appendix A.

[8] Multiproduct in the sense that the supermarket sells the three quality variants for a full range of products.

[9] The use of panel data provides additional advantages as controlling for individual hetereogeneity [Hsiao, 1986].

5.3 The data

The data set used in the analysis was already described in Chapter 4.

5.4 Methodology

5.4.1 Estimation Model

The final simultaneous equation model describing the pricing behaviour of each one of the supermarkets is as follows:

Tesco's Structural System of Simultaneous Equations

$$p_{it}^{TE_{BP}} = \alpha_1^{TE} + \gamma_{11}^{TE} p_{it}^{TE_{HQ}} + \beta_{11}^{TE} p_{it-1}^{SA_{BP}} + \beta_{12}^{TE} p_{it-1}^{SF_{BP}} + u_1^{TE}$$
$$p_{it}^{TE_{HQ}} = \alpha_2^{TE} + \gamma_{21}^{TE} p_{it}^{TE_{BP}} + \gamma_{22}^{TE} p_{it}^{TE_{LQ}} + \beta_{21}^{TE} p_{it-1}^{SA_{HQ}} + \beta_{22}^{TE} p_{it-1}^{SF_{HQ}} + u_2^{TE}$$
$$p_{it}^{TE_{LQ}} = \alpha_3^{TE} + \gamma_{31}^{TE} p_{it}^{TE_{HQ}} + \beta_{31}^{TE} p_{it-1}^{SA_{LQ}} + \beta_{32}^{TE} p_{it-1}^{SF_{LQ}} + u_3^{TE}$$

Sainsbury's Structural System of Simultaneous Equations

$$p_{it}^{SA_{BP}} = \alpha_1^{SA} + \gamma_{11}^{SA} p_{it}^{SA_{HQ}} + \beta_{11}^{SA} p_{it-1}^{TE_{BP}} + \beta_{12}^{SA} p_{it-1}^{SF_{BP}} + u_1^{SA}$$
$$p_{it}^{SA_{HQ}} = \alpha_2^{SA} + \gamma_{21}^{SA} p_{it}^{SA_{BP}} + \gamma_{22}^{SA} p_{it}^{SA_{LQ}} + \beta_{21}^{SA} p_{it-1}^{TE_{HQ}} + \beta_{22}^{SA} p_{it-1}^{SF_{HQ}} + u_2^{SA}$$
$$p_{it}^{SA_{LQ}} = \alpha_3^{SA} + \gamma_{31}^{SA} p_{it}^{SA_{HQ}} + \beta_{31}^{SA} p_{it-1}^{TE_{LQ}} + \beta_{32}^{SA} p_{it-1}^{SF_{LQ}} + u_3^{SA}$$

Safeway's Structural System of Simultaneous Equations

$$p_{it}^{SF_{BP}} = \alpha_1^{SF} + \gamma_{11}^{SF} p_{it}^{SF_{HQ}} + \beta_{11}^{SF} p_{it-1}^{TE_{BP}} + \beta_{12}^{SF} p_{it-1}^{SA_{BP}} + u_1^{SF}$$
$$p_{it}^{SF_{HQ}} = \alpha_2^{SF} + \gamma_{21}^{SF} p_{it}^{SF_{BP}} + \gamma_{22}^{SF} p_{it}^{SF_{LQ}} + \beta_{21}^{SF} p_{it-1}^{TE_{HQ}} + \beta_{22}^{SF} p_{it-1}^{SA_{HQ}} + u_2^{SF}$$
$$p_{it}^{SF_{LQ}} = \alpha_3^{SF} + \gamma_{31}^{SF} p_{it}^{SF_{HQ}} + \beta_{31}^{SF} p_{it-1}^{TE_{LQ}} + \beta_{32}^{SF} p_{it-1}^{SA_{LQ}} + u_3^{SF}$$

Variable definition:

$p_{it}^{J_q}$: logarithm of the price of the quality variant q of product i in fortnight t at supermarket J; J : Supermarkets considered: Tesco, Sainsbury, Safeway ; q : quality variants: BP, HQ and LQ; $i = 1, ..., 46$ products in the sample ; $t = 1, ..., 27$ fortnightly observations.

In each one of the structural-form systems above, we assume a one-way error component for the disturbances. Thus, the disturbance of the j structural equation is given by:

$$u_j = Z_\mu \mu_j + v_j \text{ for } j = 1,...,3$$

where $Z_\mu = (I_N \otimes i_t)$ [10]and $\mu_j' = (\mu_{1j}, \mu_{2j}, ..., \mu_{Nj})$ and

$v_j' = (v_{11j}, v_{12j}, ..., v_{1Tj}, ..., v_{N1j}, v_{N2j}, ..., v_{NTj})$ are random vectors with zero mean and covariance matrix

$$\Omega_{jl} = E(u_j u_l') = \sigma^2_{\mu_{jl}}(I_N \otimes J_T) + \sigma^2_{v_{jl}}(I_N \otimes I_T)$$

The consideration of the vector of product specific effects (μ_j) as random arises from the fact that the random effect model seems to be the appropriate specification when the sample is drawn from a large population as it is our case. Furthermore, it is assumed that the product specific effects are different for each one of the supermarkets, which will allow us for the separate estimation of the system of simultaneous equations that correspond to each one of the supermarkets.

The variance-covariance matrix for the set of M[11] structural equations is given by:

$$\Omega = \Sigma\,(uu') = \Sigma_\mu \otimes (I_N \otimes J_T) + \Sigma_v \otimes (I_N \otimes I_T)$$

where $u' = (u_1', u_2', ...u_M')$ is a $1\times$ MNT vector of disturbances. $\Sigma_\mu = \left[\sigma^2_{\mu_{jl}}\right]$ and $\Sigma_v = \left[\sigma^2_{v_{jl}}\right]$ are $M \times M$ matrices.

5.4.2 Identification and estimation method

Identification

Before proceeding to estimation we need to study identification.

We assume that at time t supermarket J, when setting the prices for the three quality variants of product m, has perfect information about the prices at time $t-1$ of the three quality variants of product m at supermarkets H and K[12]. Using this

[10] I_N : identity matrix of dimension N with N=46
i_t : vector of ones of dimension T with T=27
J_T : matrix of ones of dimension T
$\otimes$: Kronecker product

[11] In our particular case $M = 3$.

[12] This seems quite reasonable when we find advertising like this one by Tesco: "*We check more than 18000 prices every week so you do not have to do it*"

information and given qualities, supermarket J chooses prices to maximize profits. With this assumption, we can consider as exogenous for the estimation of supermarket J system the variables representing the prices set by supermarkets H and K at time $t-1$. The simultaneously decided prices of the three quality variants sold at supermarket J are considered as endogenous variables.

Given the identical structure of the structural form of the three systems of simultaneous equations specified above, we will illustrate identification using Tesco's structural system of simultaneous equations. For this system we consider as endogenous variables: $p_{it}^{TE_{BP}}, p_{it}^{TE_{HQ}}$ and $p_{it}^{TE_{LQ}}$. We consider as exogenous variables for the estimation of Tesco's system: $p_{it-1}^{SA_{BP}}, p_{it-1}^{SA_{HQ}}, p_{it-1}^{SA_{LQ}}, p_{it-1}^{SF_{BP}}, p_{it-1}^{SF_{HQ}}$ and $p_{it-1}^{SF_{LQ}}$.

We say that structural equation i is identified if the number of excluded exogenous variables (k_2) is larger than or equal to the number of right hand side endogenous variables (g_1)[13]. All the three equations of the identically structured systems of equations considered above satisfy this condition and therefore we can proceed to the estimation.

Estimation

Because the endogenous variables included in the right-hand side of each structural equation are correlated with the disturbances, usual OLS procedures provide inconsistent estimates of the structural parameters. We can consider two approaches that solve the inconsistency problem using instrumental variables. Single equation estimation methods like two-stage least squares (2SLS) obtain consistent estimations by estimating each equation separately. System methods of estimation like three-stage least squares (3SLS) that allow to control for relationships between equations provide an increase in efficiency [Greene, 1996].

When using a one-way error component model the equivalent estimation procedures

[13]Usually the order condition for identification is expressed as $k_2 > g_1$ for each one of the equations. It is also possible to show that each one of the equations satisfy the rank condition for identification.

to 2SLS and 3SLS are Error Components two-stage least squares (EC2SLS) and Error Components three-stage least squares (EC3SLS) as described by Baltagi [1995].

Given the efficiency gains of EC3SLS over EC2SLS, we will use EC3SLS as the estimation method. The estimation of the structural system of simultaneous equations provides us with estimators for the direct between and within supermarket price effects.

First, we estimate separately the structural form coefficients that correspond to each one of the supermarket systems using the EC3SLS estimator. Then, from the coefficients and variance-covariance matrix obtained in the estimation of the structural system of equations for each one of the supermarkets we can obtain estimations for the reduced form parameters and their correspondent variance-covariance matrix. We will use them to carry out tests concerning price effects between supermarket-differentiated variants of the same quality and price effects between supermarket differentiated variants of different quality. These reduced form systems take the following form for each one of the supermarkets:

Tesco's Reduced-Form System of Simultaneous Equations

$$\begin{aligned}
p_{it}^{TE_{BP}} &= A_1^{TE} + \pi_{11}^{TE} p_{it-1}^{SA_{BP}} + \pi_{12}^{TE} p_{it-1}^{SF_{BP}} + \pi_{13}^{TE} p_{it-1}^{SA_{HQ}} + \pi_{14}^{TE} p_{it-1}^{SF_{HQ}} + \pi_{15}^{TE} p_{it-1}^{SA_{LQ}} + \pi_{16}^{TE} p_{it-1}^{SF_{LQ}} \\
p_{it}^{TE_{HQ}} &= A_2^{TE} + \pi_{21}^{TE} p_{it-1}^{SA_{BP}} + \pi_{22}^{TE} p_{it-1}^{SF_{BP}} + \pi_{23}^{TE} p_{it-1}^{SA_{HQ}} + \pi_{24}^{TE} p_{it-1}^{SF_{HQ}} + \pi_{25}^{TE} p_{it-1}^{SA_{LQ}} + \pi_{26}^{TE} p_{it-1}^{SF_{LQ}} \\
p_{it}^{TE_{LQ}} &= A_3^{TE} + \pi_{31}^{TE} p_{it-1}^{SA_{BP}} + \pi_{32}^{TE} p_{it-1}^{SF_{BP}} + \pi_{33}^{TE} p_{it-1}^{SA_{HQ}} + \pi_{34}^{TE} p_{it-1}^{SF_{HQ}} + \pi_{35}^{TE} p_{it-1}^{SA_{LQ}} + \pi_{36}^{TE} p_{it-1}^{SF_{LQ}}
\end{aligned}$$

Sainsbury's Reduced-Form System of Simultaneous Equations

$$\begin{aligned}
p_{it}^{SA_{BP}} &= A_1^{SA} + \pi_{11}^{SA} p_{it-1}^{TE_{BP}} + \pi_{12}^{SA} p_{it-1}^{SF_{BP}} + \pi_{13}^{SA} p_{it-1}^{TE_{HQ}} + \pi_{14}^{SA} p_{it-1}^{SF_{HQ}} + \pi_{15}^{SA} p_{it-1}^{TE_{LQ}} + \pi_{16}^{SA} p_{it-1}^{SF_{LQ}} \\
p_{it}^{SA_{HQ}} &= A_2^{SA} + \pi_{21}^{SA} p_{it-1}^{TE_{BP}} + \pi_{22}^{SA} p_{it-1}^{SF_{BP}} + \pi_{23}^{SA} p_{it-1}^{TE_{HQ}} + \pi_{24}^{SA} p_{it-1}^{SF_{HQ}} + \pi_{25}^{SA} p_{it-1}^{TE_{LQ}} + \pi_{26}^{SA} p_{it-1}^{SF_{LQ}} \\
p_{it}^{SA_{LQ}} &= A_3^{SA} + \pi_{31}^{SA} p_{it-1}^{TE_{BP}} + \pi_{32}^{SA} p_{it-1}^{SF_{BP}} + \pi_{33}^{SA} p_{it-1}^{TE_{HQ}} + \pi_{34}^{SA} p_{it-1}^{SF_{HQ}} + \pi_{35}^{SA} p_{it-1}^{TE_{LQ}} + \pi_{36}^{SA} p_{it-1}^{SF_{LQ}}
\end{aligned}$$

Safeway's Reduced-Form System of Simultaneous Equations

$$\begin{aligned}
p_{it}^{SF_{BP}} &= A_1^{SF} + \pi_{11}^{SF} p_{it-1}^{TE_{BP}} + \pi_{12}^{SF} p_{it-1}^{SA_{BP}} + \pi_{13}^{SF} p_{it-1}^{TE_{HQ}} + \pi_{14}^{SF} p_{it-1}^{SA_{HQ}} + \pi_{15}^{SF} p_{it-1}^{TE_{LQ}} + \pi_{16}^{SF} p_{it-1}^{SA_{LQ}} \\
p_{it}^{SF_{HQ}} &= A_2^{SF} + \pi_{21}^{SF} p_{it-1}^{TE_{BP}} + \pi_{22}^{SF} p_{it-1}^{SA_{BP}} + \pi_{23}^{SF} p_{it-1}^{TE_{HQ}} + \pi_{24}^{SF} p_{it-1}^{SA_{HQ}} + \pi_{25}^{SF} p_{it-1}^{TE_{LQ}} + \pi_{26}^{SF} p_{it-1}^{SA_{LQ}} \\
p_{it}^{SF_{LQ}} &= A_3^{SF} + \pi_{31}^{SF} p_{it-1}^{TE_{BP}} + \pi_{32}^{SF} p_{it-1}^{SA_{BP}} + \pi_{33}^{SF} p_{it-1}^{TE_{HQ}} + \pi_{34}^{SF} p_{it-1}^{SA_{HQ}} + \pi_{35}^{SF} p_{it-1}^{TE_{LQ}} + \pi_{36}^{SF} p_{it-1}^{SA_{LQ}}
\end{aligned}$$

5.5 Analysis of the results

The results of the estimations of the three systems of equations both in their structural form and reduced form are included in Appendix B[14].

It is possible to observe that except one all the coefficients of the structural system of equations describing the supermarkets' pricing behaviour are different from zero at 10% significance level (most of them at 5%). Therefore, both between and within supermarket factors seem to be important to explain supermarkets' pricing behaviour.

We start the interpretation of the results by analysing between supermarket competition in section 5.5.1 and 5.5.2. Section 5.5.1 is devoted to the analysis of price effects between supermarket-differentiated variants of the same quality. In section 5.5.2 we analyse price effects between supermarket-differentiated variants of different quality to assess their relative importance with respect to the price effects between supermarket-differentiated variants of the same quality. Section 5.5.3 is addressed to test the predictions of the theoretical model about within supermarket competition.

5.5.1 Between supermarket competition: price effects between supermarket differentiated variants of the same quality

Price effects between supermarket-differentiated variants of the same quality: direct and indirect effects

When analysing price effects between supermarket-differentiated variants of the same quality, we can distinguish between the direct price effects caught by the structural form coefficients and the total price effects caught by the reduced form coefficients. The difference between direct price effect and total price effect, the indirect price effect, is given by the price readjustment process that takes place in each supermarket when facing changes in prices by the other supermarkets.

[14]We do not provide descriptive statistics for all the price series (414) for a question of space. They are available on request.

In Table 5.1, we show both total price effects (TPE) and direct price effects (DPE). We will use an example to explain how to read this table: 0.354 in the second row of the first column is the estimated parameter (reduced form parameter) catching TPE of $p_{it-1}^{SA_{BP}}$ over $p_{it}^{TE_{BP}}$ whereas 0.336 in the same row but in the second column is the estimated parameter (structural form parameter) catching only the direct price effect. It is possible to observe in this table that the DPE always represents at least 90% of the total price TPE. This evidence suggests us that most of the total effect of a change in the price of the variant q at supermarket J over the price of variant q at supermarket H takes place through the direct effect in the price of this quality variant and only a small portion of the change is explained through the price readjustment for the three quality variants that the supermarkets carries out to maximize the price quality space.

Table 5.1: Total and Direct Price Effects

BP	$p_{it}^{TE_{BP}}$		$p_{it}^{SA_{BP}}$		$p_{it}^{SF_{BP}}$	
	TPE	DPE	TPE	DPE	TPE	DPE
$p_{it-1}^{TE_{BP}}$			0.403	0.382	0.449	0.420
$p_{it-1}^{SA_{BP}}$	0.354	0.336			0.366	0.343
$p_{it-1}^{SF_{BP}}$	0.566	0.538	0.471	0.446		
HQ	$p_{it}^{TE_{HQ}}$		$p_{it}^{SA_{HQ}}$		$p_{it}^{SF_{HQ}}$	
	TPE	DPE	TPE	DPE	TPE	DPE
$p_{it-1}^{TE_{HQ}}$			0.516	0.486	0.447	0.414
$p_{it-1}^{SA_{HQ}}$	0.258	0.244			0.123	0.114
$p_{it-1}^{SF_{HQ}}$	0.282	0.267	0.154	0.145		
LQ	$p_{it}^{TE_{LQ}}$		$p_{it}^{SA_{LQ}}$		$p_{it}^{SF_{LQ}}$	
	TPE	DPE	TPE	DPE	TPE	DPE
$p_{it-1}^{TE_{LQ}}$			0.213	0.212	0.500	0.492
$p_{it-1}^{SA_{LQ}}$	0.330	0.328			0.407	0.401
$p_{it-1}^{SF_{LQ}}$	0.581	0.579	0.268	0.266		

As we are interested in the total between supermarket price effects once considered price readjustment within the supermarket, we analyse price effects between supermarket-differentiated variants of the same quality using the reduced form coefficients. One might expect an inverse relationship between the size of $\pi's$ that correspond to price effects between supermarket-differentiated variants of the same quality and the possibilities of supermarket product differentiation for each one of the quality variants. However, it is possible that these π's are catching some form of price leadership. We think that if there exists an explicit dominance of the influence of the price setting by one of the supermarkets in the other supermarkets price setting, we should control for the possibility of price leadership. Therefore, the interpretation of the π's that correspond to price effects between supermarket-differentiated variants of the same quality should first account for price leaderships and then for the possible inverse relationship between supermarket product differentiation and intensity of between supermarket competition, where intensity of between supermarket competition is proxied by the π's size.

Testing for price leadership

Before interpreting the estimated coefficients of the variables representing price effects between supermarket-differentiated variants of the same quality as inversely related with the possibilities of supermarket product differentiation for each one of the quality variants considered in the analysis, we should check for price leaderships. We understand that a price leadership of supermarket J for a given quality variant q exists if there is an explicit dominance of the price setting of supermarket J over the price setting of supermarkets K and H in this quality variant. On the basis of this definition of price leadership, we require two conditions for the price leadership of supermarket J for the quality variant q to exist[15]:

- the influence of price setting by supermarket J at time $t-1$ over price setting by supermarket H (K) at time t has to be significantly greater than the influence of price setting by supermarket $K(H)$ at time $t-1$ over price setting by supermarket $H(K)$

[15] The π parameters used in the tests of sections 5.5.1 and 5.5.2 correspond to the parameters of each one of the supermarkets reduced form systems of equations specified in section 5.4.2.

at t . For example, to check for price leadership by Sainsbury in the HQ variant we require that : $\pi_{23}^{TE} > \pi_{24}^{TE}$ and $\pi_{24}^{SF} > \pi_{23}^{SF}$

- and the influence of price setting by supermarket $H(K)$ at time $t-1$ over the price setting by supermarket J at time t has to be significantly smaller than the influence of price setting by supermarket J at time $t-1$ over the price setting by supermarket $H(K)$ at time t. For example, to check for price leadership by Sainsbury in the HQ category we require: $\pi_{23}^{SA} < \pi_{23}^{TE}$ and $\pi_{24}^{SA} < \pi_{24}^{SF}$.

The only phenomenon of price leadership that we detect is that by Tesco for the HQs[16]. In order to prove it we can check that Tesco's HQ price setting fulfills the two conditions that we have imposed for price leadership.

Both for Sainsbury's and Safeway's systems the coefficients that correspond to $p_{it-1}^{TE_{HQ}}$ (0.516 and 0.447) are significantly higher than the coefficients that correspond respectively to Safeway and Sainsbury HQ price setting in these two systems ($p_{it-1}^{SF_{HQ}}$[0.154] and $p_{it-1}^{SA_{HQ}}$[0.123] respectively). Therefore, the first of the conditions for price leadership is satisfied.

The fulfillment of the second condition, and so the price leadership by Tesco in the HQ variant, is confirmed when comparing the estimated coefficients that correspond to $p_{it-1}^{SA_{HQ}}$ and $p_{it-1}^{SF_{HQ}}$ in Tesco's system with the coefficients of $p_{it-1}^{TE_{HQ}}$ in Safeway's and Sainsbury's systems. Both the estimated coefficients for $p_{it-1}^{SA_{HQ}}$ (0.258) and $p_{it-1}^{SF_{HQ}}$(0.282) in Tesco's system of simultaneous equations are significantly lower than the coefficients for $p_{it-1}^{TE_{HQ}}$ in the other two systems of simultaneous equations (0.516 in the Sainsbury's system and 0.447 in Safeway's system)

Further insights about a possible Tesco's price leadership in the other quality variants have a negative result. The estimated coefficients representing the between supermarket influence of Tesco's price setting for BPs and LQs are not significantly higher

[16]The statistical analysis of Tesco's HQ price leadership is presented in Appendix C.

than those representing the price settings by Sainsbury and Safeway.

Supermarket product differentiation and price effects between supermarket-differentiated variants of the same quality.

Once we have accounted for Tesco price leadership for the HQ variant, we are interested in exploring the existence of a possible inverse relationship between possibilities of supermarket product differentiation and intensity of between supermarket competition for each one of quality variants.

Although, we already analysed the possibilities of supermarket product differentiation for each one of the quality variants in Chapter 4, we briefly recall them here. We explained that for the BPs, provided with identical specifications to all the supermarkets, the only possibility of product differentiation is supermarket location. The very nature of the LQ variant is limiting their possibilities of horizontal product differentiation. The LQs are basic products addressed to compete in price for the lowest segment of the market. Any additional product refinement would increase the price of the product and contradict the aim for which they were created. The result is products that are hardly differentiated across supermarkets. It is for the HQs that the supermarkets have the highest possibilities of differentiation. These products are addressed to compete with the BPs for the upper medium segment of the consumer distribution. This segment of consumers is concerned not only about the price but also about the characteristics of the products. Therefore, supermarkets have the possibility of differentiating their HQs introducing elements of horizontal product differentiation by means for example of advertising, taste, packaging, etc.

Thus, in absence of any price leadership, as HQs are the quality variant that offers greater possibilities of supermarket product differentiation, for the inverse relationship between supermarket product differentiation and intensity of between supermarket competition to be true the two following predictions should be confirmed for the three supermarket considered in the analysis:

1.- The influence of BP price setting by supermarket $H(K)$ on BP price setting by supermarket J should be greater than the influence of HQ price setting by supermarket $H(K)$ on HQ price setting by supermarket J. As we are testing separately for the influences by supermarkets H and K, we will check this prediction by means of two identical one-sided t-tests with null and alternative hypotheses[17]:

H-Influence	K-influence
$H^J_{011} : \varphi^J_{11} = \pi^J_{11} - \pi^J_{23} = 0$	$H^J_{012} : \varphi^J_{12} = \pi^J_{12} - \pi^J_{24} = 0$
$H^J_{111} : \varphi^J_{11} = \pi^J_{11} - \pi^J_{23} > 0$	$H^J_{112} : \varphi^J_{12} = \pi^J_{12} - \pi^J_{24} > 0$

For example, for the Tesco's system of simultaneous equations we could be testing if Tesco's BP price setting is more influenced by Sainsbury's BP price setting than Tesco's HQ price setting is influenced by Sainsbury's HQ price setting.

2.- The influence of LQ price setting by supermarket $H(K)$ on LQ price setting by supermarket J should be greater than the influence of HQ price setting by supermarket $H(K)$ on HQ price setting by supermarket J. As in prediction 1, the null and alternative hypotheses are:

H-Influence	K-influence
$H^J_{021} : \varphi^J_{21} = \pi^J_{35} - \pi^J_{23} = 0$	$H^J_{022} : \varphi^J_{22} = \pi^J_{36} - \pi^J_{24} = 0$
$H^J_{121} : \varphi^J_{21} = \pi^J_{35} - \pi^J_{23} > 0$	$H^J_{122} : \varphi^J_{22} = \pi^J_{36} - \pi^J_{24} > 0$

For example for Tesco's system of simultaneous equations, we could be testing if Safeway's LQ price setting affects Tesco's LQ price setting more than Safeway's HQ price setting affects Tesco's HQ price setting

[17]With respect to the subindex of the null and alternative hypotheses. The first number of the subindex is 0 if we are referring to a null hypothesis and 1 if we are referring to an alternative hypothesis. The two following numbers are test indicators. For example, H_{01} is the null hypothesis of test 1.

Table 5.2: Between supermarket price effects between variants of the same quality

	Description	Coefficient	Std.Errors.
TESCO			
$H_{011}: \varphi_{11}^{TE}=0;\ H_{111}: \varphi_{11}^{TE}>0$	SA→TE	0.096**	0.036
$H_{012}: \varphi_{12}^{TE}=0;\ H_{112}: \varphi_{12}^{TE}>0$	SF→TE	0.284**	0.036
$H_{021}: \varphi_{21}^{TE}=0;\ H_{121}: \varphi_{21}^{TE}>0$	SA→TE	0.071**	0.041
$H_{022}: \varphi_{22}^{TE}=0;\ H_{122}: \varphi_{22}^{TE}>0$	SF→TE	0.299**	0.037
SAINSBURY			
$H_{011}: \varphi_{11}^{SA}=0;\ H_{111}: \varphi_{11}^{SA}>0$	TE→SA	$\varphi_{11}^{SA}<0$	
$H_{012}: \varphi_{12}^{SA}=0;\ H_{112}: \varphi_{12}^{SA}>0$	SF→SA	0.317**	0.045
$H_{021}: \varphi_{21}^{SA}=0;\ H_{121}: \varphi_{21}^{SA}>0$	TE→SA	$\varphi_{21}^{SA}<0$	
$H_{022}: \varphi_{22}^{SA}=0;\ H_{122}: \varphi_{22}^{SA}>0$	SF→SA	0.114**	0.035
SAFEWAY			
$H_{011}: \varphi_{11}^{SF}=0;\ H_{111}: \varphi_{11}^{SF}>0$	TE→SF	0.001	0.047
$H_{012}: \varphi_{12}^{SF}=0;\ H_{112}: \varphi_{12}^{SF}>0$	SA→SF	0.249**	0.045
$H_{021}: \varphi_{21}^{SF}=0;\ H_{121}: \varphi_{21}^{SF}>0$	TE→SF	0.053	0.047
$H_{022}: \varphi_{22}^{SF}=0;\ H_{122}: \varphi_{22}^{SF}>0$	SA→SF	0.283**	0.044

** Rejection of the null hypothesis (5% level of significance);* Rejection of the null hypothesis (10% level of significance)

We can observe in Table 5.2 that for Tesco the two predictions made about between supermarket competition are confirmed. The influence of between supermarket competition[18] on Tesco's price setting is higher for BP and LQ than for HQ (H_{011}, H_{012} and H_{021}, H_{022} are rejected). Therefore for Tesco, we find an inverse relationship between product differentiation possibilities and between supermarket influence in the patterns of price setting.

Obviously, all the tests concerning Sainsbury and Safeway will be conditioned by Tesco's strong price leadership for the HQ variant. Whereas Sainsbury's influence on Safeway's price setting and viceversa confirm the predictions about product differentiation possibilities (H_{012} and H_{022} are rejected), these predictions are not true for those comparisons in which the coefficients representing Tesco's HQ price leadership are present.

[18]From now on, when talking about between supermarket competition if nothing is specified, it should be understood that we are referring to price effects between supermarket-differentiated variants of the same quality.

To sum up, the analysis of between supermarket competition sheds light on two facts. On the one hand, the recognition of Tesco's leadership for HQ price setting. On the other hand, if we isolate this leadership, the hypothesis of a negative relationship between product differentiation possibilities and intensity of between supermarket price competition seems to be true. Therefore, the results obtained in Chapter 4 when considering only the influence of between supermarket competition are confirmed when we consider both the effects of between and within supermarket competition: whenever it is possible supermarkets will be interested in the introduction of elements of horizontal product differentiation to relax price competition.

Just to remember that this result was used in Chapter 4 to explain the higher profits enjoyed by the UK supermarkets in comparison with their continental counterparts. The traditional factors used to explain this phenomenon are: more advanced supply management systems and the existence of high property costs acting as barriers to entry [The Economist, 1995]. We provide an additional explanation to the higher profits of UK supermarkets even ignoring the traditional factors. Because the market share of HQs in total supermarket sales is greater in the UK than in any other country of the EU, we believe that the softer intensity of price competition for the HQs is a key factor to understand these higher profits. This seems even more evident when we consider that gross profit margins are 20 to 30% higher for HQs than BPs.

5.5.2 Between supermarket competition: price effects between supermarket differentiated variants of different quality.

As a result of the assumptions of the theoretical model, price effects between supermarket-differentiated variants of different quality only take place through price adjustment within the supermarket and therefore they are considered as indirect price effects. For example, a change in $p_{it-1}^{TE_{HQ}}$ only has an effect over $p_{it}^{SA_{BP}}$ through the within supermarket price readjustment process that starts the direct price effect of $p_{it-1}^{TE_{HQ}}$ on $p_{it}^{SA_{HQ}}$. Whereas the structural coefficients do not catch indirect price effects, these are caught by the reduced form coefficients that correspond to supermarket-differentiated variants of different quality.

Our aim in this section is on the one hand to compare price effects between supermarket-differentiated variants of the same quality with price effects between supermarket-differentiated variants of different quality and on the other hand to assess the intensity of between supermarket price effects between variants of different quality.

Price effects between supermarket-differentiated variants of the same quality vs. price effects between supermarket-differentiated variants of different quality

In order to compare price effects between supermarket-differentiated variants of the same quality and supermarket-differentiated variants of different quality, we define a new series of parameters. For each one of the quality variants, we obtain these parameters by substracting to the reduced form parameter representing the price effect of the supermarket-differentiated variant of the same quality the reduced-form parameter representing the price effect of the supermarket-differentiated variant of different quality. In Table 5.3 we show these estimated parameters and between brackets their standard errors. Therefore, the first figure in this table (0.323) should be interpreted just as the parameter resulting from obtaining the difference between the reduced-form parameter representing the influence of Sainsbury BP price setting over Tesco BP price setting and the parameter representing the influence of Sainsbury HQ price setting over Tesco BP price setting; as it was told above the figure between brackets is the correspondent standard error of the parameter.

In general, we expect price effects between supermarket-differentiated variants of the same quality to be no smaller and most of the time greater than price effects between supermarket-differentiated variants of different quality.

It is possible to observe in Table 5.3 that the BP variant confirms this prediction at all the supermarkets. The price effects within[19] the BP quality variant are greater than the price effects over the BPs of any of the other quality variants. Even more, both for Tesco and Sainsbury other supermarkets LQ prices do not have a significant effect over the BPs.

Table 5.3: Price effects between supermarket differentiated variants of the same quality versus price effects between supermarket differentiated variants of different quality

	TESCO		SAINS		SAFE	
	SA→TE	SF→TE	TE→SA	SF→SA	TE→SF	SA→SF
BP-BP vs HQ-BP	0.323**	0.533**	0.317**	0.445**	0.344**	0.337**
	(0.027)	(0.027)	(0.038)	(0.036)	(0.033)	(0.030)
BP-BP vs LQ-BP	-	-	-	-	0.429**	0.350**
	-	-	-	-	(0.028)	(0.028)
HQ-HQ vs BP-HQ	0.110**	0.045	0.389**	0.006	0.323**	0.022
	(0.032)	(0.038)	(0.044)	(0.039)	(0.050)	(0.040)
HQ-HQ vs LQ-HQ	-	-	-	-	0.360**	0.152**
	-	-	-	-	(0.042)	(0.037)
LQ-LQ vs BP-LQ	0.317**	0.561**	0.158**	0.203**	0.489**	0.397**
	(0.035)	(0.028)	(0.031)	(0.031)	(0.030)	(0.037)
LQ-LQ vs HQ-LQ	0.308**	0.558**	-0.011	0.201**	0.459**	0.395**
	(0.037)	(0.029)	(0.037)	(0.032)	(0.035)	(0.037)

** The parameter is significant at 5% level, i.e. rejection of the null hypothesis of no difference between price effects (at 5% level of significance)

For the HQs, within quality variant price effects are significantly greater than the effects of LQ price setting (other supermarkets LQ prices do not have a significant influence over HQ prices at Tesco and Sainsbury). However, BP price effects $SF_{BP} \rightarrow TE_{HQ}$, $SF_{BP} \rightarrow SA_{HQ}$ and $SA_{BP} \rightarrow SF_{HQ}$ have a similar importance to their respective within quality variants price effects. We find two factors explaining this phenomenon: on the one hand, once we have taken into account Tesco's HQ price leadership, within quality

[19]Price effects between supermarket differentiated variants of the same quality.

variant price effects are significantly smaller for the HQs than for the BPs or LQs, signalling a lower degree of price competition for this variant; on the other hand, the within supermarket price effects of BPs on HQs are greater than the within supermarket price effects of HQs on BPs (see section 5.5.3) and in the supermarket price readjustment process most of the other supermarket BP price effects act through this within supermarket price effect of BPs on HQs.

As regards the LQs, within quality variant price effects are significantly greater than price effects of supermarket differentiated variants of different quality except for the price effect of Tesco's HQ on Sainsbury's LQ. The combination of the direct influence of Tesco's HQ price setting over Sainsbury's HQ price setting (Tesco's HQ price leadership) and the high influence of HQ price setting on LQ price setting within Sainsbury could explain this result (see section 5.5.3).

Price effects between supermarket-differentiated variants of different quality.

With respect to the price effects between supermarket-differentiated variants of different qualities, we expect price effects to be greater between quality neighbours. Therefore, we expect that for a given supermarket price setting, the influence of other supermarkets BP(LQ) price setting will be greater on HQ than in LQ(BP). We can check these predictions by means of two identical structured one sided t-tests.

In the first, we test if the influence of BP price setting by supermarket $H(K)$ is greater on the HQ price setting than on the LQ price setting by supermarket J.

H-Influence	K-influence
$H^J_{031}: \varphi^J_{31} = \pi^J_{21} - \pi^J_{31} = 0$	$H^J_{032}: \varphi^J_{32} = \pi^J_{22} - \pi^J_{32} = 0$
$H^J_{131}: \varphi^J_{31} = \pi^J_{21} - \pi^J_{31} > 0$	$H^J_{132}: \varphi^J_{32} = \pi^J_{22} - \pi^J_{32} > 0$

In the second one, if the influence of LQ price setting by supermarket $H(K)$ is greater on the HQ price setting than on the BP price setting by supermarket J.

H-Influence	K-influence
$H_{041}^{J}: \varphi_{41}^{J} = \pi_{25}^{J} - \pi_{15}^{J} = 0$	$H_{042}^{J}: \varphi_{42}^{J} = \pi_{26}^{J} - \pi_{16}^{J} = 0$
$H_{141}^{J}: \varphi_{41}^{J} = \pi_{25}^{J} - \pi_{15}^{J} > 0$	$H_{142}^{J}: \varphi_{42}^{J} = \pi_{26}^{J} - \pi_{16}^{J} > 0$

As it is possible to observe in Table 5.4 the results of the first pair of tests confirm the predictions in all the cases: for a given supermarket the influence of other supermarkets' BP price setting is greater over its HQ than over its LQ price setting. Neither BP nor HQ price setting at Tesco and Sainsbury are significantly influenced by LQ prices at the other two supermarkets. For Safeway, the results of the second pair of tests described above confirm the prediction of a greater influence of the LQ price setting by the other two supermarkets over its HQ than over its BP price setting.

Table 5.4: Price effects between supermarket differentiated variants of different quality

	Description	Coefficient	Std.Error
Tesco			
$H_{031}: \varphi_{31}^{TE} = 0; H_{131}: \varphi_{31}^{TE} > 0$	SA→TE	0.135**	0.015
$H_{032}: \varphi_{32}^{TE} = 0; H_{132}: \varphi_{32}^{TE} > 0$	SF→TE	0.217**	0.020
$H_{041}: \varphi_{41}^{TE} = 0; H_{141}: \varphi_{41}^{TE} > 0$	SA→TE	-	-
$H_{042}: \varphi_{42}^{TE} = 0; H_{142}: \varphi_{42}^{TE} > 0$	SF→TE	-	-
$H_{051}: \varphi_{51}^{TE} = 0; H_{151}: \varphi_{51}^{TE} \neq 0$	SA→TE	-0.009	0.008
$H_{052}: \varphi_{52}^{TE} = 0; H_{152}: \varphi_{52}^{TE} \neq 0$	SF→TE	-0.010	0.009
Sainsbury			
$H_{031}: \varphi_{31}^{SA} = 0; H_{131}: \varphi_{31}^{SA} > 0$	TE→SA	0.071**	0.010
$H_{032}: \varphi_{32}^{SA} = 0; H_{132}: \varphi_{32}^{SA} > 0$	SF→SA	0.083**	0.012
$H_{041}: \varphi_{41}^{SA} = 0; H_{141}: \varphi_{41}^{SA} > 0$	TE→SA	-	-
$H_{042}: \varphi_{42}^{SA} = 0; H_{142}: \varphi_{42}^{SA} > 0$	SF→SA	-	-
$H_{051}: \varphi_{51}^{SA} = 0; H_{151}: \varphi_{51}^{SA} \neq 0$	TE→SA	0.141**	0.020
$H_{052}: \varphi_{52}^{SA} = 0; H_{152}: \varphi_{52}^{SA} \neq 0$	SF→SA	0.042**	0.010
Safeway			
$H_{031}: \varphi_{31}^{SF} = 0; H_{131}: \varphi_{31}^{SF} > 0$	TE→SF	0.112**	0.020
$H_{032}: \varphi_{32}^{SF} = 0; H_{132}: \varphi_{32}^{SF} > 0$	SA→SF	0.091**	0.016
$H_{041}: \varphi_{41}^{SF} = 0; H_{141}: \varphi_{41}^{SF} > 0$	TE→SF	0.066**	0.012
$H_{042}: \varphi_{42}^{SF} = 0; H_{142}: \varphi_{42}^{SF} > 0$	SA→SF	0.054**	0.011
$H_{051}: \varphi_{51}^{SF} = 0; H_{151}: \varphi_{51}^{SF} \neq 0$	TE→SF	-0.063**	0.018
$H_{052}: \varphi_{52}^{SF} = 0; H_{152}: \varphi_{52}^{SF} \neq 0$	SA→SF	-0.017**	0.006

** Rejection of the null hypothesis at 5% level of significance

Hence, these two pair of tests confirm for all the three supermarkets that between supermarkets, BP and LQ price effects are greater over their quality neighbour variant, (HQ), than over the variant for which they do not have a direct quality neighborhood (LQ and BP respectively)

For the HQ variant, with two quality neighbours, we are interested in finding out if there is any difference between the influence of HQ price setting by supermarkets $H(K)$ on BP price setting and LQ price setting by supermarket J. We can test if this difference exists using a two-sided t-test with the following null and alternative hypotheses:

H-Influence	K-influence
$H_{051}^{J}: \varphi_{51}^{J} = \pi_{33}^{J} - \pi_{13}^{J} = 0$	$H_{052}^{J}: \varphi_{52}^{J} = \pi_{34}^{J} - \pi_{14}^{J} = 0$
$H_{151}^{J}: \varphi_{51}^{J} = \pi_{33}^{J} - \pi_{13}^{J} \neq 0$	$H_{152}^{J}: \varphi_{52}^{J} = \pi_{34}^{J} - \pi_{14}^{J} \neq 0$

As we can observe in Table 5.4, the result of this test varies across supermarkets. Although both for Safeway and Sainsbury we reject the null hypothesis, further testing reveals that whereas other supermarkets' HQ price setting affects more Safeway's BP price setting than Safeway's LQ price setting for Sainsbury the opposite is true. For Tesco, the result of the tests does not show any difference between the influence of other supermarkets HQ price setting over its price setting for BPs and LQs. The effect of HQ price setting by supermarket J on BP and LQ price setting by supermarket H depends on the direct between supermarket price effect of HQ price setting by supermarket J on HQ price setting by supermarket H and on the within supermarket H price effect of HQ on BP and LQ . The study of within supermarket price effects in the next section reveals that the cause of the differences detected here is differences in within supermarket price effects of HQ over BP and LQ.

5.5.3 Within supermarket price competition

In order to analyse within supermarket price competition, we consider as an indicator of within supermarket price competition the correspondent structural form coefficients, i.e. we analyse how the change in the price of one of the quality variants sold by the supermarket affects to the price of its quality neighbour assuming that all the other prices remain unchanged.

On the basis of the aims for which the two own brand variants were introduced in the supermarkets (section 5.2.1), we consider two main predictions to be tested about within supermarket competition:

1.- For a given supermarket J at time t : HQ price setting is influenced more by BP price setting than by LQ price setting.

If we define $\gamma_1^J = \gamma_{21}^J - \gamma_{22}^J$, we can check the prediction above by means of a one-sided t-test with the following null and alternative hypotheses:

$H_{06}^J : \gamma_1^J = 0$

$H_{16}^J : \gamma_1^J > 0$

We can observe in Table 5.5 that the results of this test always lead to reject H_{06}. For all the three supermarkets, the influence of BP price setting on HQ price setting is greater than the influence of LQ price setting on HQ price setting. Within the supermarket, the price setting of the HQ variant mainly depends on the price of the variant they were created to compete with. Price movements by the LQ variant, introduced in the supermarket to fight back the discounter, have a much lower influence.

2.- For a given supermarket J at time t: the influence of HQ price setting on BP price setting should be greater than on LQ price setting. In order to test this prediction we first define $\gamma_2^J = \gamma_{11}^J - \gamma_{31}^J$ and then we carry out a one-sided t-test with the following null and alternative hypotheses:

$H_{07}^{J}: \gamma_2^J = 0$

$H_{17}^{J}: \gamma_2^J > 0$

Safeway is the only supermarket that confirms the above prediction. At this supermarket, price adjustment of the HQ variant affects the price setting of the BP variant more than the price setting of the LQ variant. Sainsbury represents the opposite situation: when adjusting prices to maximize the price-quality space, given qualities, the effect of HQ price setting is greater over LQ than over BP price setting. At Tesco, there is no significant difference between the effect on BP and LQ price setting.

Table 5.5: Within supermarket price effects

	Description	Coefficient	Std. Error
TESCO			
$H_{06}: \gamma_1^{TE} = 0;\ H_{16}: \gamma_1^{TE} > 0$	Tesco	0.374**	0.020
$H_{07}: \gamma_2^{TE} = 0;\ H_{17}: \gamma_2^{TE} > 0$	Tesco	0.038	0.033
SAINSBURY			
$H_{06}: \gamma_1^{SA} = 0;\ H_{16}: \gamma_1^{SA} > 0$	Sains.	0.296**	0.056
$H_{07}: \gamma_2^{SA} = 0;\ H_{17}: \gamma_2^{SA} > 0$	Sains.	$\widehat{\gamma}_2^{SA} < 0$	
SAFEWAY			
$H_{06}: \gamma_1^{SF} = 0;\ H_{16}: \gamma_1^{SF} > 0$	Safe.	0.109**	0.056
$H_{07}: \gamma_2^{SF} = 0;\ H_{17}: \gamma_2^{SF} > 0$	Safe	0.142**	0.040

** Rejection of the null hypothesis (5% level of significance)

For Tesco and Sainsbury, the effect of the price choice for BPs on the price of the HQs is significantly greater than the effect of HQs on BPs. For Safeway no significant difference could be found[20]. There are two possible explanations for this. On the one hand, while the supermarkets have the total control over the price setting of the HQs, the price setting for the BPs is conditioned by the BP manufacturer wholesale price. On the other hand, if consumer distribution is asymmetric [Katz,1984], for the

[20] The results of testing :
$H_0: \widehat{\delta}_w = \widehat{\gamma}_{21}^J - \widehat{\gamma}_{11}^J = 0$
$H_1: \widehat{\delta}_w = \widehat{\gamma}_{21}^J - \widehat{\gamma}_{11}^J > 0$
for $J = TE, SA, SF$ are the following:

	TE	SA	SF
$\widehat{\delta}_w$	0.2975	0.1453	0.038
Standard Error	(0.0363)	(0.0417)	(0.0435)

upper segment of the consumer distribution product attributes will be more important than price when making the purchase decision and so there will exist some kind of brand preference [Rao, 1991]. If there is brand preference in the upper segment of the consumer distribution the supermarket has an incentive to follow both increases and decreases in the price of the BPs caused by an increase/decrease of the wholesale price with similar changes in the HQs. However, the supermarket will have an incentive to increase the price of BPs when increasing the price of the HQs but not to decrease the price of the BPs when reducing the price of the HQs because it could induce losing the upper part of the usual HQ purchasers.

With respect to the relationship within supermarket between the price setting for HQs and LQs this varies across supermarkets. The main fact that calls our attention is that the coefficient of $p_{it}^{SA_{HQ}}$ in the third equation of Sainsbury system (0.4401) is much higher than the correspondent coefficients for Tesco and Safeway systems (0.0829 and 0.0913 respectively). The greater influence of HQ price setting on LQ price setting at Sainsbury could be signalling that this supermarket managers are specially concerned about the possibility of consumers' switching between the HQs and LQs due to changes in HQ prices and so HQ price changes are followed by price changes for the LQs.

5.6 Concluding Remarks

Our econometric analysis shows the relevance of taking into account both the influences of between and within supermarket competition when analysing supermarket price setting.

The use of panel data allows the multiproduct-multiquality nature of the supermarket to be taken into account. In addition, the use of EC3SLS estimation provides efficient and consistent estimators of the parameters representing between supermarket and within supermarket price competition.

The analysis performed clearly reveals the price leadership by Tesco in the HQ variant. This result is not surprising if we consider that in the last years Tesco has taken over Sainsbury's leadership in the sector. Once this price leadership is taken into account, the results of the between supermarket analysis confirm the predictions of the model. Price interdependence between supermarkets seems to be higher for the quality variants for which the possibilities of product differentiation are smaller: brand products and low quality own brand products. This suggest that supermarkets can relax price competition through horizontal product differentiation.

Whereas in other markets as the car market, [Berry, Levinsohn and Pakes, 1995 and Feenstra and Levinsohn, 1995] cross price elasticities are lower in the high quality segment, for the supermarkets price interdependence between supermarkets is not necessarily lower in the high quality segment. This is related again to horizontal product differentiation possibilities and its inverse relationship with price competition. While high quality cars offer the biggest possibilities of horizontal product differentiation, in the case of supermarkets it was argued above that the biggest possibilities of horizontal product differentiation do not correspond to the top quality (BP) but rather to the intermediate quality (HQ).

The softer intensity of price competition for the HQs provides an additional explanation to the traditional explanations of the high profits of the UK supermarket (in comparison to their continental counterparts) based on the existence of high property costs that act as a barrier to entry and on the use of more advanced supply systems in the UK. This additional explanation is based on the joint consideration of the softer price competition for the HQs and the fact that the HQ market share over the total supermarket sales is higher in the UK than in any other country of the EU.

Within supermarket results are related to the supermarket perception of the underlying distribution of consumers. The fact that in all the supermarkets HQ price setting is more affected by BP price setting than by LQ price setting suggests that the supermarkets are more concerned about consumers' possible switching between HQs and BPs due to a change in BP prices not followed by HQ prices, rather than consumers' switching between HQs and LQs due to changes in LQ prices not followed by HQ prices.

Further research should look deeper into the relationship between the underlying consumer distribution perceived by each supermarket and the price interdependence between quality variants within the supermarket.

5.7 Appendices

A: Reduced Form Parameters

Reduced Form Parameters (Dropping the J superindex)

1st Equation		2nd Equation		3rd Equation	
A_1	$[\alpha_1(1-\gamma_{22}\gamma_{31})+$ $\alpha_2\gamma_{11}+\alpha_3\gamma_{11}\gamma_{22}]/M$	A_2	$[\alpha_2+\gamma_{21}\alpha_1+$ $\gamma_{22}\alpha_3]/M$	A_3	$[\alpha_3(1-\gamma_{11}\gamma_{21})+$ $\alpha_2\gamma_{31}+\alpha_1\gamma_{21}\gamma_{31}]/M$
π_{11}	$\beta_{11}(1-\gamma_{22}\gamma_{31})/M$	π_{21}	$\gamma_{21}\beta_{11}/M$	π_{31}	$\gamma_{31}\gamma_{21}\beta_{11}/M$
π_{12}	$\beta_{12}(1-\gamma_{22}\gamma_{31})/M$	π_{22}	$\gamma_{21}\beta_{12}/M$	π_{32}	$\gamma_{31}\gamma_{21}\beta_{12}/M$
π_{13}	$\gamma_{11}\beta_{21}/M$	π_{23}	β_{21}/M	π_{33}	$\gamma_{31}\beta_{21}/M$
π_{14}	$\gamma_{11}\beta_{22}/M$	π_{24}	β_{22}/M	π_{34}	$\gamma_{31}\beta_{22}/M$
π_{15}	$\gamma_{11}\gamma_{22}\beta_{31}/M$	π_{25}	$\gamma_{22}\beta_{31}/M$	π_{35}	$\beta_{31}(1-\gamma_{21}\gamma_{11})/M$
π_{16}	$\gamma_{11}\gamma_{22}\beta_{32}/M$	π_{26}	$\gamma_{22}\beta_{32}/M$	π_{36}	$\beta_{32}(1-\gamma_{21}\gamma_{11})/M$

$$M = 1-\gamma_{11}\gamma_{21}-\gamma_{22}\gamma_{31}$$

B: Results of the Estimation

Table B.1: EC3SLS estimation results: structural equations

First Equation

	$p_{it}^{TE_{BP}}$		$p_{it}^{SA_{BP}}$		$p_{it}^{SF_{BP}}$
α_1	0.0601**	α_1	0.0627**	α_1	0.0792**
	(0.0230)		(0.0304)		(0.0369)
$p_{it}^{TE_{HQ}}$	0.1190**	$p_{it}^{SA_{HQ}}$	0.1671**	$p_{it}^{SF_{HQ}}$	0.2337**
	(0.01792)		(0.0237)		(0.0242)
$p_{it-1}^{SA_{BP}}$	0.3363**	$p_{it-1}^{TE_{BP}}$	0.3825**	$p_{it-1}^{TE_{BP}}$	0.4203**
	(0.0255)		(0.0330)		(0.0266)
$p_{it-1}^{SF_{BP}}$	0.5387**	$p_{it-1}^{SF_{BP}}$	0.4469**	$p_{it-1}^{SA_{BP}}$	0.3430**
	(0.0258)		(0.0337)		(0.0268)

Second Equation

	$p_{it}^{TE_{HQ}}$		$p_{it}^{SA_{HQ}}$		$p_{it}^{SF_{HQ}}$
α_2	0.0301	α_2	0.1144*	α_2	0.1999**
	(0.0718)		(0.0665)		(0.0818)
$p_{it}^{TE_{BP}}$	0.4165**	$p_{it}^{SA_{BP}}$	0.3124**	$p_{it}^{SF_{BP}}$	0.2717**
	(0.0345)		(0.0382)		(0.0442)
$p_{it}^{TE_{LQ}}$	0.0420*	$p_{it}^{SA_{LQ}}$	0.0169	$p_{it}^{SF_{LQ}}$	0.1628**
	(0.0241)		(0.0299)		(0.0290)
$p_{it-1}^{SA_{HQ}}$	0.2446**	$p_{it-1}^{TE_{HQ}}$	0.4860**	$p_{it-1}^{TE_{HQ}}$	0.4142**
	(0.0230)		(0.0341)		(0.0365)
$p_{it-1}^{SF_{HQ}}$	0.2676**	$p_{it-1}^{SF_{HQ}}$	0.1452**	$p_{it-1}^{SA_{HQ}}$	0.1140**
	(0.0245)		(0.0274)		(0.0301)

Third Equation

	$p_{it}^{TE_{LQ}}$		$p_{it}^{SA_{LQ}}$		$p_{it}^{SF_{LQ}}$
α_3	-0.0593	α_3	0.0772	α_3	0.0158
	(0.0616)		(0.0858)		(0.0662)
$p_{it}^{TE_{HQ}}$	0.0829**	$p_{it}^{SA_{HQ}}$	0.4401**	$p_{it}^{SF_{HQ}}$	0.0913**
	(0.0281)		(0.0301)		(0.0321)
$p_{it-1}^{SA_{LQ}}$	0.3287**	$p_{it-1}^{TE_{LQ}}$	0.2121**	$p_{it-1}^{TE_{LQ}}$	0.4924**
	(0.0325)		(0.0280)		(0.0293)
$p_{it-1}^{SF_{LQ}}$	0.5794**	$p_{it-1}^{SF_{LQ}}$	0.2665**	$p_{it-1}^{SA_{LQ}}$	0.4006**
	(0.0265)		(0.0280)		(0.0352)

Standard errors between brackets.

** Significant at 5% level.* Significant at 10% level

	Tesco System	Sainsbury System	Safeway System
$\overline{R}^2$	0.9958	0.9903	0.9815

With the estimation procedure used $\overline{R}^2$ is not necessarily between 0 and 1.

Table B.2: Estimations of the reduced form coefficients

First Equation

	$p_{it}^{TE_{BP}}$		$p_{it}^{SA_{BP}}$		$p_{it}^{SF_{BP}}$
A_1	0.0667**	A_1	0.0868**	A_1	0.1361**
	(0.0243)		(0.0337)		(0.0436)
$p_{it-1}^{SA_{BP}}$	0.3539**	$p_{it-1}^{TE_{BP}}$	0.4038**	$p_{it-1}^{TE_{BP}}$	0.4493**
	(0.0261)		(0.0340)		(0.0274)
$p_{it-1}^{SF_{BP}}$	0.5669**	$p_{it-1}^{SF_{BP}}$	0.4715**	$p_{it-1}^{SA_{BP}}$	0.3667**
	(0.0259)		(0.0345)		(0.0277)
$p_{it-1}^{SA_{HQ}}$	0.0307**	$p_{it-1}^{TE_{HQ}}$	0.0863**	$p_{it-1}^{TE_{HQ}}$	0.1046**
	(0.0054)		(0.0133)		(0.0133)
$p_{it-1}^{SF_{HQ}}$	0.0336**	$p_{it-1}^{SF_{HQ}}$	0.0258**	$p_{it-1}^{SA_{HQ}}$	0.0289**
	(0.0058)		(0.0060)		(0.0081)
$p_{it-1}^{SA_{LQ}}$	0.0017	$p_{it-1}^{TE_{LQ}}$	0.0006	$p_{it-1}^{TE_{LQ}}$	0.0203**
	(0.0010)		(0.0011)		(0.0042)
$p_{it-1}^{SF_{LQ}}$	0.0031	$p_{it-1}^{SF_{LQ}}$	0.0008	$p_{it-1}^{SA_{LQ}}$	0.0165**
	(0.0018)		(0.0014)		(0.0037)

Second Equation

	$p_{it}^{TE_{HQ}}$		$p_{it}^{SA_{HQ}}$		$p_{it}^{SF_{HQ}}$
A_2	0.0555	A_2	0.1439**	A_2	0.2431**
	(0.0742)		(0.0703)		(0.0874)
$p_{it-1}^{SA_{BP}}$	0.1479**	$p_{it-1}^{TE_{BP}}$	0.1273**	$p_{it-1}^{TE_{BP}}$	0.1239**
	(0.0165)		(0.0184)		(0.022)
$p_{it-1}^{SF_{BP}}$	0.2369**	$p_{it-1}^{SF_{BP}}$	0.1484**	$p_{it-1}^{SA_{BP}}$	0.1011**
	(0.0227)		(0.0212)		(0.018)
$p_{it-1}^{SA_{HQ}}$	0.2584**	$p_{it-1}^{TE_{HQ}}$	0.5168**	$p_{it-1}^{TE_{HQ}}$	0.4475**
	(0.0238)		(0.0331)		(0.0369)
$p_{it-1}^{SF_{HQ}}$	0.2826**	$p_{it-1}^{SF_{HQ}}$	0.1544**	$p_{it-1}^{SA_{HQ}}$	0.1237**
	(0.0252)		(0.0285)		(0.0323)
$p_{it-1}^{SA_{LQ}}$	0.0146	$p_{it-1}^{TE_{LQ}}$	0.0038	$p_{it-1}^{TE_{LQ}}$	0.0870**
	(0.0087)		(0.0068)		(0.0158)
$p_{it-1}^{SF_{LQ}}$	0.0257	$p_{it-1}^{SF_{LQ}}$	0.0048	$p_{it-1}^{SA_{LQ}}$	0.0707**
	(0.0148)		(0.0085)		(0.0141)

Third Equation

	$p_{it}^{TE_{LQ}}$		$p_{it}^{SA_{LQ}}$		$p_{it}^{SF_{LQ}}$
A_3	-0.0547	A_3	0.1405	A_3	0.0380
	(0.0631)		(0.0989)		(0.0636)
$p_{it-1}^{SA_{BP}}$	0.0122**	$p_{it-1}^{TE_{BP}}$	0.0559**	$p_{it-1}^{TE_{BP}}$	0.0113**
	(0.0045)		(0.0093)		(0.0046)
$p_{it-1}^{SF_{BP}}$	0.0196**	$p_{it-1}^{SF_{BP}}$	0.0653**	$p_{it-1}^{SA_{BP}}$	0.0092**
	(0.0072)		(0.0107)		(0.0037)
$p_{it-1}^{SA_{HQ}}$	0.0214**	$p_{it-1}^{TE_{HQ}}$	0.2274**	$p_{it-1}^{TE_{HQ}}$	0.0408**
	(0.0076)		(0.0196)		(0.0149)
$p_{it-1}^{SF_{HQ}}$	0.0234**	$p_{it-1}^{SF_{HQ}}$	0.0679**	$p_{it-1}^{SA_{HQ}}$	0.0110**
	(0.0083)		(0.0134)		(0.0050)
$p_{it-1}^{SA_{LQ}}$	0.3299**	$p_{it-1}^{TE_{LQ}}$	0.2138**	$p_{it-1}^{TE_{LQ}}$	0.5004**
	(0.0325)		(0.0283)		(0.0291)
$p_{it-1}^{SF_{LQ}}$	0.5815**	$p_{it-1}^{SF_{LQ}}$	0.2687**	$p_{it-1}^{SA_{LQ}}$	0.4070**
	(0.0265)		(0.0281)		(0.0351)

** Significant at 5% level

C: Testing for Tesco's price leadership in the HQs

1.- The influence of price setting by Tesco at time $t-1$ over price setting by Sainsbury (Safeway) is significantly higher than the influence of price setting by Safeway (Sainsbury) at time $t-1$ over price setting by Sainsbury(Safeway) at time t.

1.a Tesco-Sainsbury

$H_0 : \lambda_1 = \pi_{23}^{SA} - \pi_{24}^{SA} = 0$

$H_1 : \lambda_1 = \pi_{23}^{SA} - \pi_{24}^{SA} > 0$

$\hat{\lambda}_1 = 0.5168 - 0.1544 = 0.3624$

$\hat{\sigma}_{\hat{\lambda}_1} = 0.05319$

$$t = \frac{0.3624}{0.05318} = 6.8145 \rightarrow \text{Re H}_0$$

1.b Tesco-Safeway

$H_0 : \lambda_2 = \pi_{23}^{SF} - \pi_{24}^{SF} = 0$

$H_1 : \lambda_2 = \pi_{23}^{SF} - \pi_{24}^{SF} > 0$

$\hat{\lambda}_2 = 0.4476 - 0.1237 = 0.3239$

$\hat{\sigma}_{\hat{\lambda}_2} = 0.060017$

$$t = \frac{0.3229}{0.06001} = 5.396 \rightarrow \text{Re H}_0$$

2.- The influence of price setting by Sainsbury (Safeway) at time $t-1$ over the price setting by Tesco at time t have to be significantly smaller than the influence of price setting by Tesco at $t-1$ over the price setting by Sainsbury (Safeway) at time t.

- 2.a TE-SA

$H_0 : \lambda_3 = \pi_{23}^{SA}(Sainsbury\ System) - \pi_{23}^{TE}(Tesco\ System) = 0$

$H_1 : \lambda_3 = \pi_{23}^{SA}(Sainsbury\ System) - \pi_{23}^{TE}(Tesco\ System) > 0$

$\hat{\lambda}_3 =$ 0.51686-0.25840=0.25846

$\hat{\sigma}_{\hat{\lambda}_3} = 0.03187$

$$t = \frac{0.25846}{0.03187} = 8.1091 \rightarrow \text{Re H}_0$$

2.b TE-SF

$H_0 : \lambda_4 = \pi_{23}^{SF}(Safeway\ System) - \pi_{24}^{TE}(Tesco\ System) = 0$

$H_1 : \lambda_4 = \pi_{23}^{SF}(Safeway\ System) - \pi_{24}^{TE}(Tesco\ System) > 0$

$\hat{\lambda}_4 = 0.44759\text{-}0.28263\text{=}0.16496$

$\hat{\sigma}_{\hat{\lambda}_4} = 0.04468$

$$t = \frac{0.16496}{0.04468} = 3.6917 \rightarrow \text{Re H}_0$$

Hence, Tesco HQ price leader has been shown.

Chapter 6

Unbeatable Value: Low-Price Guarantee or Loss-Leaders Strategy?[1]

Abstract

This chapter investigates the effects of a low-price guarantee (price-beating guarantee) on the patterns of price setting of the supermarkets involved in it using micro level price data. Following recent theoretical developments [Hviid and Shaffer, 1998,1999] the paper analyses the influence of hassle-costs on the ability of low-price guarantees to sustain anticompetitive prices. Furthermore, the consideration of the supermarket as a multiproduct firm leads to analyse the possible relationship between low-price guarantees and loss-leaders pricing strategies.

6.1 Introduction

On September 1996 Tesco announced the introduction of the following low-price guarantee:

"Lowest Local Value or We'll Refund You DOUBLE the Difference"

As a reaction to this announcement on the eve of the start of Tesco's low-price guarantee *The Times* (5th September 96) reads :

"Tesco starts a new Price War"

However, Dixit and Nalebuff [1991] state:

[1] I would like to thank to seminar participants at the University of Warwick Workshop of Industrial Economics, Fundación Empresa Pública, University of Vigo and 26th EARIE conference (Torino) for helpful comments.

"Yet although they sound competitive, these promises to beat the rival's price can enforce discipline in a price-setting cartel".

Therefore, there is a lack of agreement about the potential effects of low-price guarantees. The purpose of this paper is to investigate the effect of Tesco's low-price guarantee over the patterns of price setting of three of the four supermarket chains with highest market share in the UK: Tesco itself, Sainsbury and Safeway. This analysis is relevant both from a competition-policy and from a managerial point of view. From the competition-policy perspective, if it turns out that low-price guarantees allow to previously competing firm to raise prices to supra-competitive levels then claims for antitrust action [Sargent, 1993 and Edlin, 1997] should be carefully listened to. From the managerial perspective, knowledge of other supermarkets' reactions to guarantees like these are a valuable instrument to devise future price strategies.

To the best of our knowledge, only Hess and Gerstner [1991] have analysed the effect of a low-price guarantee over supermarket price setting. Whereas their paper examine the effect of a price-matching guarantee, our work focus on the analysis of a price-beating one. Both Hviid and Shaffer [1994] and Corts [1995] (using oligopolistic markets as a framework) recognise the differential effects of these two guarantees: whilst price-matching guarantees allow firms to sustain anti-competitive prices, the introduction in the space of strategies of price-beating guarantees restores the incentive to compete and removes the ability of price-matching guarantees to sustain supra-competitive prices. Hess and Gerstner [1991], by means of an analysis of the degree of between-supermarket price coordination and price levels, conclude that the price-matching guarantee analysed by them allowed to the supermarkets involved to tacitly collude on increasing prices to supra-competitive levels.

The analysis carried out in this paper incorporates a novel feature in the analysis of low-price guarantees: by explicitly analysing supermarket price policies considering the supermarket as a multi-product firm [Bliss, 1988]. Tesco's low-price guarantee does not include all the product sold by the supermarket but only a subset of them. Therefore, any difference in the patterns of supermarket price setting for the products included and not included in the low-price guarantee should be carefully examined. It is this analysis of different patterns of price setting for products included and not included in the low-price guarantee that lead us to the study of a possible relationship between low-price guarantees and loss-leader strategies.

Although traditionally ignored in the analysis of low-price guarantees, Hviid and Shaffer [1998,1999] demonstrate that *hassle-costs* (costs in which the consumer has to incur to activate the low-price guarantee) can drastically remove the anticompetitive effects of low-price guarantees. In this line, this job is the first one in analysing empirically the possible impact of *hassle-costs* on the effectiveness of low-price guarantees to raise prices to supracompetitive levels.

In order to perform this analysis, we make use of a micro level set of prices directly taken in three superstores in the south of Coventry that correspond to three of the four supermarket chains with highest market share in the UK (Tesco, Sainsbury and Safeway). This data set consists of products included and not included in the Tesco's low-price guarantee for the periods before and after the start of it.

Throughout, the chapter we make use of non parametric tests, the reason is that some of the series we use to check our predictions do not fulfill the normality conditions required by the parametric tests.

The results of the empirical analysis suggest that in general in supermarket retailing the size of *hassle-costs* outweighs the potential benefits from activating low-price guarantees. According to Hviid and Shaffer [1998,1999], this phenomenon drastically removes the ability of low-price guarantees to sustain supracompetitive prices. In our analysis the increase in between-supermarket price coordination caused by the low-price guarantee goes along with a decreasing trend in the market price of the products included in it. At first glance, this could be considered as evidence of an empirical association between low-price guarantees and price wars, however the consideration of the supermarket as a multiproduct firm lead us a to analyse the possible relationship between low-price guarantees and loss-leaders strategies. The analysis of the price data suggest that Tesco could be using the products included in the low-price guarantee as part of a loss-leaders strategy to lure consumers to the shop.

The paper is organized as follows. A theoretical review of low-price guarantees is offered in section 2. Section 3 deals with the description of Tesco's low-price guarantee and characteristics of the data set. Section 4 includes the empirical analysis of the effects of the low-price guarantee over the supermarkets patterns of price setting. Section 5 analyses the empirical relationship between low-price guarantees and loss-leaders strategies. Finally the conclusions are presented in section 6.

6.2 Literature review

Low-price guarantees (LPG) are promises by firms to match or beat the price of one or several competitors. Since Salop [1986], an extensive economic literature has argued that LPGs facilitate tacit collusion leading to higher prices and profits. On the one hand by giving an incentive to the customer to report competitors' price cuts LPGs serve as an exchange information device, on the other hand by reducing the potential benefits of one-time cheating LPGs act as an incentive-management device discouraging price-cutting by rival firms. Most of the this literature has concentrated on the analysis of the effects of the price matching guarantees[2] using oligopolistic models, and only

[2]For theoretical analysis of price matching guarantees see: Png and Hirschleifer [1987], Belton [1987], Doyle [1988], Logan and Lutter [1989], Edlin [1997] and Zhang [1995].

in recent years the possible differential effects of the price-beating guarantees have been analysed. Whereas Dixit and Nalebuff [1991] and Sargent [1993] conclude that price beating guarantees are even more effective than price matching guarantees at supporting high prices, Hviid and Shaffer [1994] and Corts [1995] show that price beating guarantees restore the incentive to undercut rivals' prices and hence cannot support any supracompetitive price in equilibrium[3]. Hence, once proved the inability of price beating guarantees to support supracompetitive prices it remains the question of why they are adopted. Hviid and Shaffer [1998,1999] extend the analysis of the LPGs by removing the assumption that it is costless to the consumers to activate the LPGs. They show in their '98 paper that if there are positive hassle costs for the consumers, the ability of price beating to sustain anticompetitive prices is partly restored.

In order to provide a theoretical framework to explain the results obtained by Hviid and Shaffer [1994,1998 and 1999] and Corts [1995], let us consider a static game of complete information in which two firms (1 and 2) choose simultaneously a posted price and price policy $\{p_i, \delta_i\}$ that conform their strategy, where:

$$\delta_i = \begin{cases} NPG = \text{ No price guarantee} \\ PM = \text{ Price Matching} \\ PB = \text{ Price Beating} \end{cases}$$

and the effective price of each firm (s_i) under each one of the possible strategies:

$$s_i = \begin{cases} NPG \ s_i = p_i \text{ for } i = 1, 2 \\ PM \ s_i = \min\{p_i, p_i - (1+\lambda)(p_i - p_j)\} \text{ with } \lambda = 0 \\ PB \ s_i = \min\{p_i, p_i - (1+\lambda)(p_i - p_j)\} \text{ with } \lambda > 0 \end{cases}$$

The analysis is based on a Bertrand equilibrium model extended to the case of differentiated products in which the two firms sell a product that is identical in all respects but for the location of the sale. It is also assumed that consumers have diverse preferences regarding the location of the firm. Hence, although the product is physically identical at the two firms one firm does not capture the entire market by

[3]Other papers analysing price-beating guarantees: Baye and Kovenock [1994], Chen [1995] and Corts [1996].

slightly undercutting the other. We start the analysis assuming that for the consumers it is costless (i.e. zero hassle costs) to activate the low price guarantee

As in Hviid and Shaffer [1994] we will distinguish between:

Case I: Symmetric Market

In absence of **PM** and **PB** the unique possible equilibrium is the Bertrand-Nash equilibrium for differentiated products $B = (p_1^B, p_2^B)$. If the strategies space is widened and the firms are allowed to choose **PM** then Hviid and Shaffer [1994] and Corts [1995] among others conclude that the most profitable Nash equilibrium for the two firms is to set the collusive price $C = (p_1^C, p_2^C)$ and adopt **PM**[4]. By adopting **PM** each firm is removing the other firm's incentive to undercut its posted price. The enlargement of the strategies space to consider **PB** completely modifies the final equilibrium. Hviid and Shaffer [1994] determine that when firms can adopt **PB** all possible equilibria yield Bertrand selling prices. The possibility of **PB** restores the incentive to undercut and renders the **PM** clauses useless, as they cannot prevent a firm from lowering its selling price by raising its posted price and adopting **PB**. Corts [1995] obtains similar results both for the case of $N = 2$ and $N \geq 3$.

Case II: Asymmetric Market

Asymmetry between firms is assumed to arise from different demand conditions or differences in marginal costs. Whereas in the symmetric market the unique Bertrand price equilibrium implies both firms setting the same price, in an asymmetric market the Bertrand price is not necessarily equal for both firms.

As in **Case I** if **PM** or **PB** are not available the Bertrand-Nash equilibrium for differentiated products is the only possible equilibrium. If we assume that **PM** is available then Logan and Lutter [1989][5] and Hviid and Shaffer [1994] conclude that

[4] It is always true that $p_i^C \geq p_i^B$ for $i = 1, 2$.

[5] Logan and Lutter [1989] proposed a sequential structure for the game: in the first stage the firms decide whether to adopt PM or not; the second stage is a Bertrand differentiated price setting game.

the more asymmetric is the market the lower is the probability of both firms adopting price matching with the result of supracompetitive prices.

For *Small Asymmetry in the market* and following Doyle [1988], Hviid and Shaffer [1994] show that using Pareto Dominance Criterion to select plausible equilibrium outcomes, the equilibrium yielding higher profits for each one of the firms implies both firms adopting **PM** and selling prices[6] at P^M. With a *Sufficiently Asymmetric market* they show that a Nash Equilibrium exists if and only if the firm with the highest Bertrand price does not adopt **PM** and selling prices are P^B.

Independently of the degree of asymmetry in the market, the extension of the space of strategies to consider **PB** yields Bertrand-Nash Equilibrium (P^B) as the only possible equilibrium [Hviid and Shaffer, 1994].

Hviid and Shaffer [1998,1999] reconsider the analysis of both **Case I** and **Case II** by removing the assumption that for the consumers it is costless to activate the LPGs. They introduce the notion of *hassle costs* (z) that are defined as "any cost run by the client to make effective the price guarantee : time, discomfort of asking for the reimbursement, need of visiting two shops...". The introduction of hassle costs arises from the following considerations: the evidence about their existence in almost all the markets and the serious doubt about the possibility that any consumer invokes either **PM** or **PB** if the expected gain from doing so is small. Therefore, they substitute the assumption of automatic activation of the LPG for the following one:

- each consumer foregoes the same amount $z \geq 0$ to activate the LPG.

$$\text{If } p_i > p_j \text{ then} \begin{cases} \text{if } (1+\lambda)(p_i - p_j) \geq z \text{ then the consumers will activate the LPG} \\ \text{if } (1+\lambda)(p_i - p_j) < z \text{ then the LPG is not activated} \end{cases}$$

where $\lambda = 0$ if **PM** and $\lambda > 0$ if **PB**.

[6] $P^M = P^{C2}$ if $P^{C1} > P^{C2}$ and $P^M = P^{C1}$ otherwise. Where P^{Ci} is the maximization profits price-pair of firm i over the 45° degree line.

They show that for any $z > (1+\lambda)(p_i - p_j)$ (i.e. when the LPG is not activated) a Nash equilibrium exists if and only if the selling price-pair is P^B. In **Case I** it is always true that $p_1^B = p_2^B$ and therefore the existence of any $z > 0$ implies that only the Bertrand-Nash equilibrium is possible. Even when we include in the space of strategies **PM** and **PB**, for any advertised price above P^B and any $z > 0$ a firm can increase its profits by undercutting this price by an amount ϵ such that $\epsilon(1+\lambda) < z$. In symmetric markets, LPGs (**PM** and **PB**) cannot support supracompetitive prices if hassle costs are higher than zero.

Table 6.1: Main Theoretical Predictions

	z=0			z>(1+λ)(p$_i$−p$_j$)>0			(1+λ)(p$_i$−p$_j$) ≥z>0		
	NPG	**PM**	**PB**	**NPG**	**PM**	**PB**	**NPG**	**PM**	**PB**
Sym. Mkts	P^B	P^{M^a}	P^B	P^B	P^B	P^B	P^B	P^B	P^B
Asym. Mkts Small Asy.	P^B	P^{M^b}	P^B	P^B	P^B	P^B	P^B	P^B	P^B
Asym. Mkts Suff. Asy	P^B	P^B	P^B	P^B	P^B	P^B	P^B	P^{Z^c}	P^{Z^d}

$P^B < P^Z < P^M$

a This equilibrium involves the two firms adopting PM
b This equilibrium involves the two firms adopting PM
c This equilibrium involves either the two firms adopting PM or only the firm with the higher Bertrand price
d In this equilibrium the firm with the most generous PB has the higher Bertrand Price

With respect to **Case II,** assuming that $(1+\lambda)(p_i - p_j) \geq z > 0$ and that markets are *sufficiently asymmetric*, Hviid and Shaffer [1999] show that hassle costs make it possible for **PM** guarantees to increase prices to supracompetitive levels. However, in the presence of hassle costs, the price increase achieved by adopting **PM** is smaller than assumed by the traditional literature. Another interesting feature of this model is that it is consistent with only a subset of firms adopting **PM**. This subset should include the firms with the highest Bertrand price. When widening the space of strategies to consider the possibility of **PB,** Hviid and Shaffer [1998] show that the presence of of positive hassle cost partly restores the ability of **PB** to support supracompetitive prices and that in equilibrium the firm with the most generous **PB** guarantee has the higher price.

6.3 Unbeatable Value, an empirical case

6.3.1 Description of the Low Price Guarantee

Tesco started its "Unbeatable Value" LPG in September 1996. The slogan of the LPG was as follows:

"Lowest Local Value or we'll refund you DOUBLE the difference"

Applies to any Unbeatable Product where you buy an equivalent product of the same quality in the same week within 3 miles. Receipts are required.

Hence, four necessary conditions for the customers to make effective the price guarantee:

1. the products should be equivalent
2. the products have to be bought in the same week
3. the lower price should be found in a supermarket located within a 3 miles rank (4.8 kilometers).
4. it is a necessary condition to produce a proof of purchase.

Unbeatable Value (*UV*) does not include all the products sold by the supermarket but a selection of them (six hundred). Within the products called as *Unbeatables* it is possible to distinguish two categories:

1. Temporary *Unbeatable*: group of products included in the price guarantee for a period of three weeks. They are nothing but the temporary sales of the supermarket. These products are in most cases Brand Products (BP) and

a few times High Quality Own Brand Products (HQ). Probably the reason of using the name of *Unbeatable* for the temporary sales is addressed to get economies of scale in advertising.

2. Permanent *Unbeatable*: group of products that once included in the *Unbeatable Value* campaign remain in for all the period analysed. These products are mostly Low Quality Own Brand Products (LQ) but sometimes when the supermarket is not running a LQ in a category the Permanent *Unbeatable* is the HQ.

For the purpose of the empirical work only the second category of products is considered. To consider the first category of products would require a theoretical framework related with temporary sales out of the scope of this analysis[7].

Before proceeding, it is interesting to go deeper into the characteristics of the LQs that are relevant to the analysis:

1. As regards the sustitutability of the LQs across supermarkets, they are very basic products aimed at competing in prices for the lowest segment of the market. Their very nature as a budget line of products is limiting their possibilities of supermarket product differentiation. Any additional product refinement aimed at differentiating the product from that of the other supermarkets would increase the price of the product and contradict the aim for which they were created. If following Corstjens et *al*, 1995, we accept that any new service provided by one of the supermarkets can be copied by the other supermarkets, the only possibility of supermarket differentiation for

[7]The disctintion between *temporary* and *permanent* Unbeatable was quite obvious at the supermarket. The deadline of the sale was shown only in the price labels of the temporary unbeatables. Whilst Tesco used end-of-aisle display for the *temporary* unbeatables, it did not modify the initial shelves situation of the *permanent* unbeatable.

the LQs is given by supermarket location. Therefore, we consider as quality equivalent the LQ range of products of the three supermarkets considered in this analysis.

2. As in Giulietti [1996] we think that supermarket wholesale prices respond to a model of bilateral bargaining involving a vertical relationship between the upstream supplier and the downstream supermarket. Whereas in the bargaining process determining the BP wholesale prices the retailer interacts with powerful producers (Kellogs, Coca Cola, etc.), in the process determining own-brand product wholesale prices retailers control most of the bargaining power [Dobson, 1997]. This almost total control over the wholesale price of the LQs confers to the supermarkets an important degree of freedom when setting their prices. This clearly facilitates the implementation of the LPG in the medium term.

6.3.2 Description of the data set

The data used in this analysis are micro level data on prices that were taken directly in three selected superstores in the south of Coventry, that correspond to the first, second and fourth biggest supermarket chains in the UK: Tesco (TE), Sainsbury (SA) and Safeway (SF). As can be observed in Table 6.2 the last two supermarkets are located within the 3 milles rank specified by Tesco's LPG. It would also be interesting to analyse the effect of " *Unbeatable Value*" over a superstore belonging to the Asda chain, the third biggest supermarket chain in the UK. However, there is no Asda superstore in the south of Coventry. The smallest distance between the closest Asda superstore and Tesco is more than three miles and therefore even if some customers were able to present proof of a lower price in Asda they could not activate the LPG.

The data set comprises 27 price observations for 46 products taken from November

Table 6.2: Distances between supermarkets (miles)

	Distance(miles)
TESCO-SAFEWAY	2.8
TESCO-SAINSBURY	1.4
SAFEWAY-SAINSBURY	1.5

1995 to March 1997. Prices have been taken every two weeks but for the Christmas periods. As Tesco started the *Unbeatable Value* LPG in September '96, fifteen observations correspond to the period before the start of the LPG and twelve to the period after. This interesting fact will allow us to establish comparisons between patterns of price setting before and after the start of the LPG. Likewise, as the sample includes both products that are part of the *Unbeatable Value* LPG (twenty two) and products that are not (twenty four) it is possible to compare the patterns of price setting of included and not included products.

The criteria to choose the products were explained in Chapter 4. We include in Appendix D a classification of the products in Unbeatables (included in the LPG) and No Unbeatables (Not included in the LPG).

6.3.3 From theory to practice

The aim of this section is to analyse the features of the *Unbeatable Value* LPG to establish possible parallelisms with the theoretical models described above. First of all, it should be made clear that *Unbeatable Value* is a **PB** guarantee and not a **PM** guarantee, as consumers are promised double the price difference. If we assume perfect information on the side of the consumers the effective selling price for the supermarket offering the LPG (Tesco) would be:

$$s^{TE} = \min\left\{p^{TE}, p^{TE} - 2(p^{TE} - p^{J})\right\} \text{ for } J = SA, SF$$

For Sainsbury and Safeway, that do not offer any LPG, the effective selling price will be equal to the posted price and hence, $s^{SA} = p^{SA}$ and $s^{SF} = p^{SF}$.

With respect to the degree of asymmetry in the market, the theoretical models presented above consider asymmetries in the market as arising from two possible sources: asymmetries in demand and asymmetries in costs.

1. Asymmetries in demand. If we assume physical quality equivalence of LQs across supermarkets, asymmetries in demand between supermarket can only arise from differences in the supermarket attributes of the product. These attributes are mainly: location and mix of services provided by the supermarket (parking space, loyalty cards, packing assistance, etc.). Asymmetries originated by locational differences (horizontal component of supermarket differentiation) should be small because the three supermarkets are located close to one another in an area which is quite homogenous from a socioeconomic point of view. Likewise, as any new service provided by one of the supermarkets that successfully attracts shoppers can be quickly copied by the other supermarkets[8], differences in the mix of services provided by the three supermarkets (vertical component of supermarket differentiation) considered should be very small and so the possible asymmetries that they can generate.

2. Cost asymmetries. In order to analyse cost asymmetries we can divide the supermarket costs into two components: wholesale price of the products and all the other costs (labour costs, distribution and storage costs, advertising, etc.). The wholesale costs of the LQs respond to a process of bilateral bargaining between the upstream own brand product manufacturer and the downstream supermarket that concludes in a supply contract with specific terms. Hence, as the LQ wholesale prices at each one of the supermarkets are set via different supply contracts, with different conditions and mostly with different own brand products manufacturers, we expect some degree of wholesale-price dispersion across supermarkets. However, as the LQs are basic

[8]Recent examples of this phenomenon are: extension to opening hours and loyalty cards.

products with very similar characteristics across supermarkets and no differences are expected in the bargaining strength of the three supermarkets considered in the analysis (three of the four largest supermarket chains in the UK) the scope of the wholesale price dispersion across supermarkets should be limited and so the wholesale-price based cost asymmetries. Likewise, there is no reason to think that the second component of cost should differ substantially across supermarkets. Hence, in terms of Table 6.1 we should restrict our attention to the central row.

Tesco's *Unbeatable Value* requires proof of purchase to make effective the LPG, thus, it is not hassle free. The customer will have to incur a cost to make effective the LPG (this limits the relevant theoretical prediction to the ones included in sections 2 and 3 of the central row of Table 6.1). Moreover there are several facts that raise some doubts about the effective use of these price guarantees by supermarket clients:

1. Importance of one-stop shopping in modern societies [Smith and Hay, 1997]. At least two shops have to be visited to make the LPG effective, and this increases the cost of the shopping in terms of money and time.
2. Small price differences between products (most of the times a few pennies) lead to only small rewards

Table 6.3: Expected reward from activating the LPG (in pence)

	Expected Reward	Max Reward	Min Reward
Sainsbury Shopper	6	18	2
Safeway Shopper	8	16	2

As a proxy for the reward that a shopper can obtain if, in order to claim the LPG whenever it is possible, she visits Tesco after visiting her habitual supermarket, we calculate the expected reward for a Sainsbury or Safeway consumer buying all the

Unbeatable products included in the sample in one of these supermarkets and visiting also Tesco to claim the LPG whenever it is possible as:

$$ER_J = \frac{1}{12}\sum_{t=16}^{27}\sum_{i=1}^{22} R_{it}$$

where

$$R_{it} = \begin{cases} 2(p_{it}^{TE} - p_{it}^{J}) \text{ if } p_{it}^{TE} - p_{it}^{J} > 0 \\ 0 \text{ otherwise} \end{cases}$$

$J = SA, SF$; $i = 1, ..., 22$ are the *Unbeatable* products included in the sample; $t = 16, ..., 27$ fortnights included in the sample after the start of *Unbeatable Value* LPG

We show in Table 6.3 along with the expected reward (ER_J) also the maximum and minimum reward that an habitual Sainsbury's or Safeway's shopper might obtain from visiting also Tesco and claiming the LPG whenever it is possible. From observation of Table 6.3 it is quite clear that the expected reward that a consumer can obtain from activating the LPG (six pence for the habitual Sainsbury's shopper and eight pence for the habitual Safeway's shopper) is not enough to compensate any hassle costs ($z > 0$) in which he has to incur to activate the low price guarantee[9]. As the *Unbeatable Value* LPG requires proof of purchase, previous visit to a supermarket different from Tesco is required. Therefore the cost of this visit will be an important component of the whole hassle costs of making effective the LPG. As a result, in general we expect,

$$z > ER_J$$

and so the LPG will be rarely requested. This has important implications because Hviid and Shaffer [1998] conclude that if LPGs are not activated, the only possible equilibrium remains the Bertrand-Nash equilibrium for differentiated products.

[9]Even if we would assume that customers are buying more than one unit of each product the expected reward of the guarantee would not be enough to compensate any hassle costs. If buying five units of each product the expected reward from activating the guarantee would be thirty pence for the habitual Sainsbury's shopper and forty for the habitual Safeway's shopper.

To sum up, we think that the model that fits better with the case analysed here is a **PB** model with *small asymmetry* in the market and hassle costs as in Hviid and Shaffer [1998]. In general, we expect for Tesco's *Unbeatable Value* that the hassle costs will be higher than the expected reward from activating the LPG ($z > ER_j$). However, as it is possible to observe in the central row of Table 6.1 the predictions of the theoretical model for markets with *Small Asymmetries* are independent of the relative size of hassle costs to the expected reward from activating the LPG: in market with *Small Asymmetries* PB guarantees do not have any ability to increase price to supracompetitive levels, i.e. the only possible equilibrium remains the Bertrand-Nash equilibrium for differentiated products

6.4 Low price guarantees and prices

According to news articles[10] the adoption of a LPG is synonymous of the start of a price war; according to Salop's traditional line of analysis (for **PB** guarantees see Dixit and Nalebuff, 1991 and Sargent, 1994) **PB** guarantees are a valuable mechanism to enforce tacit collusion allowing prices to rise to supracompetive levels; finally according to the theoretical model that seems to fit better with the *Unbeatable Value* LPG, **PB** guarantees with the characteristics of *Unbeatable Value* should not have any effect over prices and supermarket pricing behaviour should remain unaltered after the start of the price guarantee.

The aim of this section is to investigate whether Tesco's LPG did have an effect over the patterns of price setting of both the LPG actor and the two supermarkets affected by the LPG in the area under analysis. We start this analysis by examining if *Unbeatable Value* had any effect over the patterns of between-supermarket price

[10]Financial Times, January 18 1996, as a reaction to the *Price Watch* LPG by Esso (price-matching guarantee) published "Petrol Rivals on Price-Footing" and The Times, September 5 1996, as a reaction to Tesco's launch of *Unbeatable Value* LPG published "Tesco launches a new price war".

coordination. Then we analyse the effects of the Tesco's LPG over supermarkets price trends.

6.4.1 Low price guarantees and price coordination

Both under the hypothesis of LPG triggering supermarkets price wars and the hypothesis of LPG facilitating tacit collusion, Tesco's **PB** guarantee should increase the between-supermarket price coordination for the products included in the LPG. However, under the hassle-costs hypothesis Tesco's **PB** guarantee should not alter significantly the patterns of between-supermarket price coordination. Therefore, we devote this subsection to analyse the effects of Tesco's **PB** guarantee over the patterns of price coordination between Tesco and each one of the other two supermarkets affected by the LPG in the geographical area considered in the analysis.

As an indicator of the degree of between-supermarkets price coordination, we use the Dynamic Degree of Price Matching Index (**DDPMI**)[11]. We build this index in the following way:

Let p_{it}^J be the price set by supermarket J in fortnight t for product i. Where:

i = 1,...,46 products included in the sample and t = 1,...,27 fortnightly taken price observations and J = TE, SA, SF stores included in the sample. Define:

$$g_{it}^J = \frac{p_{it}^J - p_{it-1}^J}{p_{it-1}^J}$$

the Dynamic Degree of Price Matching between Tesco and store J (different from Tesco) for product i in fortnight t is calculated as:

$$DDPM_{it}^{J-H} = \begin{cases} 1 \text{ if } g_{it}^{TE} = g_{it}^J = 0 \\ \frac{g_{it}^J}{g_{it}^{TE}} \text{ if } \left|g_{it}^{TE}\right| \geq \left|g_{it}^J\right| \\ \frac{g_{it}^{TE}}{g_{it}^J} \text{ if } \left|g_{it}^{TE}\right| < \left|g_{it}^J\right| \end{cases}$$

[11]This index was introduced in Chapter 4.

As we are interested in detecting possible changes in the patterns of price coordination between Tesco and Sainsbury/Safeway induced by the LPG, we calculate for each one of the products two **DDPMIs** that correspond to the pre and post-guarantee periods. These two indexes are defined as:

$$\text{Pre-Guarantee Period Index} \rightarrow \mathbf{DDPMI}^{TE-J}_{i,PRE} = \frac{1}{14}\sum_{t=2}^{15} DDPM^{TE-J}_{it}$$

$$\text{Post-Guarantee Period Index} \rightarrow \mathbf{DDPMI}^{TE-J}_{i,POST} = \frac{1}{12}\sum_{t=16}^{27} DDPM^{TE-J}_{it}$$

If both for the pre and post-guarantee periods we group together those indexes that correspond to the products included in the LPG (**UNB**) and those indexes that correspond to the products not included (**NOUNB**) the result is four series of **DDPMIs** for each one of the two supermarket pairs (TE-SA and TE-SF) considered in this analysis. For example, the series $\mathbf{DDPMI}^{TE-SA}_{UNB,PRE}$ would include $\mathbf{DDPMI}^{TE-SA}_{i,PRE}$ for the twenty-two **UNB**[12].

This index has two advantages with respect to the price matching index used by Hess and Gerstner [1991], in which a price match for a given product is accounted for if and only if the price of a given product is the same in the LPG supermarket and in one of the supermarkets affected by the LPG[13]. The first advantage is that we do not use a static but a dynamic index that allows to catch the simultaneity in the pricing behaviour between supermarkets and the extent of this simultaneity when prices change. The second advantage is that we allow for gradualism in the dynamic

[12] A list of all the variables used in the chapter including descriptive statistics can be found in Appendix A.

[13] The index used by Hess and Gerstner [1991] can lead to misinterpretations. If in a given week, the number of products for which two supermarkets are charging the same price increases then they conclude that the degree of price matching between these two supermarkets has increased. However, this increase in the number of products with the same price could happen simultaneously to an increase in the degree of price dispersion for the rest of products included in the sample. If this two events happen simultaneously we need an index allowing for gradualism to be able of extracting any conclusion about the degree of price coordination across supermarkets.

price matching: if two supermarkets increase simultaneously their prices for a given product but by a different amount this will account zero in an index like the one used by Hess and Gerstner [1991]; nevertheless we take into account that, although not by the same amount the two supermarkets are increasing their price in the same fortnight and it will have an impact in the index.

We start the analysis of price coordination by comparing the patterns of price coordination for **UNB** and **NOUNB** in the pre-guarantee period. We carry out this analysis by means of a battery of two-sided Mann-Whitney tests[14] with the following null and alternative hypotheses:

H_0 :*On average, in the pre-guarantee period there is no difference in the degree of price coordination between Tesco and Sainsbury (Safeway) for* **UNB** *and* **NOUNB**, *i.e. on average there is no difference between* $\mathbf{DDPMI}^{TE-J}_{UNB,PRE}$ *and* $\mathbf{DDPMI}^{TE-J}_{NOUNB,PRE}$ (for $J = SA, SF$).

H_1 :*On average, in the pre-guarantee period there is a difference in the degree of price coordination between Tesco and Sainsbury (Safeway) for* **UNB** *and* **NOUNB**, *i.e. on average there is a difference between* $\mathbf{DDPMI}^{TE-J}_{UNB,PRE}$ *and* $\mathbf{DDPMI}^{TE-J}_{NOUNB,PRE}$ (for $J = SA, SF$).

[14]The Mann-Whitney test should be used to test for differences in average between two independent samples. For independence, we understand that the observations in any sample are not related to the observations in any other sample. In our case, we could be using the Mann-Whitney test to check if there is any difference in average between $\mathbf{DDPMI}^{TE-SA}_{UNB,PRE}$ and $\mathbf{DDPMI}^{TE-SA}_{NOUNB,PRE}$.

The Mann-Whitney test is based in ranking the observations corresponding to each one of the two samples and then summing the ranks of the observations that belong to each one of these samples. If we define R_i as the sum of ranks for group i ($i = 1, 2$) and n_i as the size of group i, then the U statistic can be obtained as:

$$U = R_s - \frac{1}{2}n_s(n_s + 1)$$

If H_1 is one-sided then R_s is given by that sum of ranks that is expected to be smaller if the H_1 were true. If H_1 is two sided then we calculate $U_1 = R_1 - \frac{1}{2}n_1(n_1 + 1)$ and $U_2 = n_1n_2 - U_1$, and U is defined as the smaller of U_1 and U_2. A correction of the U statistic is needed if any tied observations (belonging to different samples) exist. We reject the null hypothesis of no difference on the average level of the variable under analysis for the two sample considered if $U \leq$ *critical value*. A complete description of the test can be found in Neave and Worthington [1988]; the critical values of the test are in Table D of the same book.

The results of the tests are shown in Table 6.4. Observation of this Table reveals that the null hypothesis of no difference between the average degree of price coordination of **UNB** and **NOUNB** is never rejected. Therefore, we should conclude that in the pre-guarantee period no difference between the degree of price coordination for **UNB** and **NOUNB** is observed.

Table 6.4: Mann-Whitney Test for differences on average DDPMI.UNB-NOUNB

Pre-Guarantee		Value of the test (U)	Critical Value 5%
	TE-SA	209	174.64
	TE-SF	260.5	174.59
Post-Guarantee		Value of the test (U)	Critical Value 5%
	TE-SA	182.5	188.88
	TE-SF	174.5	188.91

Rejection of the H_0 if $U \leq$ CV 5%

Both the hypothesis that relate the LPGs with the triggering of price wars and the hypothesis of LPGs as exchange-information devices facilitating tacit collusion predict that the LPGs should increase between supermarket price coordination for the **UNB**. However the hassle-costs hypothesis establishes that if LPG is rarely activated no changes in the degree of between supermarket price coordination should be observed. Hence, the next step is to check if the introduction by Tesco of the LPG actually increased the degree of price coordination for the **UNB**. As a matter of completeness, and to exclude the possibility of a general increase in the degree of between supermarket price coordination caused by a factor different from Tesco's LPG, we also check if this LPG had any effect over the degree of price coordination for the **NOUNB**.

We analyse the effects of the introduction of the LPG by means of a battery of one-sided Wilconxon test for Matched Pair Observation[15] with the following null and

[15] As explained in the Appendix B of Chapter 4, the Wilconxon test should be used to detect differences in average between two samples when each observation in one sample has some kind of natural link with an observation in the other sample. In our case, if we are detecting differences in average between $\text{DDPMI}^{TE-SA}_{UNB,PRE}$ and $\text{DDPMI}^{TE-SA}_{UNB,POST}$, the two series consist of price coordination indexes for the same products for the periods before and after the start of the LPG and so the link

Table 6.5: Wilconxon Test for differences on average DDPMI. Pre-post policy periods

NOUNB		T	C.V. 5%	CSS	One/Two Sided
	TE-SA	79	75	22	One
	TE-SF	104	91	24	One
UNB		T	C.V. 5%		
	TE-SA	8	60	20	One
	TE-SF	41	67	21	One

T: value of the test; CV 5%: Critical Value at 5% significance level ; Rejection of H_0 if $T \leq CV$ 5%; Corrected Sample Size (CSS)= Sample Size − Number of Zero differences

alternative hypotheses:

H_0 : *On average there is no difference between* $\mathbf{DDPMI}^{TE-J}_{S,PRE}$ *and* $\mathbf{DDPMI}^{TE-J}_{S,POST}$ *(for S = UNB, NOUNB and J = SA,SF).*

H_1 : *On average,* $\mathbf{DDPMI}^{TE-J}_{S,POST}$ *is higher than* $\mathbf{DDPMI}^{TE-J}_{S,PRE}$ *(for S = UNB, NOUNB and J = SA,SF).*

It is possible to observe in Table 6.5 that whereas for the **UNB** group of products the results of these tests lead to reject the null hypothesis of no difference between the degree of price coordination TE-SA/TE-SF in the periods before and after the start of the LPG, for the **NOUNB** this null hypothesis is not rejected. The results of these tests are evidence in favour of the hypothesis sustaining that the LPG would increase the degree of price coordination for the subgroup of products included in the LPG. The fact that the degree of price coordination in the **NOUNB** group of products remains unchanged supports Tesco's LPG as the factor causing the increase in the degree of price coordination for the **UNB** group of products.

The final step of this analysis of price coordination consists of checking if the increase in the degree of price coordination TE-SA/TE-SF caused by Tesco's LPG has modified the pre-guarantee period status making the degree of between-supermarket

between the observations of the two series is obvious (e.g. the price coordination index that corresponds to canned spaghetti in $\mathbf{DDPMI}^{TE-SA}_{UNB,PRE}$ is matched with the price coordination index that corresponds to the same product in $\mathbf{DDPMI}^{TE-SA}_{UNB,POST}$).

price coordination higher for the **UNB** group of products than for the **NOUNB** one. We perform this analysis using a one-sided Mann-Whitney test with the following null and alternative hypothesis:

H_0 :*On average, in the post-guarantee period there is no difference in the degree of price coordination between Tesco and Sainsbury (Safeway) for* **UNB** *and* **NOUNB**, *i.e. on average there is no difference between* $\mathbf{DDPMI}^{TE-J}_{UNB,POST}$ *and* $\mathbf{DDPMI}^{TE-J}_{NOUNB,POST}$ (for $J = SA, SF$).

H_1 :*On average, in the post-guarantee period the degree of price coordination between Tesco and Sainsbury (Safeway) is higher for* **UNB** *than for* **NOUNB**, *i.e. on average* $\mathbf{DDPMI}^{TE-J}_{UNB,POST}$ *is higher than* $\mathbf{DDPMI}^{TE-J}_{NOUNB,POST}$ (for $J = SA, SF$).

From the results of the tests shown in Table 6.4, we can conclude that in the post-guarantee period both TE-SA and TE-SF degrees of price coordination are higher for the **UNB** group of products than for the **NOUNB** one.

To sum up, consistent with the news hypothesis relating LPGs with price wars and the Salop's linc hypothesis relating LPGs with collusive outcomes, Tesco's *Unbeatable Value* **PB** guarantee has resulted in an increase in the degree of price coordination TE-SA/TE-SF for the products included in the LPG, with the final result of making the degree of price coordination for the products included in the LPG higher than for those products not included. Whereas in the scenery of a price war the increase in the degree of between-supermarket price coordination should go along a decreasing price trend, in the scenery of tacit collusion the increase in between-supermarket price coordination should involve an increasing price trend. Therefore, an analysis of price trends before and after the start of the LPG is needed to discriminate between hypotheses.

6.4.2 Low-price guarantees and price trends

Market Analysis

In order to analyse the effect of Tesco's LPG on the overall level of prices relevant for the client located in the supermarkets' geographical influence area, it is useful to define the following weighted market average relative price index:

$$\mathbf{RELPRI}_t^{ALL} = \frac{\text{PUNB}_t}{\text{PNOUNB}_t}$$

where:

$$\mathbf{PUNB}_t = \text{Unbeatable Products Basket Market Price}_t = \sum_{i=1}^{22}\left[\prod_{j=1}^{3} MS^J \times p_{it}^{UNB_J}\right]$$

$$\mathbf{PNOUNB}_t = \text{No Unb. Products Basket Market Price}_t = \sum_{i=1}^{24}\left[\prod_{j=1}^{3} MS^J \times p_{it}^{NOUNB_J}\right]$$

As the local market shares (MS^J) for each one of the supermarkets that are needed to construct the market weighted average relative price index are not available, we have assumed equal market shares for all the three supermarkets. The results do not change substantially if the market share used to build the index are the UK market shares of each one of the supermarkets chains.

An ideal construction of the baskets of **UNB** and **NOUNB** products will weight the products according to their weight in the representative consumer budget. Hess and Gerstner [1991] used as weights those of the consumer price index, however these weights are not available in the UK with the required disaggregation[16].

We analyse the effect of the low price guarantee over the Relative Price Index ($\mathbf{RELPRI}_t^{ALL}$) by running the following regression[17]:

[16] At least this was the answer of the Office of National Statistics when the author requested them. In order to show that the results obtained are robust to the set of products used in the analysis, we carry out in Appendix C a reduced sample analysis excluding from the full sample beer and toiletries. The reason for excluding these products is that these are the products for which interpurchase time is longer and/or tastes more important in the buying decision.

[17] All the standard error provided in the different estimations are the Newey-West heterocedasticity

$$\textbf{RELPRI}_t^{ALL} = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

where:

$$D_1 = \begin{cases} 0 \text{ from } t = 1 \text{ to } t = 15 \\ 1 \text{ otherwise} \end{cases} \quad \text{and } T \text{ is a time trend}$$

We show in Table 6.6 the results of the regression analysis. Figure 6.1 (Appendix B) shows real and fitted values of $\textbf{RELPRI}_t^{ALL}$. If in order to examine the effect of Tesco's LPG , we focus our attention in the analysis of the trend[18] followed by $\textbf{RELPRI}_t^{ALL}$, the results obtained for $\hat{\beta}_1$(0.0012) and $\hat{\beta}_{post}$ (-0.0016) reveal that while $\textbf{RELPRI}_t^{ALL}$ showed an increasing trend before the start of the LPG, after starting *Unbeatable Value* this trend becomes decreasing. The real effect of Tesco's LPG (as it is possible to observe in Figure 6.1) is to invert the trend of $\textbf{RELPRI}_t^{ALL}$. From a situation in which the market average level of prices of the **UNB** basket was increasing with respect to the market average level of prices of the **NOUNB** basket we move to the opposite situation.

This change in trend fits better with the price war hypothesis than with the collusive hypothesis, otherwise $\textbf{RELPRI}_t^{ALL}$ should show a steeper increasing trend after the start of Tesco's LPG. The detected change could be caused by changes in the behaviour of both the prices of the **UNB** and **NOUNB** baskets of products or by changes in only one of the two categories. Therefore, further insight is needed in the behaviour of

and autocorrelation consistent standard errors. As suggested by Pesaran and Pesaran [1997] we have used Parzen weights to calculate them.

[18]If instead of focusing our analysis on trends we would focus it on mean levels we could obtain misleading results. Let us use an example in order to illustrate this argument. From Figure 6.1, it results evident that the effect of Tesco's LPG is to invert the trend of RELPRI_t^{ALL} from increasing to decreasing, this suggests that Tesco's LPG is reducing RELPRI_t^{ALL}. However, the mean level of RELPRI_t^{ALL} is higher in the post-guarantee than in the pre-guarantee period. Therefore, an analysis based on mean levels would conclude that Tesco LPG has lead to an increase in RELPRI_t^{ALL} when the actual effect has been to reduce it. The analysis of means is clearly conditioned for the starting values in each one of the periods.

Table 6.6: RELPRI regression analysis

Dependent Variable : $\mathbf{RELPRI}_t^{ALL}$		
R^2 =77.41	$\overline{R}^2$ =74.46	
	Coefficient	Std. Error[1]
α_1	0.4249**	0.0025
α_2	0.0505**	0.0055
β_1	0.0012**	0.0003
β_2	-0.0028**	0.0004
α_{post}	0.4755**	0.0047
β_{post}	-0.0016**	0.0002
Normality	0.5462 (0.761)	
$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$		

[1]Newey-West Standard Errors;**significant at 5% level

the market average price levels of the **UNB** and **NOUNB** baskets of products. We can perform this analysis using two additional tests:

1. Let us define the following indexes[19]:

$$\mathbf{NOIND}_t^{ALL} = \frac{\sum_{i=1}^{24}\left[\prod_{j=1}^{3} MS^J \times p_{it}^{NOUNB_J}\right]}{\sum_{i=1}^{24}\left[\prod_{j=1}^{3} MS^J \times p_{i1}^{NOUNB_J}\right]}$$

$$\mathbf{UNBIND}_t^{ALL} = \frac{\sum_{i=1}^{22}\left[\prod_{j=1}^{3} MS^J \times p_{it}^{UNB_J}\right]}{\sum_{i=1}^{22}\left[\prod_{j=1}^{3} MS^J \times p_{i1}^{UNB_J}\right]}$$

where t and j are defined as above.

These two indexes are used as dependent variables of the following regression models:

$$\mathbf{NOIND}_t^{ALL} = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

$$\mathbf{UNBIND}_t^{ALL} = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

The results of these regressions are shown in Table 6.7. As regards $\mathbf{NOIND}_t^{ALL}$, it is possible to infer from the positive sign of the trend dummy coefficient (0.0025) and

[19]We are just building a price index using as basis the first period of the sample.

from the no significance of the trend coefficient for the post-guarantee period (β_{post}) that the effect of Tesco's LPG has been to cut the decreasing trend of the market price of the basket of **NOUNB** products (Figure 6.2)[20].

Table 6.7: Regression Analysis Results

Dependent Variable: $\mathbf{NOIND}_t^{ALL}$			Dependent Variable: $\mathbf{UNBIND}_t^{ALL}$		
$R^2 = 92.28$	$\bar{R}^2 = 91.28$		$R^2 = 77.51$	$\bar{R}^2 = 74.58$	
	Coefficient	Std. Error[1]		Coeffcicient	Std. Error
α_1	1.0076**	0.0032	α_1	0.9913**	0.0039
α_2	-0.0515**	0.0112	α_2	0.0600**	0.0062
β_1	-0.0027**	0.0003	β_1	0.0002	0.0005
β_2	0.0025**	0.0006	β_2	-0.0038**	0.0006
α_{post}	0.9560**	0.0107	α_{post}	1.0514**	0.0048
β_{post}	-0.00017	0.0004	β_{post}	-0.00363**	0.00022
Normality	4.6237 (0.099)		*Normality*	5.1141 (0.078)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West standard errors;*Significant at 10% level;** Significant at 5% level

With respect to $\mathbf{UNBIND}_t^{ALL}$ regression analysis, observation of Figure 6.3 and the negative and significant coefficient of the trend dummy (-0.0038) reveal the real effect of the LPG. Tesco's LPG changes the trend of $\mathbf{UNBIND}_t^{ALL}$ from a slightly increasing (0.0002) to decreasing (-0.0036).

Consequently, the decreasing trend observed in $\mathbf{RELPRI}_t^{ALL}$ for the post-guarantee period is explained by a quite stable path in the market weighted price of the basket of **NOUNB** (as it is possible to observe in Figure 6.2) that goes along a decreasing trend of the market weighted price of the basket of **UNB**.

Hence, the empirical evidence suggest the Tesco's **PB** guarantee is not triggering an increase in the market averaged price of the products included in the LPG but a reduction of it. This result is suggesting that the supposed anticompetitive effects of the LPG and the related claims of antitrust action should be reconsidered.

2.- Given that most of the price comparisons have been carried out using as basis

[20]A possible explanation of this phenomenon will be given later on in the chapter.

the first period of the sample it would be interesting to make comparisons using two different basis for $\mathbf{UNBIND}_t^{ALL}$ and $\mathbf{NOIND}_t^{ALL}$ for the periods before and after the start of the **PB** guarantee. Thus, for the period before the start of the **PB** we will use as a basis the value of the corresponding series at the first period of the sample ($\mathbf{UNBIND1}_t^{ALL}$ and $\mathbf{NOIND1}_t^{ALL}$) and for the period after the start of the LPG we will use the value of the corresponding series in the first fortnight in which the LPG was effective ($\mathbf{UNBIND16}_t^{ALL}$ and $\mathbf{NOIND16}_t^{ALL}$). We show the evolution of $\mathbf{NOIND1}_t^{ALL}$, $\mathbf{UNBIND1}_t^{ALL}$, $\mathbf{NOIND16}_t^{ALL}$ and $\mathbf{UNBIND16}_t^{ALL}$ in Figures 6.4 and 6.5 (Appendix B).

Using these Figures as reference, we can use a Wilconxon Test for Pair Matched Observations[21] to compare the patterns of behaviour of the prices of the **UNB** and **NOUNB** basket of products.

- For the period before the start of the **PB** guarantee and using the series with basis on the first period of the sample we conduct the test:

H_0: *On average, there is no difference between* $\mathbf{NOIND1}_t^{ALL}$ *and* $\mathbf{UNBIND1}_t^{ALL}$

H_1: *On average, there is a difference between* $\mathbf{NOIND1}_t^{ALL}$ *and* $\mathbf{UNBIND1}_t^{ALL}$

- For the period after the start of the **PB** guarantee and using the series with basis on the first observation in which the **PB** guarantee was effective

H_0: *On average, there is no difference between* $\mathbf{NOIND16}_t^{ALL}$ *and* $\mathbf{UNBIND16}_t^{ALL}$.

H_1: *On average,* $\mathbf{NOIND16}_t^{ALL}$ *is higher than* $\mathbf{UNBIND16}_t^{ALL}$

The results of both tests (Table 6.8) show that whilst for the first period the average level of both price indexes ($\mathbf{UNBIND1}_t^{ALL}$ and $\mathbf{NOIND1}_t^{ALL}$) is similar (Figure 6.4),

[21] We use a Wilconxon test for Matched pair observations because each observation in $\mathbf{NOIND1}_t^{ALL}$ is matched with the obervation of $\mathbf{UNBIND1}_t^{ALL}$ that correponds to the same fortnight. The same happens with the observations belonging to $\mathbf{NOIND16}_t^{ALL}$ and $\mathbf{UNBIND16}_t^{ALL}$.

the effect of *Unbeatable Value* is to keep the $\mathbf{UNBIND16}_t^{ALL}$ systematically below $\mathbf{NOIND16}_t^{ALL}$. As it is possible to observe in Figure 6.5, while $\mathbf{NOIND16}_t^{ALL}$ keeps quite a stable level during all the second part of the sample $\mathbf{UNBIND16}_t^{ALL}$ is basically always decreasing.

Table 6.8: Wilconxon Test. Different Basis Analysis

	T	C.V. 5%	CSS	One/Two Sided
Weeks 1-15	40	21	14	Two
Weeks 16-27	0	13	11	One

T: value of the test; CV 5%: Critical Value at 5% significance level ; Rejection of H_0 if T≤CV 5%; Corrected Sample Size (CSS) = Sample Size − Number of Zero differences

Supermarket Analysis

An interesting insight is to analyse in a more detailed way the pattern followed by $\mathbf{RELPRI}_t^{ALL}$. This could be done observing how the **PB** guarantee is affecting the behaviour of a relative price index per supermarket. This index is built as:

$$\mathbf{RELPRI}_t^J = \frac{\sum_{i=1}^{22} p_{it}^{UNB_J}}{\sum_{i=1}^{24} p_{it}^{NOUNB_J}}$$

where:

$i = 1, ..., n$ products ($n = 24$ for NOUNB and $n = 22$ for UNB), $J =$ *TE, SA, SF* and $t = 1, ..., 27$ fortnightly taken observations

This relative price index for each one of the supermarkets can be used as dependent variable of the following regression model:

$$\mathbf{RELPRI}_t^J = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

The results of the OLS regression of this model for each one of the supermarkets are shown in Table 6.9. Actual and fitted values of the relative price index for each one of the supermarkets are shown in Figures 6.6 to 6.8 in Appendix B.

Table 6.9: Regression Analysis by store

Dep. Variable:	$\mathbf{RELPRI}_t^{TE}$	
$R^2 = 60.23$	$\bar{R}^2 = 55.04$	
	Coefficient	Std. Error[1]
α_1	0.4257**	0.0032
α_2	0.0313**	0.0058
β_1	0.0012**	0.0004
β_2	-0.0018**	0.0005
α_{post}	0.4570**	0.0047
β_{post}	-0.0006**	0.0002
Normality	1.3583 (0.507)	
Dep. Variable:	$\mathbf{RELPRI}_t^{SA}$	
$R^2 = 85.19$	$\bar{R}^2 = 83.26$	
	Coefficient	Std. Error[1]
α_1	0.4219**	0.0028
α_2	0.0723**	0.0049
β_1	0.0020**	0.0002
β_2	-0.0043**	0.0003
α_{post}	0.4943**	0.0041
β_{post}	-0.0023**	0.0002
Normality	0.926 (0.629)	
Dep. Variable:	$\mathbf{RELPRI}_t^{SF}$	
$R^2 = 37.24$	$\bar{R}^2 = 29.05$	
	Coefficient	Std. Error[1]
α_1	0.4273**	0.0052
α_2	0.0471**	0.0101
β_1	0.0006	0.0007
β_2	-0.0024**	0.0008
α_{post}	0.4744**	0.0084
β_{post}	-0.00173**	0.0004
Normality	1.589 (0.452)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West standard errors;**Significant at 5% level; *Significant at 10% level

Table 6.10: Supermarket Decomposition of RELPRI trend dummy coeffient

	$\mathbf{RELPRI}_t^{ALL}$	$\mathbf{RELPRI}_t^{TE}$	$\mathbf{RELPRI}_t^{SA}$	$\mathbf{RELPRI}_t^{SF}$
Trend Dummy	-0.0028**	-0.0017**	-0.0043**	-0.0024**
Coefficient ($\hat{\beta}_2$)	(0.0004)	(0.0005)	(0.0002)	(0.0008)
Share (%)	100	20.24	51.19	28.57

Between brackets Newey-West standard errors. ** significant at 5% level

As regards the sign of $\hat{\beta}_2$ (coefficient of the trend dummy) the regression analysis gives the same results for the three supermarkets. $\hat{\beta}_2$ is negative and significant for the three supermarkets considered. As it is possible to observe in Table 6.9 the result of the LPG, both for the active supermarket (Tesco) and the passive supermarkets (Sainsbury and Safeway), is to invert the trend of $\mathbf{RELPRI}_t^j$ from a positive trend to a negative one (for Safeway the positive trend coefficient for the pre-guarantee period was not significant).

However, the size of $\hat{\beta}_2$ is quite different across supermarkets. The highest absolute value of $\hat{\beta}_2$ corresponds to Sainsbury (-0.0043) and the smallest one (-0.0018) corresponds to the supermarket offering the LPG, Tesco. We can use the coefficients of the trend dummy of each one of the supermarkets regressions to decompose the change in trend of the market average price index $\mathbf{RELPRI}_t^{ALL}$ (-0.0028) in the shares that correspond to each one of the supermarkets. As it is possible to see in Table 6.10, Sainsbury is the supermarket explaining most of the change of observed in $\mathbf{RELPRI}_t^{ALL}$ trend. The fact that Tesco is the supermarket changing its price pattern the less suggests that in some way it is acting as a market leader and that are the others who are accommodating their price patterns.

To sum up, after analysing supermarket pricing behaviour before and after the start of the LPG, it is clear that the increase in between supermarket price coordination for the products included in Tesco's *Unbeatable Value* did not have as effect to increase the price level. In this case the increase in price coordination cannot be explained as tacit collusion but, as a process of approximation of Sainsbury's and Safeway's prices for the products included in the LPG to the prices set by the low-price supermarket, Tesco (Figure 6.9)[22].

If we identify the prices before the start of the PB as competitive then we should conclude that *Unbeatable Value* had procompetitive effects. The only theoretical paper that recognises possible procompetitive effects for LPGs is Corts [1996]. Using a different framework in which he distinguishes between sophisticated and unsophisticated [23]consumers and with focus in the discriminatory effects of LPG, Corts shows that when the elasticity of demand (at the relevant price) of the unsophisticated consumers is higher than the elasticity of demand of the sophisticated consumers, **PB** can result in procompetitive prices. However, he states that the results of his model are more adequate for those markets in which a considerable price dispersion is present. He identifies these markets as those with a large variety of outlets resulting in limited consumers' knowledge about the relevant price alternatives (more characteristic of consumer electronics or automobile tires than groceries where most of the clients are able to identify the relevant set of supermarkets) and with an important degree of variation in the non price attributes of the product (we stressed before that the LQs are almost homogenous across supermarkets and the only difference is given by supermarket location).

[22]In the Table below we can observe the difference between the price of the basket of UNB at Tesco and at each one of the supermarkets affected by the LPG in Fortnight 16 (start of the LPG) and Fortnight 27 (end of the sample).

	Fortnight 16	Fortnight 27
TE-SA	50	8
TE-SF	15	6

It is clear the process of reduction of the prices of the products included in the LPG at Sainsbury and Safeway to converge to Tesco's prices.

[23]Unsophisticated consumers base their decissions in posted prices. Sophisticated consumer aware of actual selling prices takes the purchasing decision with basis on them. Although both types of consumers are aware of the LPGs, Corts assumes that whereas for the sophisticated consumers the cost of activating the LPG (hassle cost) is low for the unsophisticated consumers this is high enough to make unprofitable the attempt of activating them.

6.5 Is *Unbeatable Value* a loss-leader strategy?

The empirical analysis we carried out in the previous section suggests that the effects of the Tesco's LPG have been an increase in the degree of price coordination between the supermarket introducing the price guarantee and the supermarkets affected by it, and a decrease in the market average price of the basket of products included in the LPG. These results seem to be evidence in favour of the hypothesis of LPGs as triggering price wars, nevertheless there is no economic theory rationale behind this hypothesis. We think that there is a missing piece in the empirical analysis of supermarket LPGs and this is that they could be used as part of a loss-leader strategy by a multiproduct supermarket. Hess and Gerstner [1987] define loss-leader pricing as a price strategy in which retailers set very low-prices sometimes below costs to lure consumers to the shop. Because the consumers once in the shop buy products other than loss-leaders they price these other products to compensate the deals offered on the loss leaders.

Bliss [1988] uses a model of monopolistic competition between multiproduct retailers with complete information on the consumer-side to develop a theory of retail pricing and recognises the possibility of loss-leader pricing as arising because of asymmetries in the cross-price elasticities of goods sold at the supermarkets. However, the first real attempt of using a formal model to analyse loss-leaders is Hess and Gerstner [1987]. They construct a two-period model with N identical fully informed consumers that because of high transaction costs visit only one store in each period. In this model stores sell a selection of "impulse goods" (products sold without previous price comparison across stores) and only one "shopping good" (products that determine which store to visit). They show that under these assumptions, stores may be interested in pricing the shopping good below marginal costs to lure consumers to the shop and obtaining profits through their purchases of impulse goods.

Lal and Matutes [1994] using a duopoly framework in which two firms compete in price for the demand of two products, develop a model that relaxes some of the assumptions of Hess and Gerstner [1987]. They relax the assumption impulse/shopping goods and allow the consumer to decide which store to visit on the basis of the surplus derived from the purchase of an assortment of goods; furthermore they allow for the possibility of each consumer buying the two goods from different stores; finally, they relax the assumption of fully informed consumers by assuming that consumers are uninformed about prices unless advertised and in this way they introduce the role played by price expectations[24] and advertising to explain loss-leader pricing. They show that when the willingness to pay is sufficiently high for the stores to extract a large consumer surplus from the unadvertised good and the cost of advertising relative to the cost of shopping[25] is high enough, there exists a unique equilibrium in which firms advertise only one product and this is sold at price below marginal cost. This is because for the competition to be tight enough to result in loss-leader pricing, willingness to pay has to be high enough relative to the transportation costs. Similarly, very low advertising costs will lead to an equilibrium in which the two stores will advertise the two products. Lal and Matutes [1994] claim that the products more likely to be used as loss-leaders are those bought relatively often and/or with high storage costs.

6.5.1 From theory to practice

Both Dobson [1997] and the Own Brands KeyNote Report [1997] point to the use of LQs as loss-leaders by the supermarkets. Whereas the first uses as an example the accusation of the Bakers federation to the supermarkets of loss-leading as an inducement to consumers, the second reports the '96 baked beans supermarket price war that drove

[24]They assume that consumers correctly predict how unadvertised prices depend on the prices advertised by profit-maximizing firms.

[25]The opportunity cost of shopping is understood as a transportation cost.

the price of the LQ Tesco baked beans down to 3 pence[26]. LQs have two characteristics that make them the optimum quality variant to carry out a loss-leader strategy: first they are essential products with low prices and a high frequency of purchase, and second the supermarkets have almost complete control of the wholesale prices for this quality variant, and this facilitates the instrumentation of this kind of price strategies.

We can use the Known Value Item (**KVI**) list published by the Shaws List of Recommended Fair Prices to check if the LQs included in our sample accomplish one of the main characteristics required to potential loss-leaders. We could also check if belonging to this list turns out to be a factor that allows us to distinguish between the products included and not included in *Unbeatable Value.* The **KVI** list includes the branded products whose price is assumed to be common knowledge among consumers because they form part of their habitual shopping list. In order to sort the products of our sample in **KVI** and no **KVI**, we make abstraction of the brand name just considering the product as classification criterion, and include in the list white bread and rice (products missed in the list and that we think that should be included in the shopping basket of the representative English consumer[27]).

Table 6.11: KVIs Products

	KVI	no KVI	KVI (%)	no KVI (%)
NOUNB	15	9	62.5	37.5
UNB	16	6	72.73	27.27

It is possible to observe in Table 6.11 that a big percentage of the **UNB** and **NOUNB** products in the sample can be considered as **KVI**, however the percentage of **KVI** products is more than 10% higher for the **UNB** than for the **NOUNB.**

[26]An even more recent example (March-98) of a clear loss-leader strategy carried out with a LQ, was the reduction of the price of the Tesco Value white bread from 29 to 15 pence followed by both Sainbury and Safeway setting the price of their respective white bread discount line at 19 and 15 pence respectively.

[27]Probably these two products are not included in the list because there is no a clear leader brand in the market.

Therefore, this is a first element establishing a distinction between the **UNB** and **NOUNB** baskets of products.

As defined above, loss-leaders are products for which the supermarket sets very low prices sometimes below marginal cost. However, as supermarket wholesale costs are not available the possibility of identifying loss-leaders by price-cost comparison is not possible. A second possibility could be to try to identify loss-leaders by means of analysing supermarket advertising behaviour. Lal and Matutes [1994] suggest as candidate to loss leaders those products with low price and intense advertising. However, their model clearly fits with the US experience in which supermarkets advertise once a week in a local newspaper the prices of a subset of the products (loss-leaders) and are free to change the price of the other products along the week. This weekly advertising in a local newspaper does not take place in the UK[28] and therefore the identification by means of newspaper watching of those products that the UK supermarkets could be using as loss-leaders is precluded. A possible criterion to check if *Unbeatable Value* could be identified as a loss-leaders[29] strategy is to check if the probability of Tesco setting prices lower than Sainsbury and Safeway in the pre-guarantee period is significantly higher for the **UNB** than for the **NOUNB** basket of products. This is equivalent to check by means of a Wilconxon Test for Pair Matched Observations[30] if on average, $\mathbf{LPI}_{it}^{UNB}$ is higher than $\mathbf{LPI}_{it}^{NOUNB}$ for the period before the start of *Unbeatable Value*[31]. $\mathbf{LPI}_{it}^{UNB}$ and $\mathbf{LPI}_{it}^{NOUNB}$ are the correspondent Low Price Indexes for **UNB** and **NOUNB** defined as:

[28] We checked for a period of two months (Nov-96 and March-97) the only local newspaper (Evening Telegraph) and we did not find any price advertising by anyone of these supermarkets.

[29] Loss-leader is understood here in a broad sense: products sold at very low prices most of the times lower than competitors' prices, but not necessarily with prices lower than marginal cost.

[30] We use a Wilconxon test because each obervation in $\mathbf{LPI}_t^{UNB}$ is macthed with the observation of $\mathbf{LPI}_t^{NOUNB}$ that correspod to the same fortnight.

[31] Formally the null and alternative hypothesis of this one-sided Wilconxon Test for Price Matched Observations would be:

H_0 : *On average, in the pre-policy period there is no difference between* $\mathbf{LPI}_t^{UNB}$ and $\mathbf{LPI}_t^{NOUNB}$,
H_1 : *On average, in the pre-policy period* $\mathbf{LPI}_t^{UNB}$ *is higher than* $\mathbf{LPI}_t^{NOUNB}$.

$$\mathbf{LPI}_t^{UNB} = \frac{\sum_{i=1}^{22} LP_{it}}{22} \text{ where } i = 1, ..., 22 \text{ are the } \mathbf{UNB} \text{ products}$$

$$\mathbf{LPI}_t^{NOUNB} = \frac{\sum_{i=1}^{24} LP_{it}}{24} \text{ where } i = 1, ..., 24 \text{ are the } \mathbf{NOUNB} \text{ products}$$

where:

$$LP_{it} = \begin{cases} 1 \text{ if } p_{it}^{TE} < \min(p_{it}^{SA}, p_{it}^{SF}) \\ 0 \text{ otherwise} \end{cases}$$

If it turns out to be true that the probability of Tesco setting the lowest price is higher for the **UNB** than for the **NOUNB** basket of products then, we could infer that Tesco is using this group of products as part of an advertising campaign to attract customers into the shop and probably as a loss-leader strategy.

Table 6.12: Lowest Price Probability Test.UNB-NOUNB

LPI	T	C.V. 5%	CSS	One/Two Sided
$\mathbf{LPI}_t^{UNB} - \mathbf{LPI}_t^{NOUNB}$	23	30	15	One

T: value of the test; CV 5%: Critical Value at 5% significance level ; Rejection of H_0 if $T \leq CV$ 5%.
Corrected Sample Size (CSS) = Sample Size − Zero differences

The results of the Wilconxon test shown in Table 6.12 lead to reject the null hypothesis of no difference on average between $\mathbf{LPI}_t^{UNB}$ and $\mathbf{LPI}_t^{NOUNB}$ in the pre-guarantee period. They confirm that the probability of Tesco setting the minimum price in the area in the pre-guarantee period is higher for the **UNB** than for the **NOUNB** basket of products[32]. Probably Tesco, aware of this situation, is using those products for which it is more likely to enjoy a price advantage over the other supermarkets to start

[32] As it is possible to observe in the Table below, along the sample Tesco sets the lowest price alone in 21.66% of the times for the NOUNB products and in 26.67% of the times for the UNB products (5% difference).

an advertising campaign[33] based on the very low price of this subset of products to lure consumers to the shop. Even though we cannot check if the price of all these products is set below marginal cost, we think that the characteristics of *Unbeatable Value* are very similar to those of a loss-leaders strategy. Tesco is using products for which is setting a very low price (in general lower than the price at the two others supermarkets considered in the sample) as a part of an advertising campaign addressed to attract consumers into the shop.

6.5.2 *Unbeatable Value:* the start of a price war?

Once we have shown that Tesco's *Unbeatable Value* rather than a tool aimed at easing between-supermarket price coordination seems to be a loss-leading strategy to lure consumers to the supermarket, we concentrate the analysis in the effect of *Unbeatable Value* over the price of the basket of **UNB** products. Both the analysis of $\mathbf{RELPRI}_t^{ALL}$ and $\mathbf{UNBIND}_t^{ALL}$ above suggested that the start of *Unbeatable Value* triggered a supermarket price war. However, it is interesting to check if the start of this LPG was actually along a significant reduction of Tesco's price for the basket of **UNB** products (as we would expect in the event of a price war) and if Sainsbury and Safeway reacted in the same way.

Therefore, we focus our analysis on the evolution of the price of the **UNB** basket of products. We are interested not only in the evolution of the market averaged price of this basket but also in the evolution of its price at each one of the supermarkets. In

Lowest price setting (%)

	ALL	TE	SA	SF	TE-SA	TE-SF	SA-SF
NOUNB	23.33	21.66	16.66	8.89	14.17	10.83	4.44
UNB	39.69	26.67	9.69	3.03	7.87	12.12	0.90

However, we should consider the possibility of the other supermarkets setting low prices for some of the products included in the sample in order to use them as loss-leaders. Hence, we can calculate the percentage of times for which Tesco stands the lowest-price position (alone or jointly with other supermarkets). Tesco sets the lowest price of the market 86.35% of the times for the **UNB** group of products whereas only 69.99% of the times for the **NOUNB** group of products.

[33]This advertising campaign could be understood as a low-price signalling device.

order to carry out this analysis we first define the following indexes:

- Market Averaged Price of the Basket of **UNB**→

$\mathbf{PUNB}_t^{ALL} = \sum_{i=1}^{22}\left[\prod_{j=1}^{3} MS^J \times p_{it}^{UNB_J}\right]$

- Price of the Basket of **UNB** at supermarket J→

$\mathbf{PUNB}_t^{J} = \sum_{i=1}^{22} p_{it}^{UNB_J}$

and then we run the following set of regressions:

$$\mathbf{PUNB}_t^S = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

Table 6.13: PUNB Regression Analysis by store

Dependent Variable: $\mathbf{PUNB}_t^{ALL}$			Dependent Variable: $\mathbf{PUNB}_t^{TE}$		
$R^2 = 77.51$	$\bar{R}^2 = 74.58$		$R^2 = 25.00$	$\bar{R}^2 = 15.22$	
	Coefficient	Std Error[1]		Coefficient	Std. Error[1]
α_1	853.435**	3.394	α_1	834.1658**	4.7166
α_2	51.668**	5.343	α_2	14.5131	8.5111
β_1	0.1638	0.440	β_1	-0.5718	0.6965
β_2	-3.291**	0.481	β_2	-0.6310	0.7662
α_{post}	905.103**	4.120	α_{post}	848.6789**	6.9152
β_{post}	-3.1272**	0.194	β_{post}	-1.2028**	0.2883
Normality	5.141 (0.078)		*Normality*	3.0903 (0.213)	
Dependent Variable: $\mathbf{PUNB}_t^{SA}$			Dependent Variable: $\mathbf{PUNB}_t^{SF}$		
$R^2 = 88.68$	$\bar{R}^2 = 87.21$		$R^2 = 79.91$	$\bar{R}^2 = 77.30$	
	Coefficient	Std. Error[1]		Coefficient	Std. Error[1]
α_1	840.7180**	5.1178	α_1	885.4219**	6.0204
α_2	132.8139**	8.1861	α_2	7.6785	7.8128
β_1	3.1494**	0.4235	β_1	-2.0860**	0.6844
β_2	-8.7264**	0.5256	β_2	-0.5157	0.7264
α_{post}	973.5319**	6.3962	α_{post}	893.1004**	4.9801
β_{post}	-5.5770**	0.3125	β_{post}	-2.6017**	0.2437
Normality	0.0578 (0.971)		*Normality*	2.3816 (0.304)	

$\alpha_{post} = \alpha_1 + \alpha_2; \beta_{post} = \beta_1 + \beta_2$

[1]Newey-West standard errors; **Significant at 5% level; *Significant at 10% level

It is possible to observe in Table 6.13 and in Figure 6.10 that the introduction of *Unbeatable Value* changes the trend of $\mathbf{PUNB}_t^{ALL}$ from increasing (0.1638) to decreasing (-3.1272). As $\mathbf{PUNB}_t^{ALL}$ can be obtained as a weighted average of the $\mathbf{PUNB}_t^{J}$

at each supermarket, we can use the estimated coefficients of the trend dummy ($\hat{\beta}_2$) of each one of the supermarket regressions to calculate the share that corresponds to each supermarket in the change of trend of $\mathbf{PUNB}_t^{ALL}$.

Table 6.14: Supermarket Decomposition of PUNB trend dummy coefficient

	$\mathbf{PUNB}_t^{ALL}$	$\mathbf{PUNB}_t^{TE}$	$\mathbf{PUNB}_t^{SA}$	$\mathbf{PUNB}^{SF}$
Trend Dummy	-3.291**	-0.6310	-8.7264**	-0.5157
Coefficient ($\hat{\beta}_2$)	(0.481)	(0.7662)	(0.5256)	(0.7264)
Share (%)	100	6.39	88.39	5.22

Between brackets Newey-West standard errors. ** significant at 5% level

As it is possible to observe in Table 6.14, Sainsbury price setting is the main responsible of the change in trend (from increasing to decreasing) of $\mathbf{PUNB}_t^{ALL}$. We can use the results obtained from the regression models to disentangle this phenomenon. It is possible to observe in Table 6.13 that the estimated coefficient of the trend dummy in Tesco's regression model is not significant, this is signalling that no change in trend is observed as consequence of the start of the LPG[34]. This Tesco's result fits with the hypothesis about the real aim of Tesco's action stated before: Tesco, aware of its price advantage in a given subset of products, launches an advertising strategy based on the low price of these products to attract consumers into the store[35]. We can observe in

[34]The negative trend coefficient is not significant in the pre-policy period and significant in the post-policy period. However, one is not significantly different from the other.

[35]As it is possible to observe in Figure 6.11 another effect of Tesco's LPG on Tesco's price setting for the UNB basket of products has been to reduce the variability of the price of this basket. We can check statistically this hypothesis by means of an F-test for equal variances with the following null and alternative hypothesis:

H_0 : There is no difference between the variance of PUNB_t^J for pre and post-guarantee periods.

H_1: The variance of PUNB_t^J is greater in the post-guarantee than in the pre-guarantee period.

As it is posible to observe in the table below, the results of the F-test confirm that the introduction of the LPG had as effect a reduction in the degree of variation of the price of the basket of UNB at Tesco. A possible interpretation of this fact is that Tesco when introducing the LPG is loosing freedom in the price setting for the products included in the LPG.

	f	$P(F \leq f)$
PUNB_t^{TE}	4.5706	0.0078
PUNB_t^{SA}	1.6380	0.2079
PUNB_t^{SF}	2.4663	0.0694

F is a random variable that follows and F distribution

It is also possible to observe that for Sainsbury and Safeway the null hypothesis of equal variances

Figures 6.12 and 6.13 that the reaction of the two supermarkets affected in the area under study by Tesco's LPG seems to be quite different. Figure 6.12 clearly shows that the reaction of Sainsbury to *Unbeatable Value* is a continuous reduction of the price of the basket of **UNB** that inverts the trend of $\mathbf{PUNB}_t^{SA}$ (whereas in the pre-policy period the trend coefficient is 3.1494 in the post-policy period it is -5.5770). Moreover, Sainsbury's regression model is the only one for which the coefficient of the trend dummy is significant. This result clearly matches with the declarations of a Sainsbury's spokesman shortly after the start of Tesco's LPG that although neglecting the need of a direct reaction to Tesco's move says: " *When we launch Unbeatable Autumn, we said we would undercut the competitors and that is just what we have done with this offer"*[36]. It seems that Sainsbury understood *Unbeatable Value* as a further Tesco's threat to its lost market share leadership[37]. With respect to Safeway the not significant coefficient of the trend dummy seems to indicate no significant change in Safeway's price trend for the **UNB** products after the introduction of the LPG, however we have still the doubt if this decreasing trend would have continued for so long without the Tesco's *Unbeatable Value.*

There is a still a prediction about the loss-leaders strategies that we have not checked for *Unbeatable Value*: if a subset of products is used as loss-leader the supermarket must

is not rejected at 5% of significance. Therefore, for these supermarkets no difference is detected in the variability of the price of the basket of UNB between the pre and post-policy periods.

[36]Marketing Week , 13th September 1996.

Although *Autumn Value* was in principle advertised as a LPG over 700 product, it cannot be considered as an actual LPG because it was always linked to a multi-unit product purchase of the kind "Buy two units and have the third at half price". Additionally, it was never stated if the price relevant for the LPG was the price per unit of the multiproduct purchase or the price when only one unit was purchased.

Autumn Value started just in the fortnight after the start of Tesco's *Unbeatable Value* and it lasted until Christmas (five observations in our sample) whereas the last one was still operating at the end of the sample. It is possible to observe in Figure 6.11 that while the start of Tesco's LPG substantially affected the patterns of price setting of Tesco for the products included in the LPG *Autumn Value* does not seem to have any relevant effect.

[37]Along 1995-1996 Tesco took over Sainsbury's market share leadership.

obtain higher margin for other products in order to compensate. We can assume for this analysis that these "other products" are the **NOUNB** products and we examine if the LPG has any effect over Tesco's pricing for these products. It is possible to observe in Figure 6.14 that whereas in the pre-guarantee period the price of the basket of **NOUNB** products followed an ever decreasing trend, the start of the LPG breaks this trend. The price of this basket is almost completely stable in the post-guarantee period. If first we define:

$$\mathbf{PNOUNB}_t^{TE} = \sum_{i=1}^{22} p_{it}^{NOUNB_{TE}}$$

and then we perform the usual regression analysis:

$$\mathbf{PNOUNB}_t^{TE} = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

the results (Table 6.15) just confirm the intuition we got through observation of Figure 6.14. Whilst the trend coefficient (-6.3512) in the pre-guarantee period is negative and significant, in the post-guarantee period this trend coefficient (-0.1626) is no significant. Another time, Tesco's pricing behavior after the start of the LPG fits quite well with a loss-leaders strategy: once, by means of advertising the attention is placed on the low prices of the subset of LPG products the process of reduction of the prices of "other products" is halted.

To sum up, Tesco's *Unbeatable Value* did not consist in a significant reduction of the prices of the products included in the campaign with the aim of triggering a price war. We think that *Unbeatable Value* is an advertising campaign with all the characteristics of a loss-leader strategy (although we cannot prove the fact of possible pricing under marginal cost) in which Tesco, after recognition of its price advantage in a group of LQs, is using their low prices to lure consumers to the shop with the aim of earning higher margins on other products. However, Sainsbury interpreted Tesco's *Unbeatable*

Table 6.15: PNOUNB regression analysis

Dependent Variable : **PNOUNB**$_t^{TE}$		
$R^2 = 87.59$		$\overline{R}^2 = 85.97$
	Coefficient	Std. Error[1]
α_1	1958.3**	7.4520
α_2	-101.0240**	26.0618
β_1	-6.3512**	0.8196
β_2	6.1886**	1.4096
α_{post}	1857.3**	24.9737
β_{post}	-0.1626	1.1469
Normality	0.2792 (0.870)	
$\alpha_{post} = \alpha_1 + \alpha_2; \beta_{post} = \beta_1 + \beta_2$		

[1]Newey-West Standard Errors;** significant at 5% level; *significant at 10% level

Value as a clear threat, thus started a process of reduction of the prices included in Tesco's *Unbeatable Value* that produced a change in the trend of the market average price of the basket of these products.

6.6 Concluding Remarks

The empirical analysis of Tesco's LPG sheds light about the possible anticompetitive effects of LPGs. Although it turns out to be true that this LPG resulted in a higher degree of between-supermarkets price coordination for the products included in it, this goes along with a price decreasing trend and not with a increasing trend such as predicted by Dixit and Nalebuff [1991].

In general, we expect that in supermarket retailing the expected reward from activating the LPG usually will not to be big enough to compensate the costs in which the consumer has to incur to activate it. This could explain the inability of Tesco's LPG to raise prices to supracompetitive levels, but by no means it serves as explanation of the procompetitive pattern detected. In order to explain the procompetitive effects of the LPG over the prices of the products included in it, it is necessary to bear in mind the nature of the supermarket as a multiproduct firm. The results of our analysis indicate that Tesco's *Unbeatable Value* did not consist in a significant reduction of the prices of the products included in the campaign with the aim of triggering a price war. *Unbeatable Value* seems an advertising campaign with all the characteristics of a loss-leader strategy (although we cannot prove the fact of possible pricing under marginal cost) in which Tesco, after recognition of its price advantage in a group of LQs, is using their low prices to lure consumers to the shop with the aim of earning higher margins on other products. However, Sainsbury interpreted Tesco's *Unbeatable Value* as a clear threat to its market share and reacted with a significant reduction of the prices of the products included in the guarantee. Hence, antitrust claims related with LPGs [Sargent, 1993] should be revisited in those cases involving multiproduct firms. These claims should carefully analyse the real objective of the multiproduct firms when announcing a given strategy. Otherwise they run a clear risk of misunderstanding.

6.7 Appendices

A: Variables Description and Descriptive Statistics

A.1 Variables Used in the Price Coordination Analysis

Variable	Description	Sample	Observations	Period	Mean	Std. Desviation
$DDPMI^{TE-SA}_{ALL,PRE}$	Price Coordination TE-SA	All Products	46	Pre-Guarantee period	0.6539	0.2243
$DDPMI^{TE-SA}_{NOUNB,PRE}$	Price Coordination TE-SA	No Unbeatables	24	Pre-Guarantee period	0.6877	0.2296
$DDPMI^{TE-SA}_{UNB,PRE}$	Price Coordination TE-SA	Unbeatables	22	Pre-Guarantee period	0.6169	0.2245
$DDPMI^{TE-SF}_{ALL,PRE}$	Price Coordination TE-SF	All Products	46	Pre-Guarantee period	0.6885	0.1916
$DDPMI^{TE-SF}_{NOUNB,PRE}$	Price Coordination TE-SF	No Unbeatables	24	Pre-Guarantee period	0.6995	0.1982
$DDPMI^{TE-SF}_{UNB,PRE}$	Price Coordination TE-SF	Unbeatables	22	Pre-Guarantee period	0.6765	0.2540
$DDPMI^{TE-SA}_{ALL,POST}$	Price Coordination TE-SA	All Products	46	Post-Guarantee period	0.7980	0.1641
$DDPMI^{TE-SA}_{NOUNB,POST}$	Price Coordination TE-SA	No Unbeatables	24	Post-Guarantee period	0.7583	0.1601
$DDPMI^{TE-SA}_{UNB,POST}$	Price Coordination TE-SA	Unbeatables	22	Post-Guarantee period	0.8413	0.1172
$DDPMI^{TE-SF}_{ALL,POST}$	Price Coordination TE-SF	All Products	46	Post-Guarantee period	0.7953	0.1865
$DDPMI^{TE-SF}_{NOUNB,POST}$	Price Coordination TE-SF	No Unbeatables	24	Post-Guarantee period	0.7468	0.1771
$DDPMI^{TE-SF}_{UNB,POST}$	Price Coordination TE-SF	Unbeatables	22	Post-Guarantee period	0.8482	0.1440

A.2 Variables used in the Price Trends Analysis

Variable	Description	Observations	Mean	Std. Desv.
$RELPRI_t^{ALL}$	Market Averaged Price Index	27	0.4381	0.0074
$NOIND_t^{ALL}$	Index of the Market Price of the Basket of No Unbeatable Products. Basis in Period 1	27	0.9712	0.0201
$UNBIND_t^{ALL}$	Index of the Market Price of the Basket of Unbeatable Products. Basis in Period 1	27	0.9842	0.0149
$NOIND1_t^{ALL}$	Index of the Market Price of the Basket of No Unbeatable Products. Basis in Period 1	15	0.9863	0.0137
$UNBIND1_t^{ALL}$	Index of the Market Price of the Basket of Unbeatable Products. Basis in Period 1	15	0.9929	0.0093
$NOIND16_t^{ALL}$	Index of the Market Price of the Basket of No Unbeatable Products. Basis in Period 16	12	1.0044	0.0043
$UNBIND16_t^{ALL}$	Index of the Market Price of the Basket of Unbeatable Products. Basis in Period 16	12	0.9781	0.0135
$RELPRI_t^{TE}$	Price Index for Tesco	27	0.4389	0.0078
$RELPRI_t^{SA}$	Price Index for Sainsbury	27	0.4407	0.0099
$RELPRI_t^{SF}$	Price Index for Safeway	27	0.4347	0.0084
$PUNB_t^{ALL}$	Market Price of the Basket of Unbeatable products	27	847.2452	12.8053
$PUNB_t^{TE}$	Price of the Basket of Unbeatable Products at Tesco	27	826.5814	9.6413
$PUNB_t^{SA}$	Price of the Basket of Unbeatable Products at Sainsbury	27	860.4520	18.8940
$PUNB_t^{SF}$	Price of the Basket of Unbeatable Products at Safeway	27	854.7023	20.6158
$PNOUNB_t^{TE}$	Price of the Basket of No Unbeatable Products at Tesco	27	1883.6674	36.6148

B. FIGURES

Figure 6.1: RELPRI (ALL) Actual and Fitted Values

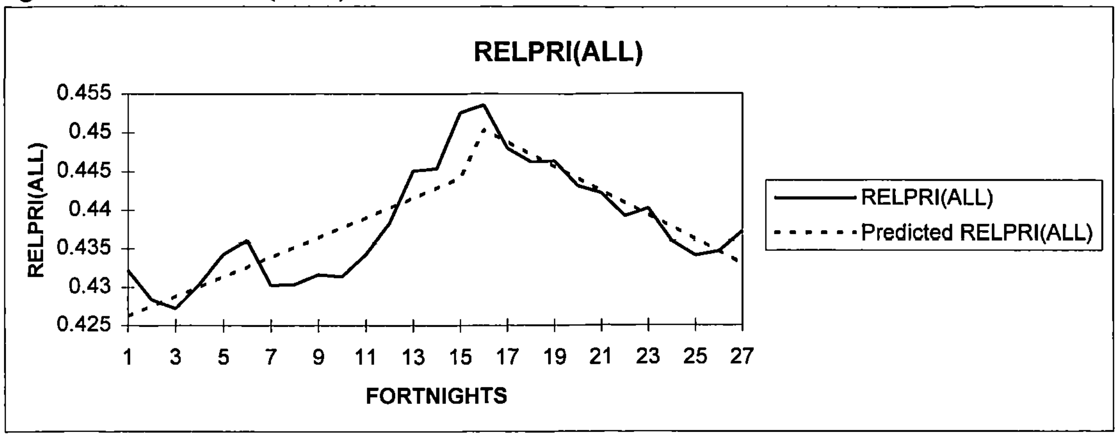


Figure 6.2: NOIND(ALL) Actual and Fitted Values

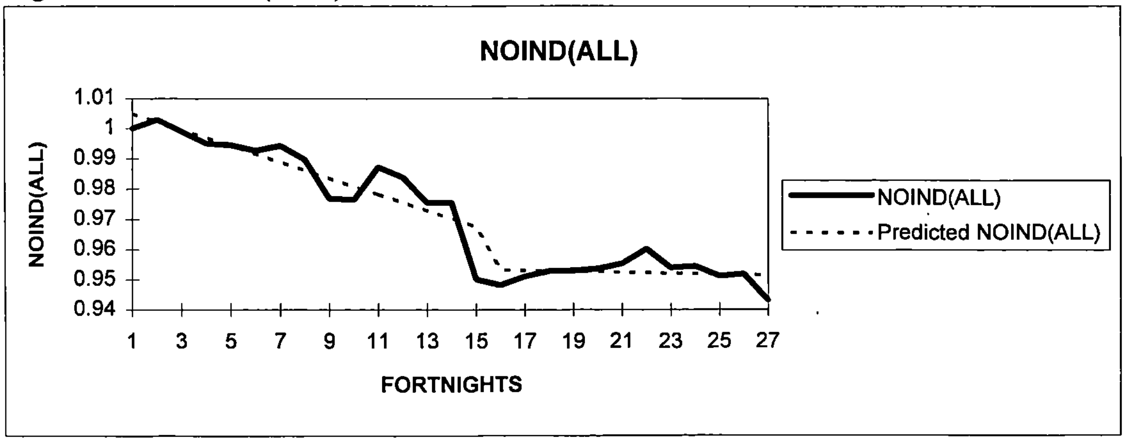


Figure 6.3: UNBIND(ALL) Actual and Fitted Values

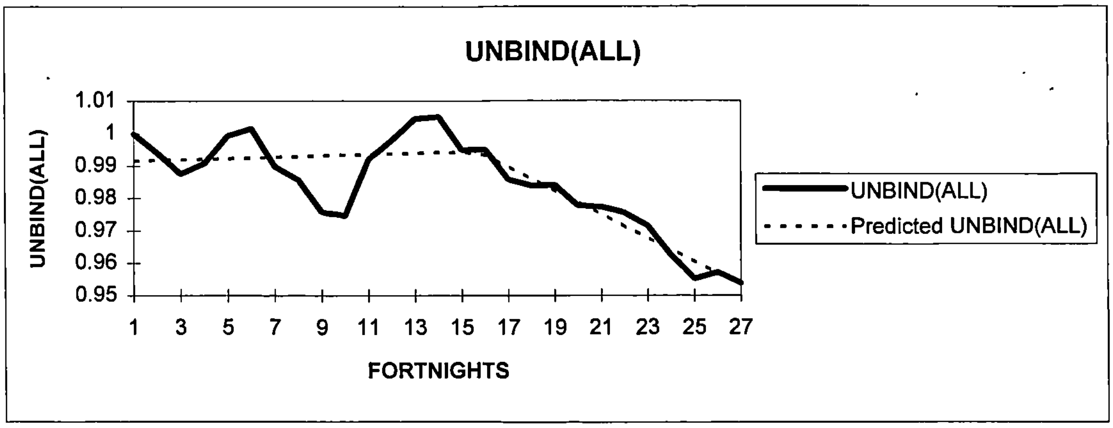


Figure 6.4: NOIND1/UNBIND1.Basis Fortnight 1

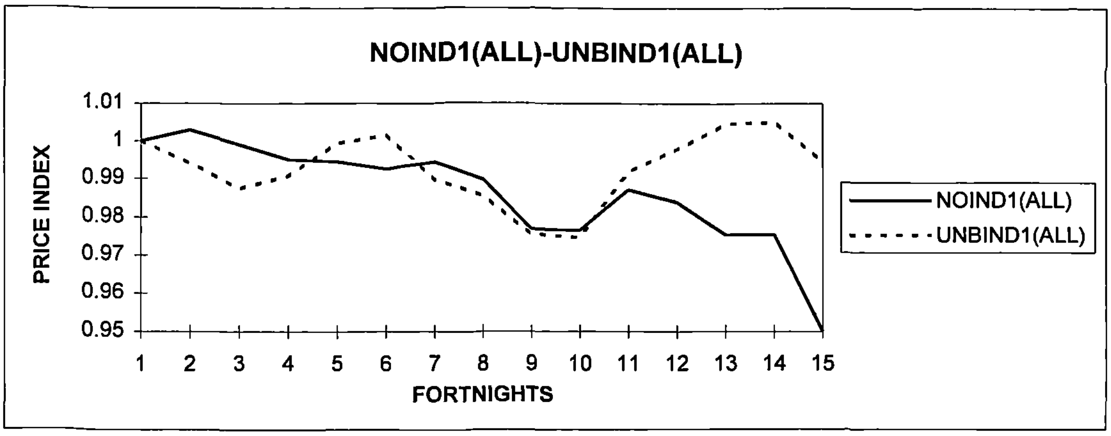


Figure 6.5: NOIND16/UNBIND16.Basis Fortnight 16

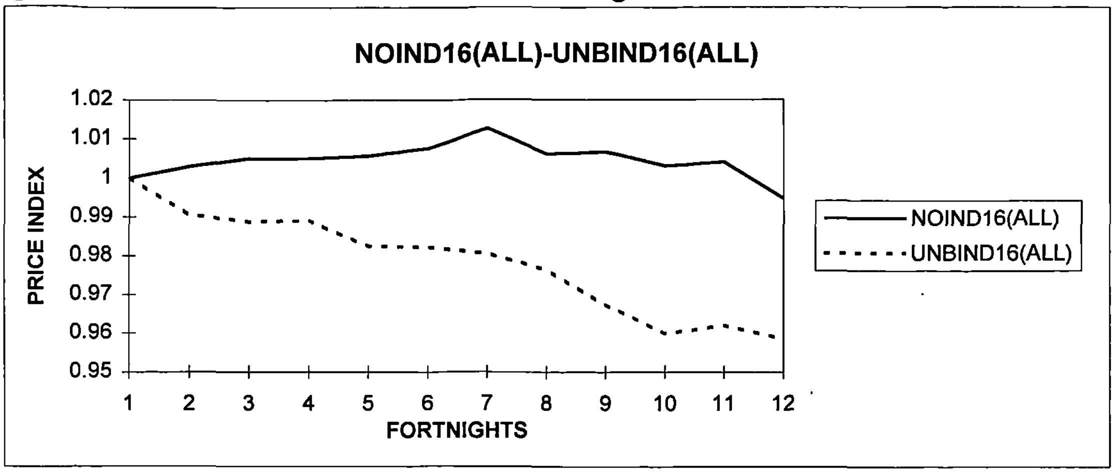


Figure 6.6: RELPRI(TE): Actual and Fitted Values

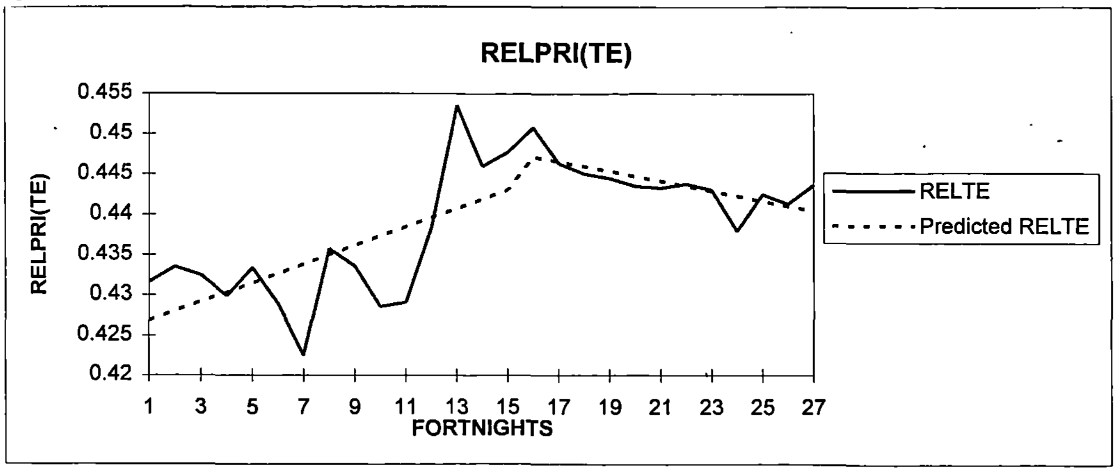


Figure 6.7: RELPRI(SA): Actual and Fitted Values

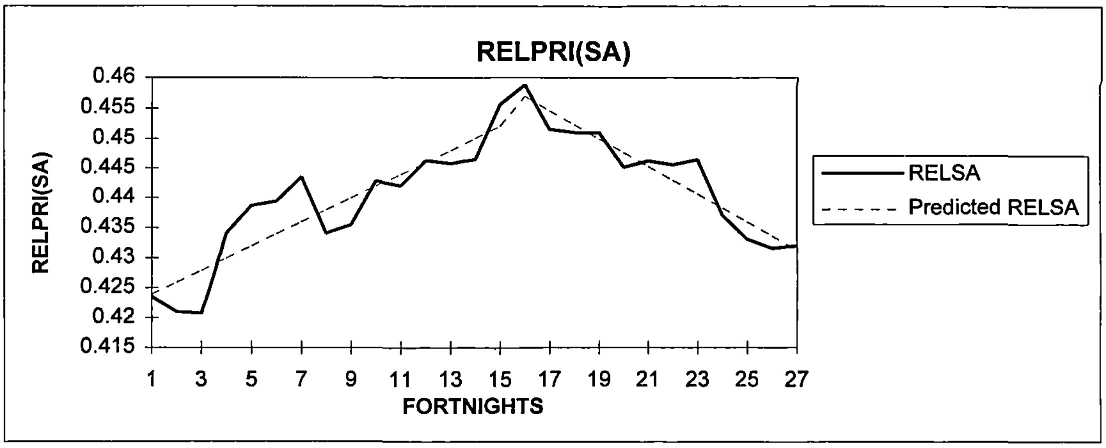


Figure 6.8: RELPRI(SF): Actual and Fitted Values

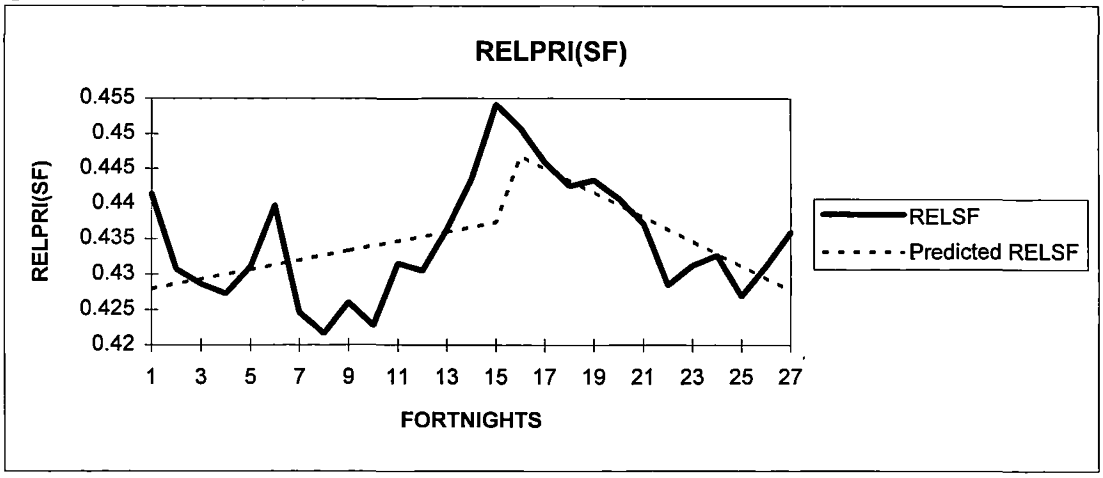


Figure 6.9: Evolution of the Price of the Basket of UNB products

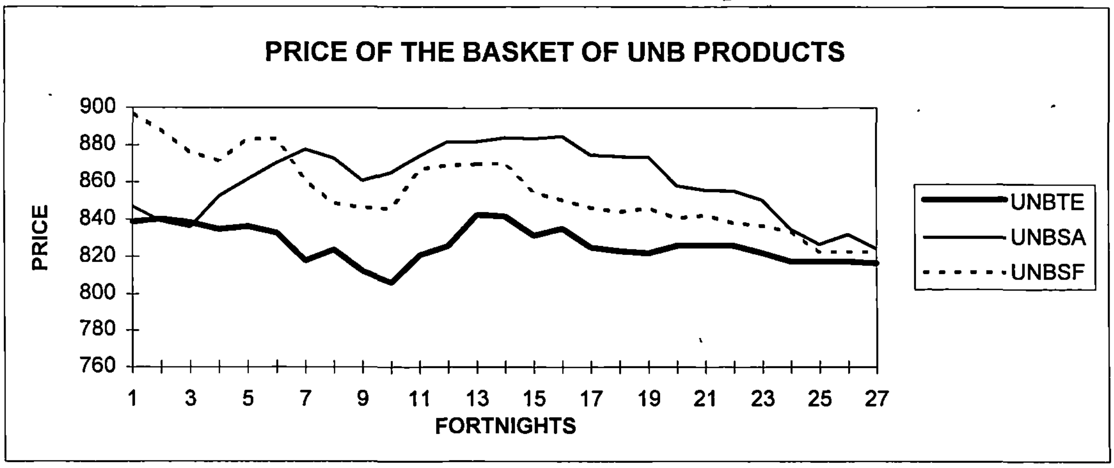


Figure 6.10: PUNB(ALL): Actual and Fitted Values

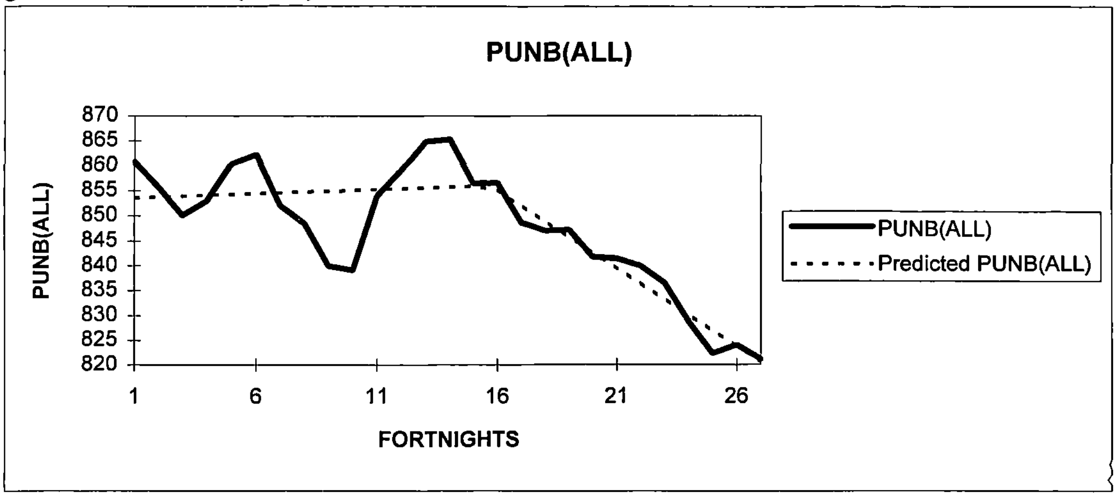


Figure 6.11: PUNB(TE) Actual and Fitted Values

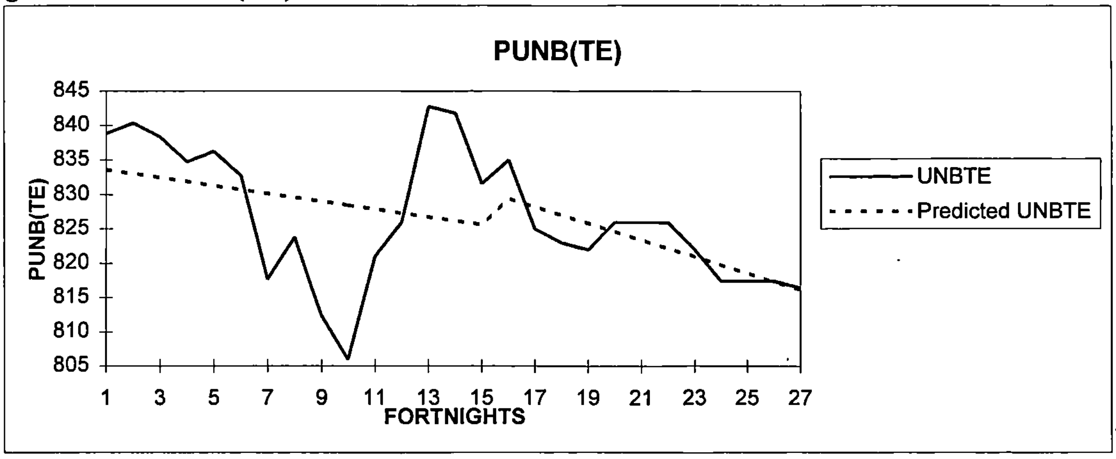


Figure 6.12: PUNB(SA) Actual and Fitted Values

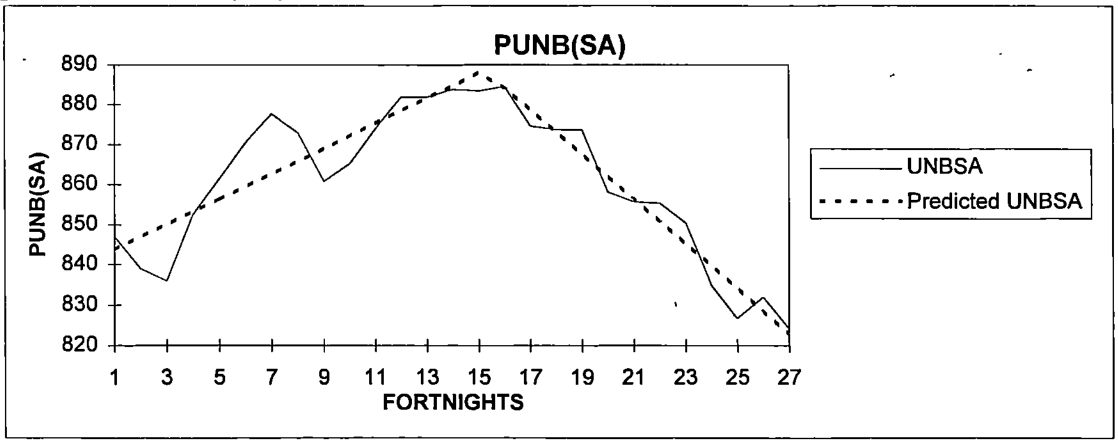


Figure 6.13: PUNB(SF) Actual and Fitted Values

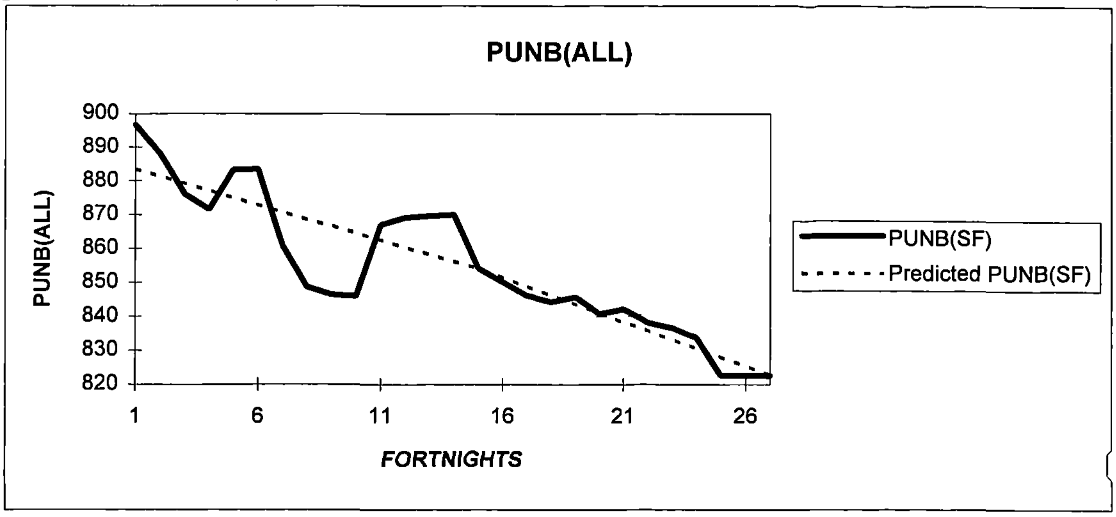
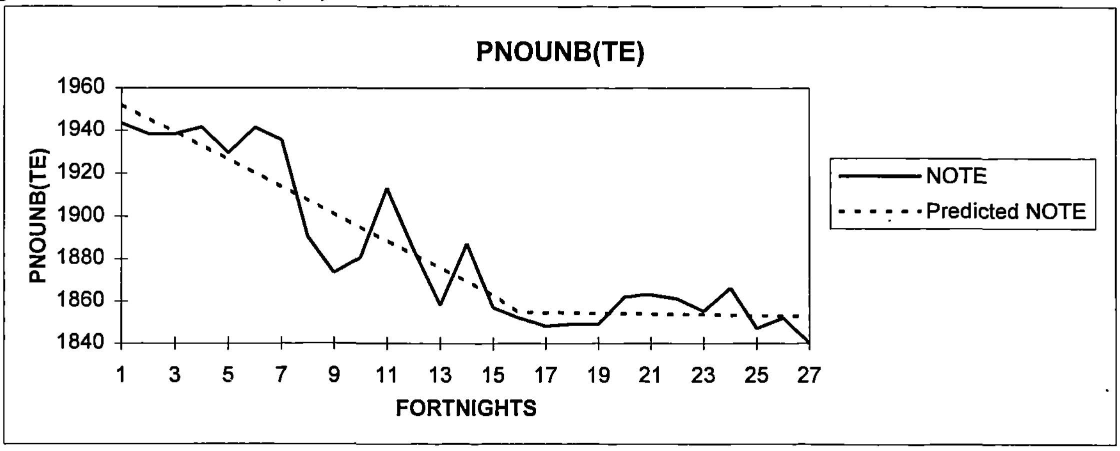


Figure 6.14: PNOUNB(TE) Actual and Fitted Values



C. Reduced Sample Analysis

Motivated for the lack of weights when building the basket of products included (**UNB**) and not included in the LPG (**NOUNB**), the aim of this Appendix is to show the robustness of the results to the subset of products included in the sample. With respect of the sample used in the general body of the paper (full sample), we exclude here the categories of alcoholic products (beer) and toiletries (deodorant, hair shampoo, shower gel, toothpaste, sanitary towels, soap). The reason for this exclusion is that this is the subset of products for which interpurchase time is longer and/or tastes more important in the buying decision.

The numbering of the Tables in this Appendix corresponds to that of the general body of the paper and an *a* is added to distinguish them.

Table 6.4a: Mann-Whitney Test for differences on average DDPMI. UNB-NOUNB

Pre-guarantee		Value of the test (U)	Critical Value 5%	One/Two Sided
	TE-SA	179	120.07	Two
	TE-SF	178	119.91	Two
Post-guarantee		Value of the test (U)	Critical Value 5%	One/Two Sided
	TE-SA	105.5	131	One
	TE-SF	114	131.24	One

Rejection of the H_0 if U$\leq CV5\%$

It is possible to observe in Table 6.4a that the results obtained do not differ from the results obtained with the full sample. Whereas in the pre-guarantee period the average **DDPMI** is similar for **UNB** and **NOUNB** (the null hypothesis is not rejected), in the post-guarantee period the average **DDPMI** is higher for **UNB** than for **NOUNB**.

Table 6.5a: Wilconxon Test for differences on average DDPMI. Pre-post guarantee

NOUNB		T	C.V. 5%	CSS	One/Two Sided
	TE-SA	47	41	17	One
	TE-SF	63	53	19	One
UNB		T	C.V. 5%		
	TE-SA	8	47	18	One
	TE-SF	29	53	19	One

T: value of the test; CV 5%: Critical Value at 5% significance level ; Rejection of H_0 if $T \leq CV$ 5%; Corrected Sample Size (CSS) = Sample Size − Number of Zero Differences.

As for the full sample, the results shown in Table 6.5a suggest that while for the **NOUNB** there is no difference in the average **DDPMI** between the pre and post-guarantee period, for the **UNB** the **DDPMI** is higher in the post-guarantee period.

Table 6.6a: RELPRI regression analysis

Dependent Variable : $\mathbf{RELPRI}_t^{ALL}$		
	Coefficient	Std. Error[1]
	R^2 =73.62	$\overline{R}^2$ =70.18
α_1	0.5262**	0.0047
α_2	0.0680**	0.0065
β_1	0.0015**	0.0006
β_2	-0.0034**	0.0007
α_{post}	0.5943**	0.0042
β_{post}	-0.0019**	0.0002
Normality	4.4569 (0.108)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West Standard Errors; ** significant at 5% level; * significant at 5% level

The results of the regression analysis (Table 6.6a) show that Tesco's LPG is inverting the trend of $\mathbf{RELPRI}_t^{ALL}$ from increasing to decreasing confirming the evidence obtained with the full sample (whereas in the pre-policy period the trend coefficient is 0.0015 in the post policy period it is -0.0019).

Table 6.7a: Regression Analysis Results

Dependent Variable: $\mathbf{NOIND}_t^{ALL}$			Dependent Variable: $\mathbf{UNBIND}_t^{ALL}$		
$R^2 = 83.16$	$\bar{R}^2 = 80.97$		$R^2 = 67.74$		$\bar{R}^2 = 63.53$
	Coefficient	Std. Error[1]		Coefficient	Std. Error
α_1	1.0116**	0.0049	α_1	0.9810**	0.0048
α_2	-0.0732**	0.0170	α_2	0.0460**	0.0076
β_1	-0.0032**	0.0005	β_1	-0.0006	0.0006
β_2	0.00321**	0.0009	β_2	-0.0028**	0.0007
α_{post}	0.9384**	0.1633	α_{post}	1.0359	0.0059
β_{post}	0.00001	0.0007	β_{post}	-0.0034	0.0003
Normality	3.3542(0,187)		*Normality*	4.5651(0.102)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West Standard Errors; ** significant at 5% level; * significant at 5% level

It is possible to observe in Table 6.7a that as with the full sample Tesco's LPG changes the trend coefficient $\mathbf{NOIND}_t^{ALL}$ from negative and significant to a no significant one. The trend coefficient of $\mathbf{UNBIND}_t^{ALL}$ changes from no significant to negative and significant.

Table 6.8a: Wilconxon Test. Different Base Analysis

NOUNB	T	C.V. 5%	CSS	One/Two Sided
Weeks 1-15	38	21	14	Two
Weeks 16-27	0	13	11	One

T: value of the test; CV 5%: Critical Value at 5% significance level ; Rejection of H_0 if $T \leq CV$ 5%; Corrected Sample Size (CSS) = Sample Size − Number of Zero Differences

Table 6.8a confirms the results obtained using the full sample. Whilst for the pre-guarantee period the average level of **UNBIND1** and **NOIND1** is similar, the effect of Tesco's LPG is to keep **UNBIND16** systematically below **NOIND16**.

Table 6.9a: Regression Analysis by store

Dependent Variable: **RELPRI**$_t^{TE}$		
$R^2 = 62.10$	$\bar{R}^2 = 57.15$	
	Coefficient	Std. Error[1]
α_1	0.5364**	0.0058
α_2	0.0466**	0.0086
β_1	0.0008	0.0008
β_2	-0.0017*	0.0009
α_{post}	0.5830**	0.0060
β_{post}	-0.0010**	0.0003
Normality	0.7105 (0.705)	
Dependent Variable:**RELPRI**$_t^{SA}$		
$R^2 = 72.99$	$\bar{R}^2 = 69.47$	
	Coefficient	Std. Error[1]
α_1	0.5149**	0.0067
α_2	0.0739**	0.0089
β_1	0.0027**	0.0005
β_2	-0.0047**	0.0006
α_{post}	0.5888**	0.0059
β_{post}	-0.0020**	0.0003
Normality	1.5773 (0.454)	
Dependent Variable:**RELPRI**$_t^{SF}$		
$R^2 = 44.79$	$\bar{R}^2 = 37.59$	
	Coefficient	Std. Error[1]
α_1	0.5283**	0.0125
α_2	0.0830**	0.0131
β_1	0.0010	0.0014
β_2	-0.0037**	0.0014
α_{post}	0.6113**	0.0035
β_{post}	-0.0028**	0.0001
Normality	2.3698(0.306)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West Standard Errors; ** significant at 5% level; * significant at 5% level

Table 6.10a: Supermarket Decomposition of RELPRI trend dummy coefficient

	RELPRI$_t^{ALL}$	**RELPRI**$_t^{TE}$	**RELPRI**$_t^{SA}$	**RELPRI**$_t^{SF}$
Trend Dummy Coefficient ($\hat{\beta}_2$)	-0.0034** (0.00067)	-0.0017* (0.00087)	-0.0047** (0.00063)	-0.0037** (0.00013)
Share (%)	100	16.80	46.17	37.03

Between brackets Newey-West standard errors. ** significant at 5% level;* significant at 10% level

The joint observation of Tables 6.9a and 6.10a reveals that all the results obtained with the full sample are confirmed when using the reduced sample. On the one hand the effect of Tesco's LPG is to invert the trend of $\mathbf{RELPRI}_t^J$ (from increasing to decreasing) at each one of the supermarkets, on the other hand as it is possible to observe in Table 6.10a. Sainsbury is the supermarket that has altered more its pricing behavior as a consequence of the LPG.

Table 6.11a: KVIs Products

	KVI	no KVI	KVI (%)	no KVI (%)
NOUNB	11	8	57.90	42.10
UNB	15	5	75.00	25.00

As when using the full sample the percentage of **KVI** products is more than 10% higher for the products included in the LPG that for the products not included (Table 6.11a)

Table 6.12a: Lowest Price Probability Test. UNB-NOUNB

LPI	T	C.V. 5%	CSS	One/Two Sided
$\mathbf{LPI}_t^{UNB} - \mathbf{LPI}_t^{NOUNB}$	23	30	15	One

T: value of the test; CV 5%: Critical Value at 5% significance level ;Rejection of H_0 if T$\leq$CV 5%; Corrected Sample Size (CSS) = Sample Size − Number of Zero Differences

The results we get using the reduced sample and shown in Table 6.12a confirm that the probability of Tesco setting the lowest price of the three supermarkets is significantly higher for the UNB than for the NOUNB.

Table 6.13a: PUNB Regression Analysis by store

Dependent Variable: $\mathbf{PUNB}_t^{ALL}$			Dependent Variable: $\mathbf{PUNB}_t^{TE}$		
$R^2 = 76.16$	$\bar{R}^2 = 73.05$		$R^2 = 25.32$	$\bar{R}^2 = 15.58$	
	Coefficient	Std Error[1]		Coefficient	Std. Error[1]
α_1	790.92**	3.8235	α_1	773.88**	6.9511
α_2	36.7966**	6.0703	α_2	2.9779	9.1278
β_1	-0.4656	0.5070	β_1	-1.1111	0.9493
β_2	-2.2349**	0.5495	β_2	0.3278	1.0097
α_{post}	827.7213**	4.7161	α_{post}	776.858**	5.1050
β_{post}	-2.7006**	0.2128	β_{post}	-0.78322**	0.2178
Norm.	2.9835(0.225)		*Norm.*	3.0419 (0.219)	
Dependent Variable:PUNB_t^{SA}			Dependent Variable: PUNB_t^{SF}		
$R^2 = 83.02$	$R^2 = 80.81$		$R^2 = 67.74$	$R^2 = 63.53$	
	Coeffcient	Std.Error		Coeffcient	Std. Error
α_1	779.681**	6.6892	α_1	819.21**	10.7016
α_2	105.813**	10.7207	α_2	1.5985	12.3524
β_1	2.0822**	0.6062	β_1	-2.368[2]**	1.0808
β_2	-7.1893**	0.7505	β_2	0.1562	1.1181
α_{post}	885.4951**	7.8052	α_{post}	820.8109	6.1200
β_{post}	-5.1071**	0.3503	β_{post}	-2.2115**	0.2782
Norm.	0.6868 (0.709)		*Norm.*	0.0583 (0.971)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West Standard Errors; ** significant at 5% level; * significant at 5% level

Table 6.14a: Supermarket Decomposition of PUNB trend dummy coefficient

	$\mathbf{PUNB}_t^{ALL}$	$\mathbf{PUNB}_t^{TE}$	$\mathbf{PUNB}_t^{SA}$	$\mathbf{PUNB}^{SF}$
Trend Dummy	-2.2349	0.3278	-7.1893	0.1566
Coefficient ($\hat{\beta}_2$)	(0.5495)**	(0.7691)	(0.7016)**	(1.118)
Share (%)	100	-4.89	107.22	-2.32

[1]Newey-West Standard Errors; ** significant at 5% level, * significant at 10% level

The joint consideration of the results shown in tables 6.13a and 6.14a confirms the evidence obtained when using the full sample. Whilst in the period before the start of the LPG, $\mathbf{PUNB}_t^{ALL}$ did not follow a defined trend, this trend is clearly decreasing after the start of the LPG. Most of this phenomenon is explained by the change in the price setting behaviour of Sainsbury.

Table 6.15a: PNOUNB regression analysis

Dependent Variable : $\mathbf{PNOUNB}_t^{TE}$		
	$R^2 = 83.16$	$\overline{R}^2 = 80.97$
	Coefficient	Std. Error[1]
α_1	1442.1**	8.2317
α_2	-110.2637**	28.7888
β_1	-3.7548**	0.9053
β_2	4.8159**	1.5571
α_{post}	1331.8**	27.5867
β_{post}	1.0621	1.2669
Normality	0.2471 (0.884)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West Standard Errors; ** significant at 5% level; * significant at 5% level

It is possible to observe in Table 6.15a that the results using the reduced sample confirm the no significant trend coefficient for the basket of NOUNB products at Tesco after the start of the LPG.

D	PRODUCTS INCLUDED IN THE SAMPLE	
LPG	PRODUCT	KVI
NO UNBEATABLES	Canned Sweet Corn (Green Giant 340grs)	
	Bleach (Domestos Bleach 2l)	KVI
	Conditioner (Lenor Ultra Plus Fabric Conditioner 2l)	KVI
	Kitchen Foil (Bacofoil 450mm x5m)	
	Washing Powder (Ariel Future 2kgs)	KVI
	Washing Up Liquid (Fairy Excel Plus 500ml)	KVI
	Beer (Heineken 330 ml)	
	Bread (Mighty White. 800 grs)	KVI
	Cat Food (Whiskas 400grs)	KVI
	Coffee (Nescafe Gold 200grs)	KVI
	Dog Food (Chum Original Large 400gr)	KVI
	Frozen Peas (Birds Eye 340 grs)	KVI
	Ice Cream (Walls Vanilla 750grs)	
	Oven Chips (McCain 1810 grs)	
	Pasta Sauce (Dolmio Pasta sauce Original 475 grs)	
	Salad Dressing (Heinz Salad Dressing 285 grs)	KVI
	Tea (PG Tips 250 grs)	KVI
	Tuna in Oil (John West 200grs)	
	Yogourth (Muller Strawberry 200 grs)	
	Orange Juice (Del Monte 1 L)	
	Deodorant (Sure 24 hours Apa 150 ml)	KVI
	Hair Shampoo (Timotei Herbs Shampoo 400grs)	KVI
	Shower Gel (Imperial Leather 500ml)	KVI
	Toothpaste (Colgate Total 100ml)	KVI
UNBEATABLE	Baked Beans in Tomato Sauce (Heinz 425 grs)	KVI
	Canned Peas (Hartley's Garden Peas)	
	Canned Spaghetti (Heinz 200 grs)	KVI
	Canned Tomatoes (Napolina Chopped Tomatoes 400grs)	
	Kitchen Towel (Sterling Luxury Kitchen Towel Twin Pack)	KVI
	Tissues (Ultra 90. Kleenex)	KVI
	Toilet Roll (Twin Andrex 4)	KVI
	Cornflakes (Kellogs Cornflakes 500grs)	KVI
	Fish Fingers (10 Birds Eye)	KVI
	Flour (Homepride Flour 1,5kgs)	KVI
	Ketchup (Heinz 340grs)	KVI
	Margarine (Flora 500 grs)	KVI
	Mayonneise (Hellmans 400grs)	KVI
	Peach Halves in Natural Juice (Del Monte 415 grs)	
	Rice (Uncle Ben Long Grain Rice 1 kg)	KVI
	Smoked Back (Danepack 8s)	
	Spaghetti (Buitoni 500grs)	
	Strawberry Jam (Robertson 454 grs)	KVI
	Walkers Crisps (Variety Multipack. 6 packs)	
	Coca-Cola (2 l)	KVI
	Sanitary towels (Always 16)	KVI
	Soap (Dove 250 grs)	KVI

Chapter 7

Do the supermarkets compete with the discounters?

Abstract

In the UK, supermarkets face not only the competition of other supermarkets but also the competition of discounters. Whereas the physical characteristics of the products sold by supermarkets and discounters are almost identical, supermarkets provide a higher service quality than discounters. Using a micro-level data set of prices, we study the implications of this service quality differential (as an element of vertical product differentiation) over the patterns of price setting observed in the market. In addition, we explore the possible influence of this differential in service quality on the effects over supermarkets and discounters price setting of a LPG offered by one of the supermarkets considered.

7.1 Introduction

In the UK market, supermarkets face not only the competition of other supermarkets but also the competition of discounters. Although the physical characteristics of the goods sold by supermarkets and discounters are almost identical, the level of service quality provided clearly differentiate them.

Supermarkets provide a "high" service quality level. Beside selling the product, supermarkets offer additional services such as a nice shopping environment, in-store delicatessen and fishmonger or loyalty cards and banking services. Discounters offer a "low" service quality level focusing their attention on offering the lowest possible price.

The aim of this chapter is to investigate the role played by this difference in service quality in the patterns of competition between supermarkets and discounters. With this purpose, we carry out a twofold analysis: on the one hand, we analyse the patterns of price setting when supermarkets and discounters are considered as forming part of a unique relevant market; on the other hand, we analyse differences and similarities in the reactions of supermarkets and discounters to a low-price guarantee offered by one of the competing supermarkets.

The first piece of analysis uses as starting point the Garcia, Georgantzis and Petit [1998] model, that we slightly modify to allow for location asymmetries. In this model, vertical product differentiation is given by the difference in consumers' reservation price depending on whether the product is bought at a "high" or "low" service quality outlet. The horizontal differentiation (as in the Hotelling model) is given by the outlet location. Considering in the sample a discounter (providing "low" service quality) and two supermarkets (providing "high" service quality) asymmetrically located with respect to the discounter will allow us to analyse the importance of horizontal and vertical product differentiation in determining supermarket price setting. Additionally, the fact that both supermarkets and discounters sell branded products (BP) and low-quality own brand products (LQ) will allow us to compare the patterns of price setting for these two quality variants.

The result of this analysis signals that both for BPs and LQs the vertical component is the main element explaining observed differences in food-retailing price setting. For the BPs locational asymmetries do not seem to play a relevant role to explain price setting, and service quality differentials seem to be a sufficient element to isolate supermarkets from the competition of discounters. However, for the LQs service quality loses part of its ability to segment the market and locational asymmetries arise as a potential element in determining price setting.

The second piece of analysis compares the effects of Tesco's *Unbeatable Value* low-price guarantee over a Sainsbury and a Kwik Save outlets affected by the guarantee in the south of Coventry. By means of an analysis of price coordination and price trends, we detect a clear reaction of Sainsbury to Tesco's LPG whereas Kwik Save´s price setting behaviour does not seem to be affected.

In this work, we use a micro level data set of prices that were directly taken in two supermarkets (Tesco and Sainbury) and a discounter (Kwik Save) in the south of Coventry. Throughout all the paper, we make use of non parametric tests, the reason is that some of the price series and indexes we use do not fullfil the normality conditions required by the parametric tests.

UK supermarkets do not necessarily set their prices nationally. Supermarket chains adapt price setting to local competition conditions. This allows us to interpret the results as arising from the specific conditions of the local area considered[1].

The rest of the chapter is organized as follows. In Section 2, we present a theoretical model of price setting in presence of service quality differentials. In Section 3, we describe the characteristics of the market analysed and introduce the data set we use. In Section 4, we empirically test the predictions of the theoretical model presented in Section 2. In Section 5, we investigate the effects of Tesco's LPG over price coordination and price trends. Finally, Section 6 is devoted to the conclusions.

7.2 The model

In order to analyse the effects of horizontal and vertical product differentiation over the patterns of price competition between supermarkets and discounters, we use a slightly modified version of the model proposed by Garcia, Georgantzis and Petit [1998]. Their model allows to take into account both vertical quality differences and horizontal as-

[1] We have known this through interviews with some supermarket managers.

pects. Whereas they assume firms to be symmetrically located, we introduce locational asymmetries.

Firms (two supermarkets and a discounter) are located along a circle of length L. Supermarket 1 (s_1) is at the same distance (equidistant) from supermarket 2 (s_2) and discounter (v), being this distance l_1 (Figure 7.1). The distance between s_2 and v is l_2, with $l_1 > l_2$. Consumers are located uniformly on the circle of length L with density equal to 1. Consumers' reservation price for the product sold in the market differs depending on whether the product is purchased in a supermarket or in a discounter. If the product is purchased in a supermarket then the reservation price is R, if the product is purchased in a discounter then the reservation price is r (with $R > r$). It is assumed that in any case, reservation prices are high enough to ensure that in equilibrium all consumers are served. Each consumer buys one unit of the product that is homogeneous except in location and service quality. Locational differences are given by the distance along the circle between the consumer's location and the point-of-purchase. Differences in service quality are reflected in the different consumers' reservation prices for purchases at supermarkets or discounters.

Therefore, the utility that a consumer located at X obtains from purchasing one unit of the product at supermarket s_i (for $i = 1, 2$),

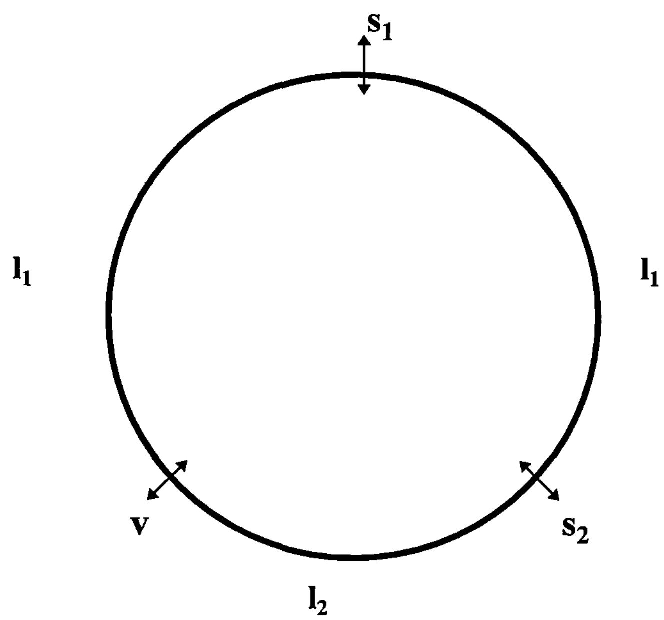
$$U_{X,s_i} = R - p_{s_i} - tx_{s_i} \tag{7.1}$$

and the utility from purchasing one unit of the product from the discounter is,

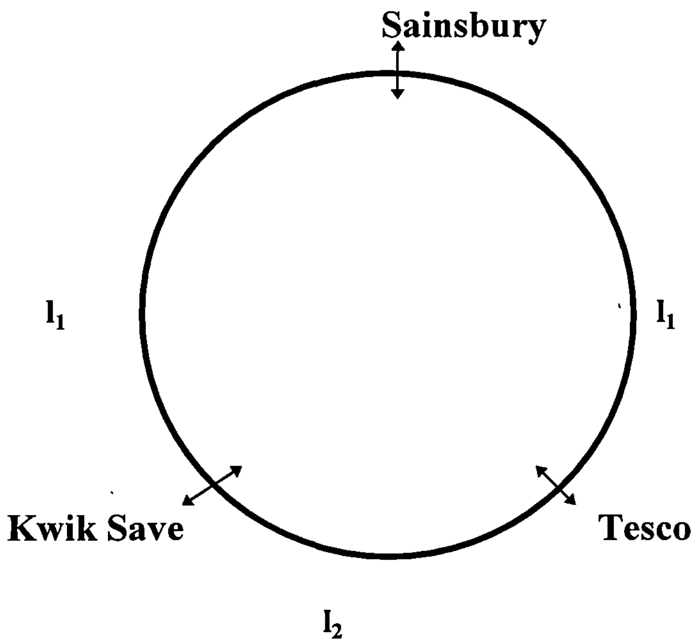
$$U_{X,v} = r - p_v - tx_v \tag{7.2}$$

Figure 7.1: Location along the circumference

a) Theretical Model



b) Empirical Application



where x_i for $i = s_1, s_2, v$ is the distance from X to the point-of-purchase and t is the transportation cost for unit of distance. p_{s_1}, p_{s_2} and p_v are respectively the prices at the two supermarkets and at the discounter.

For a given set of prices, $M = (p_{s_1}, p_{s_2}, p_v)$, a consumer located at X_1 between the two supermarkets will be indifferent between buying at one or at the other if $U_{X_1,s_1} = U_{X_1,s_2}$. This indifference condition determines the distance between the location of the consumer that is indifferent between the two supermarkets and the location of s_1,

$$x_1 = \frac{(p_{s_2} - p_{s_1})}{2t} + \frac{l_1}{2} \tag{7.3}$$

By analogy, the indifference condition $U_{X_2,s_2} = U_{X_2,v}$ determines the distance between the location (X_2) of the consumer (situated between s_2 and v) that is indifferent between s_2 and v, and the location of s_2

$$x_2 = \frac{R - r + p_v - p_{s_2}}{2t} + \frac{l_2}{2} \tag{7.4}$$

Finally, the indifference condition $U_{X_3,s_1} = U_{X_3,v}$ determines the distance between the location (X_3) of the consumer (situated between s_1 and v) that is indifferent between s_1 and v, and the location of v

$$x_3 = \frac{r - R + p_{s_1} - p_v}{2t} + \frac{l_1}{2} \tag{7.5}$$

Given that the consumer density along the circle is equal to 1, from (7.3), (7.4) and (7.5) we get the market demands for each one of the firms. From (7.3) and (7.5) the market demand for s_1 can be written as,

$$d_{s_1} = x_1 + (l_1 - x_3) = \frac{(p_{s_2} - p_{s_1}) + (p_v - p_{s_1}) + (R - r)}{2t} + l_1 \tag{7.6}$$

In the same way, using (7.3) and (7.4), we can obtain the market demand for s_2 as,

$$d_{s_2} = x_2 + (l_1 - x_1) = \frac{(p_{s_1} - p_{s_2}) + (p_v - p_{s_2}) + (R - r)}{2t} + \frac{(l_1 + l_2)}{2} \tag{7.7}$$

Similarly, from (7.4) and (7.5) we get the market demand for v as,

$$d_v = x_3 + (l_2 - x_2) = \frac{(p_{s_1} - p_v) + (p_{s_2} - p_v) + 2(r - R)}{2t} + \frac{(l_1 + l_2)}{2} \tag{7.8}$$

Let us consider the single stage game in which the two supermarkets (s_1 and s_2) and the discounter choose simultaneously their prices. Each firm has the cost function

$$C_m = \begin{cases} wd_m + K \text{ if } m = s_1, s_2 \\ wd_m + k \text{ if } m = v \end{cases} \tag{7.9}$$

With the aim of focusing in the analysis of demand related factors, we assume that the wholesale cost (w) is the same for the three firms in the market. Hence, we place all the burden of providing a better service quality on the fixed costs[2]. The profits of each one of the firms will be given by,

$$\Pi_{s_1} = (p_{s_1} - w)\, d_{s_1} - K \tag{7.10}$$

$$\Pi_{s_2} = (p_{s_2} - w)\, d_{s_2} - K \tag{7.11}$$

$$\Pi_v = (p_d - w)\, d_v - k \tag{7.12}$$

where K is the fixed cost of providing the "high" service quality associated to the supermarkets and k is the fixed cost of providing the "low" service quality associated to the discounters ($K > k$). The resulting Bertrand-Nash equilibrium[3] is characterised

[2] This assumption is standard in models of pure vertical product differentiation such as Shaked and Sutton [1983].

[3] The equilibrium prices are obtained by solving the system of FOCs resulting from the maximization of each one of the three firms. We restrict our analysis to those values of f for which equilibrium margins are non-negative (non trivial configuration), i.e. $f < \frac{t(3l_1 + 2l_2)}{2}$. This same condition ensures non-negative shares for all the three firms in the market.

by the following prices for each one of the firms (without loss of generality we set $w = 0$),

$$p_{s_1} = \frac{1}{5}\left[f + t\left(4l_1 + l_2\right)\right] \tag{7.13}$$

$$p_{s_2} = \frac{1}{5}\left[f + t\left(3l_1 + 2l_2\right)\right] \tag{7.14}$$

$$p_v = \frac{1}{5}\left[t\left(3l_1 + 2l_2\right) - 2f\right] \tag{7.15}$$

where $f = R - r$. From these equilibrium prices we can derive the following proposition,

Proposition 1 *In the Bertrand-Nash equilibrium the highest price corresponds to the supermarket that is located furthest away from the discounter (s_1). The lowest price corresponds to the discounter (v) and the supermarket located closest to the discounter (s_2) sets a price such that $p_{s_1} > p_{s_2} > p_v$.*

Proof:

$$p_{s_1} - p_{s_2} = \frac{1}{5}t\left(l_1 - l_2\right) > 0 \tag{7.16}$$

$$p_{s_2} - p_v = \frac{3}{5}f > 0 \tag{7.17}$$

The intuition behind this result is clear: the higher consumers' reservation price for the product when it is bought at a supermarket allows the two supermarkets to set a price higher than the price set by the discounter. The fact that s_1 is located further from v than s_2 confers it a certain degree of price setting power (monopoly power), that translates in $p_{s_1} > p_{s_2}$.

7.3 From the theory to the practice

7.3.1 Characterising supermarkets and discounters

The supermarket outlets considered in our analysis belong to the superstore format. With a floor space over 25.000 square feet and located out of town, these superstores sell a large range of food and non-food products. The discounter outlets with a floor space between 6.000 and 12.000 square feet sells also a range of food and non-food products but more limited in size than the supermarket range.

Supermarkets and discounters differ in the rank of quality variants sold. The supermarkets sell three quality variants: Branded Products (BP)[4], High Quality Own Brand Products (HQ) and Low Quality Own Brand Products (LQ). For BP, we are referring to the manufacturer product sold under the manufacturer brand name (eg: Heinz Baked Beans). The BPs are considered the highest quality variant available at the supermarket. Although both HQs and LQs are own-brand products sold under the supermarket's brand name, there exists a clear gap of qualities between them. With the aim of competing with the BPs for the high segment of the consumer distribution, the supermarket offers with the HQs an alternative of very similar quality to the BPs. LQs are instead very basic generic products that were introduced by the supermarkets since the arrival in the UK of the continental discounters (Aldi, Netto,...) to face their competition for the lowest segment of the consumer distribution. In order to distinguish it from the hard or Continental discounters[5], Kwik Save is usually qualified as a soft discounter. In Kwik Save we can find only the two extreme quality variants: BPs and LQs. As in the case of the supermarkets the introduction of the generic own

[4]Although the characteristics of these three quality variants were presented in Chapter 2, we briefly recall them here.

[5]Continental discounters sell only a limited and discontinuous line of generic own-brand products (lowest quality variant) in outlets that are smaller in size than Kwik Save ones. Only occasionally it is possible to find BPs among their assortment.

brand products was a reaction to the arrival in the UK of the Continental discounters. Therefore, our analysis will focus on the quality variants sold by supermarkets and discounters: BP and LQ.

As explained in the theoretical model, apart from the price the utility that a consumer gets from buying a product depends also on the physical characteristics of the product, on the location of the food-retailer and on the level of service quality provided by the food-retailer. As regards the physical characteristics of the product, the BPs provided by the same manufacturer to all the food-retailers are homogeneous both in quality and horizontal characteristics other than location. The LQs are very basic products; for this quality line food-retailers avoid the introduction of any element of horizontal product differentiation that could increase the price. The relevant competition dimension is the price and as a result these products have very similar and basic characteristics at supermarkets and discounters.

Nevertheless, supermarkets and discounters offer a different level of service quality. The first element determining this difference in service quality is the shopping environment. The supermarkets offer a nice shopping atmosphere with wide aisles, tidy shelves and big number of check-out lines to assure short queuing times and convenience. In contrast, in Kwik Save aisles are narrower, products are just piled up on the shelves, the number of check-outs is small and the queues are frequent, etc. Supermarkets accept all major debit and credit cards whilst Kwik Save only accepts some of them. Supermarkets offer loyalty cards with accumulable points that later on will be transformed in monetary discounts, and the possibility of using them in the own supermarket petrol station. Recently, supermarkets have started offering banking services and the possibility of home shopping via Internet. Supermarkets offer wider opening hours. Finally and more importantly, supermarkets offer a larger range of products making possible the desired one-stop shopping and reducing in this way the cost of shopping in terms of time. The implications of this higher service quality provided by the supermarkets are twofold. On the one hand, consumers will be willing to pay more for the same product when they buy it at the supermarket (this is reflected by the difference between R and r in the theoretical model). On the other hand, the fixed costs that the supermarket has to incur to provide the "high" quality service are greater (this is reflected by the difference between K and k in the theoretical model).

7.3.2 The data

The data used in this analysis are a micro level data set of prices that were taken directly in three selected stores in the south of Coventry. Two of them, Tesco and Sainsbury, belong to the two supermarket chains with the biggest market share in the UK and the third belongs to Kwik Save, the largest discounter chain. Tesco and Kwik Save stores considered are located in Cannon Park shopping center[6] and Sainsbury is located approximately one and a half mile from them.

The data set comprises 27 price observations for each one of the products taken from November 1995 to March 1997. Prices have been taken every two weeks but for the Christmas periods. For each one of the products considered the price of the BP and LQ variants were taken.

With respect to the criteria to choose the products, it was already described in Chapter 4. The list of the products used in the analysis is included in Appendix F.

7.4 Empirical Part I: Are supermarkets competing with discounters?

The objective of this section is to test Proposition 1 both for the BPs and LQs. The first step is to translate the theoretical model to our market: the discounter v of the

[6]This shopping center includes a few small shops, a pharmacy from a national chain, Tesco and Kwik Save.

theoretical model is Kwik Save in our real market, the supermarket s_2 (located closer to the discounter) is Tesco and the supermarket s_1 located further from the discounter is Sainsbury. Just to note that with $l_2 - l_1 > 0$ we are not trying to measure a geographical distance but the asymmetric location of the supermarkets with respect to the discounter. The aim is to check if the presence of Kwik Save in the same shopping center is influencing Tesco's pricing behaviour.

Let $p_{it}^{J_k}$ be the price set by food retailer J in fortnight t for the quality variant k of product i. We can formulate Proposition 1 for each one of the products in the sample as,

$$\text{On average, } p_i^{SA_k} > p_i^{TE_k} > p_i^{KW_k}$$

where $p_i^{J_K}$ is the series integrated for $p_{it}^{J_K}$ for $t = 1, ..., 27$; $i = 1, ..., 46$.

The testing procedure proposed used to establish a supermarket price rank for each one of the products in the sample[7] consists of two steps: first, we use a Friedman test to check if there is any difference between the average prices set for the same product at the three food-retailers; second, if the Friedman test detects a difference, we use the Dunn´s multiple comparison method to establish the supermarket price rank for the product. The reason for using these two non parametric tests is that most of the price series do not follow a normal distribution and in these circumstances parametric test do not result appropriate[8]. The results of this testing procedure are summarized in Table 7.1.

In the rows of Table 7.1, we show both for the BPs and LQs the number of products that satisfy a given supermarket price rank. The first one of these supermarket price

[7] This testing procedure is specified in Appendix B. We also explain in this appendix the choice of these two tests

We do not provide descriptive statistics for all the price series (276) just for a question of space. They are available on request.

[8] For a full description of the test see Neave and Worthington [1988].

Table 7.1: Testing Proposition 1: Summary Table

	BPs	LQs
$p_{SA} > p_{TE} > p_{KW}$	1	3
$p_{SA} \approx p_{TE} > p_{KW}$	37	20
$p_{SA} \approx p_{TE} \approx p_{KW}$	2	8
$p_{SA} > p_{TE} \approx p_{KW}$	1	7
$p_{TE} > p_{SA} > p_{KW}$	1	1
$p_{KW} > p_{SA} > p_{TE}$	0	1
$p_{KW} \approx p_{SA} > p_{TE}$	0	3
$p_{KW} > p_{SA} \approx p_{TE}$	4	3
Total	46	46

ranks is just the one predicted by Proposition 1, $p^{SA} > p^{TE} > p^{KW}$. A predominance of this price rank would confirm the predictions of the theoretical model and would signal that both vertical and horizontal asymmetries are important factors in determining price setting behaviour. A predominance of $p_{SA} \approx p_{TE} > p_{KW}$ would indicate that whilst service quality is the main factor determining differences in price setting behaviour, locational asymmetries between supermarkets are not relevant. On the contrary a predominance of $p_{SA} > p_{TE} \approx p_{KW}$ would reveal that locational asymmetries are more important than service quality differentials in determining food-retailers price setting behaviour. Similar levels of prices at the three food retailers considered ($p_{SA} \approx p_{TE} \approx p_{KW}$) would be the recognition that neither locational asymmetries nor differences in service quality are important factors in determining price setting behaviour. The predominance of a situation in which Tesco is pricing above Sainsbury and this above Kwik Save ($p_{TE} > p_{SA} > p_{KW}$) would not respect the pricing predictions of the model but would still signal service quality as the element segmenting the market. From row six onwards, we show all those price ranks for which the price of the low service quality retailer (Kwik Save) is significantly higher than the price of at least one of the two high service quality retailers (Sainsbury and Tesco).

As we can see for the BPs the prediction of Proposition 1 turns out to be true only for 1 out of the 46 products of the sample. Whereas the theoretical model predicts lower prices for the supermarket located closer to the discounter, for the BPs evidence shows that for 43 of the 46 products of the sample average prices are equal at the two supermarkets[9]. Furthermore, for 37 of these 43 products average prices are significantly higher at the two supermarkets than at Kwik Save. Two implications follow from these results. The first, they clearly signal service quality as the main determinant of food-retailer pricing behaviour. The second, they reveal that the degree of neighborhood with the discounter does not have any impact on supermarkets' price setting policy. For the BPs service quality is segmenting the market and isolating supermarkets from the potential competition of the discounters.

For the LQs, the prediction of Proposition 1 is satisfied for 3 of the 46 products. As for the BPs, also for the LQs the predominant price rank is $p^{SA} \approx p^{TE} > p^{KW}$, however the number of products satisfying this price rank is much smaller (20, compared to the previous 37)

In order to compare the observed distribution of supermarket price ranks for BPs and LQs, we build a contingency table with the distributions of supermarket price ranks as shown in Table 7.1 and test the null hypothesis of no association between quality variant and distribution of supermarket price ranks. The rows of this contingency table are the distribution of price ranks for BPs and LQs such as specified in Table 7.1.

Table 7.2: Contingency Table Association Test

	Pearson-χ^2	D. of F.	Significance
BPs-LQs	18.313	7	0.011

The test of association leads to reject the null hypothesis of no association between quality variant and distribution of supermarket price ranks (Table 7.2). This result is

[9] To those satisfying the price rank $p_{SA} \approx p_{TE} > p_{KW}$ we should add the two products satisfying $p_{SA} \approx p_{TE} \approx p_{KW}$ and the four products satisfying $p_{KW} > p_{SA} \approx p_{TE}$.

evidence in favour of a different distribution of supermarket price ranks for each one of the quality variants considered. In order to disclose the causes behind the rejection of the test of association, we stress the main differences between the distributions of supermarket price ranks for the BPs and LQs. The first of these differences is related with the importance of locational asymmetries in determining supermarkets price setting: whereas the number of products for which $p_{TE} > p_{SA}$ is equal for BPs and LQs (one product), the number of products for which $p_{SA} > p_{TE}$ is significantly higher for LQs than for the BPs (14 and 2 respectively). Whilst locational asymmetries do not seem to be a relevant factor to explain BP price setting, they play a relevant role in the price setting of the LQs: the supermarket located closer to the discounter prices almost a third of the products cheaper than the supermarket located further. The second difference gives us evidence both about the importance of locational asymmetries and service quality differentials as determinants of price setting. First, as it is possible to observe in Table 7.3,[10] the number of products for which $p_{SA} > p_{KW}$ and the number of products for which $p_{TE} > p_{KW}$, is lower for the LQs than for the BPs. It seems that the ability of service quality differentials to isolate supermarkets from the discounters is lower for LQs than for BPs. Second, we can observe in Table 7.3 that whereas for the BPs the number of products for which $p_{TE} > p_{KW}$ is similar to the number of products for which $p_{SA} > p_{KW}$, for the LQs the number of products for which $p_{TE} > p_{KW}$ is significantly smaller. This result confirms the importance of locational asymmetries to explain LQs price setting.

Table 7.3: Summarizing Price Differences

	BP	LQ
$p_{TE} > p_{KW}$	39	24
$p_{SA} > p_{KW}$	40	31

[10]This Table has been extracted from Table 7.1.

Summing up, for the BPs service quality differentials seem to be the main determinant of price setting. The higher service quality offered by the supermarkets (with respect to the discounters) segments the market and allows them to set prices significantly higher than the discounter for a large proportion of the products included in the sample. The fact that the BPs are addressed to the highest segment of the consumer distribution and that very likely these consumers are not only concerned about the price but also about the service quality level offered by the supermarket could explain the ability of service quality to segment the market. Locational asymmetries do not seem to play an important role in BP price setting as it is shown by the fact that for 42 out of 46 product prices on average are equal at Tesco and Sainsbury. With respect to the LQs, service quality differentials seem to lose part of their capacity to segment the market (as shown by the fact that the number of products for which price is higher at the supermarkets than at the discounter is smaller for the LQs) and locational asymmetries seem to play an important role in price setting. The LQs are addressed to the lowest segment of the consumer distribution for whom price is the main relevant dimension, this could explain the loss of segmentation ability of service quality differentials for the LQ market.

7.5 Empirical Part II: Analysis of Tesco's LPG

On September 1996 Tesco announced the introduction of the following low-price guarantee (LPG):

"Lowest Local Price or We'll Refund you DOUBLE the Difference"[11]

This LPG included 22 of the 46 of the products of our sample and split it into two periods, before (pre-guarantee period) and after the start (post-guarantee period) of

[11] This LPG was already analysed for a sample of three supermarkets offfering homogeneous level of service quality in Chapter 6. For a full description of the LPG see that chapter.

the LPG (the length of these periods is fifteen and twelve fortnights respectively). This event offered us the invaluable opportunity of investigating the effects of Tesco's LPG over the supermarkets and the discounter included in our sample and to check whether the effects of the LPG (if any) are homogenous for the two groups of food-retailers considered, independently of the different service quality provided[12].

7.5.1 A brief theoretical introduction to LPGs

Low-price guarantees can be defined as promises by firms to match or beat the price of one or several rivals[13]. Salop [1986] seminal paper argued that LPGs could facilitate tacit collusion leading to higher prices and profits. On the one hand by giving an incentive to the customer to report rivals' price cuts LPGs serve as an exchange-information device; on the other hand, by reducing the potential benefits of one-time cheating LPGs act as an incentive-management device discouraging price-cutting by rival firms. Most of the literature stream following Salop [1986] has concentrated on the analysis of the effects of price-matching guarantees using oligopolistic models, and only in recent years the possible differential effects of the price-beating guarantees have been analysed. In order to illustrate the differences between these two variants of LPG, let us consider a static game of complete information in which two firms (1 and 2) choose simultaneously a posted price and a price policy $\{p_i, \delta_i\}$ that conform their strategy, where:

$$\delta_i = \begin{cases} NPG = \text{ No price guarantee} \\ PM = \text{ Price Matching} \\ PB = \text{ Price Beating} \end{cases}$$

and the effective price of each firm (s_i) under each one of the possible strategies:

[12] With the aim of showing that the results obtained when analysing food-retailers price setting in the previous section are not caused by Tesco LPG, we replicate the analysis using only the fortnights of the sample before the LPG (1 to 15) in Appendix B.

[13] Although, we included in Chapter 6 a theoretical review about LPGs, we briefly describe here some theoretical aspects of LPGs interesting for this analysis.

$$s_i = \begin{cases} NPG \ s_i = p_i \text{ for } i = 1,2 \\ PM \ s_i = \min\{p_i, p_i - (1+\lambda)(p_i - p_j)\} \text{ with } \lambda = 0 \\ PB \ s_i = \min\{p_i, p_i - (1+\lambda)(p_i - p_j)\} \text{ with } \lambda > 0 \end{cases}$$

If a firm offers PM, it is just compromising to match any price set by the rival, if a firm offers PB it is compromising to undercut by a given proportion λ any price set by the rival. Tesco's LPG should be considered as a price-beating guarantee, with Tesco's effective price for the products included in the LPG given by:

$$s_{TE} = \min\{p_{TE}, p_j - 2(p_{TE} - p_j)\} \text{ with } j = SA, KW$$

Whilst Dixit and Nalebuff [1991] and Sargent [1993] conclude that they are even more effective than price-matching guarantees at supporting high prices, Hviid and Shaffer [1994] and Corts [1995] show that price-beating guarantees restore the incentive to undercut rival's prices and that independently of the degree of asymmetry in the market they cannot support any anticompetitive prices in equilibrium[14]. Hviid and Shaffer [1998,1999] extend the analysis of the PB by removing the assumption that it is costless to the consumers to activate the LPG. They substitute the assumption of automatic activation of the LPG by the assumption that each consumer foregoes the same amount $z \geq 0$ to activate the LPG[15]. Therefore, in the static game described before, if firm i is offering a PB guarantee and $p_i > p_j$, customers will activate it if and only if $(1+\lambda)(p_i - p_j) \geq z$. By analogy, when $(1+\lambda)(p_i - p_j) < z$ the PB guarantee will never be activated. They show that in this last case the only possible equilibrium prices are those of the Bertrand-Nash equilibrium with differentiated products. They also show that when $(1+\lambda)(p_i - p_j) \geq z$, and for sufficiently asymmetric markets, the existence of $z > 0$ makes it possible for the PB guarantees to increase prices to supracompetitive levels.

[14]Other papers analysing price-beating guarantees: Baye and Kovenock [1994], Chen [1995] and Corts [1996].

[15]z is defined as a hassle cost: "any cost run by the client to make effective the price guarantee: time, discomfort of asking for the reinsburment, need of visting two shops...".

Because of its contrast with the economic theory, it is also interesting to recall the reaction of the press to the retailers' announcements of LPGs. Usually, the news relate LPGs with the triggering of price wars. An example is that *The Times* (September, 5-1996) as a reaction to Tesco's announce of *Unbeatable Value* publishes " *Tesco launches a new price war*"[16]

Hess and Gerstner [1991] and Chapter 6 of this PhD dissertation consider a sample of supermarkets offering homogenous levels of service quality to analyse the possible pro-competitive or anti-competitive effects of the low-price guarantees. Nevertheless, in this section we consider a sample of food-retailers offering different levels of service quality (Tesco and Sainsbury as supermarkets and Kwik Save as a discounter) and focus our analysis on the possible differential effects of Tesco's LPG over the supermarket and the discounter considered in the analysis. This offers the possibility of checking the extent to which supermarkets and discounters are effectively competing. With the aim of detecting possible differential effects of the LPG over the pattern of price setting of the two supermarkets and the discounter, we will analyse first the effects of the LPG over the patterns of price coordination, and then over price trends.

7.5.2 Low-price guarantees and price coordination

In Chapter 6 analysing the same LPG but using supermarkets only data, we show that Tesco's PB guarantee increased the degree of price coordination between the supermarket actor of the LPG and the supermarkets affected by the LPG for the products included in it (**UNB** products). The pattern of price coordination for the products not included in the LPG (**NOUNB** products) remained unchanged.

Here, following with the empirical analysis carried out in former sections, we check if the observed differential in service quality between supermarkets and discounters

[16] Another example is the Financial Times, January 18 1996, as a reaction to the *Price Watch* LPG by Esso (price-matching guarantee) published "Petrol Rivals on Price-Footing".

conditioned the effect of Tesco's LPG on the degree of price coordination between this retailer and the other two retailers considered in the analysis. We use as analytical tool the Dynamic Degree of Price Matching Index (**DDPMI**)[17]. We build this index in the following way:

Let p_{it}^{J} be the price set by supermarket J in fortnight t for product i. Where:

$i = 1,...,46$ products included in the sample and $t = 1,...,27$ fortnightly taken price observations; J = TE, SA, KW stores included in the sample.

Then if we define:

$$g_{it}^{J} = \frac{p_{it}^{J} - p_{it-1}^{J}}{p_{it-1}^{J}}$$

the Dynamic Degree of Price Matching between Tesco and store J (different from Tesco) for product i in fortnight t is calculated as:

$$DDPM_{it}^{J-H} = \begin{cases} 1 \text{ if } g_{it}^{TE} = g_{it}^{J} = 0 \\ \frac{g_{it}^{J}}{g_{it}^{TE}} \text{ if } \left|g_{it}^{TE}\right| \geq \left|g_{it}^{J}\right| \\ \frac{g_{it}^{TE}}{g_{it}^{J}} \text{ if } \left|g_{it}^{TE}\right| < \left|g_{it}^{J}\right| \end{cases}$$

As we are interested in detecting possible changes in the patterns of price coordination between Tesco and Sainsbury/Kwik Save induced by the LPG and the influence over these changes of the differential in service quality between supermarkets and discounters, we calculate for each one of the products two **DDPMIs** that correspond to the pre and post-guarantee periods. These two indexes are defined as:

$$\text{Pre-Policy Period Index} \rightarrow \mathbf{DDPMI}_{i,PRE}^{TE-J} = \frac{1}{14}\sum_{t=2}^{15} DDPM_{it}^{TE-J}$$

$$\text{Post-Policy Period Index} \rightarrow \mathbf{DDPMI}_{i,POST}^{TE-J} = \frac{1}{12}\sum_{t=16}^{27} DDPM_{it}^{TE-J}$$

[17] This index has been already used in other chapters. We described its characteristics in Appendix C of Chapter 4.

If both for the pre and post-guarantee periods we group together the indexes that correspond to the products included in the LPG (**UNB**) and those that correspond to the products not included (**NOUNB**) the result are four series of **DDPMIs** for each one of the two retailer pairs (TE-SA and TE-KW) considered in this analysis. For example, the series $\mathbf{DDPMI}^{TE-SA}_{UNB,PRE}$ would include $\mathbf{DDPMI}^{TE-SA}_{i,PRE}$ for the twenty-two **UNB**

In order to obtain a benchmark case to analyse the effects of the LPG over the degree of between-retailers price coordination, we start by investigating if there was any difference in the degree of between-retailers price coordination for **UNB** and **NOUNB** in the pre-guarantee period. We perform this analysis by means of a two-sided Mann-Whitney[18] test with the following null and alternative hypotheses:

H_0 :*On average, in the pre-guarantee period there is no difference in the degree of price coordination between Tesco and Sainsbury (Kwik Save) for* **UNB** *and* **NOUNB**, *i.e. on average there is no difference between* $\mathbf{DDPMI}^{TE-J}_{UNB,PRE}$ *and* $\mathbf{DDPMI}^{TE-J}_{NOUNB,PRE}$ (for $J = SA, KW$).

H_1 :*On average, in the pre-guarantee period there is a difference in the degree of price coordination between Tesco and Sainsbury (Kwik Save) for* **UNB** *and* **NOUNB**, *i.e. on average there is a difference between* $\mathbf{DDPMI}^{TE-J}_{UNB,PRE}$ *and* $\mathbf{DDPMI}^{TE-J}_{NOUNB,PRE}$ (for $J = SA, KW$).

As it is possible to observe in Table 7.4 this test leads to the same results for the two pairwise comparisons considered. Neither the null hypothesis of no difference between $\mathbf{DDPMI}^{TE-SA}_{UNB,PRE}$ and $\mathbf{DDPMI}^{TE-SA}_{NOUNB,PRE}$, nor the null hypothesis of no difference between $\mathbf{DPPMI}^{TE-KW}_{NOUNB,PRE}$ and $\mathbf{DDPMI}^{TE-KW}_{UNB,PRE}$ are rejected.

Once we have a general picture of between-retailers price coordination before the start of the LPG, the next step is to check if the LPG had any effect over the degree

[18]For the reasons to use this non-parametric test see section 4.1 in Chapter 6.

Table 7.4: Mann-Whitney Test for differences on average DDPMI.UNB-NOUNB

Pre-Guarantee		Value of the test (U)	Critical Value 5%
	TE-SA	209	174.64
	TE-KW	258	174.45

Rejection of the H_0 if $U \leq$ CV 5%

of between-retailers price coordination and if this effect is dependent upon retailers service quality level. We perform this analysis by means of a battery of one-sided Wilconxon test[19] with the following null and alternative hypotheses:

H_0 : *On average, there is no difference between* $\mathbf{DDPMI}^{TE-J}_{S,PRE}$ *and* $\mathbf{DDPMI}^{TE-J}_{S,POST}$ *(for S = UNB, NOUNB and J = SA,KW).*

H_1 : *On average,* $\mathbf{DDPMI}^{TE-J}_{S,POST}$ *is higher than* $\mathbf{DDPMI}^{TE-J}_{S,PRE}$ *(for S = UNB, NOUNB and J = SA,KW).*

Table 7.5: Wilconxon Test for differences on average DDPMI. Pre-post policy periods

NOUNB		T	C.V. 5%	CSS	One/Two Sided
	TE-SA	79	75	22	One
	TE-KW	49.50	83	23	One
UNB		T	C.V. 5%		
	TE-SA	8	60	20	One
	TE-KW	38	75	22	One

T: value of the test; CV 5%: Critical Value at 5% significance level ; Rejection of H_0 if $T \leq$ CV 5%; Corrected Sample Size (CSS) = Sample Size − Number of Zero Differences

Observation of Table 7.5 reveals that the effects of the LPG are not homogeneous across retailers with different service quality levels. Let us analyse first the price co-ordination between the actor of the LPG (Tesco) and the other retailer offering the same service quality level (Sainsbury). Consistently both with the news hypothesis and with the Salop's line of analysis, the LPG increased the degree of price coordination between Tesco and Sainsbury for the products included in the LPG (the null hypothesis $\mathbf{DDPMI}^{TE-SA}_{UNB,PRE} \approx \mathbf{DDPMI}^{TE-SA}_{UNB,POST}$ is rejected). However, the LPG

[19]For the reasons to use this non-parametric test see section 4.1 in Chapter 6.

did not change the average degree of price coordination between these two retailers for the products not included in the LPG (the null hypothesis $\mathbf{DDPMI}^{TE-SA}_{NOUNB,PRE} \approx \mathbf{DDPMI}^{TE-SA}_{NOUNB,POST}$ is not rejected).

The degree of price coordination between Tesco (the actor of the LPG) and Kwik Save (low service quality retailer) is higher in the post guarantee period both for the products included and for the products not included in *Unbeatable Value* LPG (both the null hypotheses of $\mathbf{DDPMI}^{TE-KW}_{UNB,PRE} \approx \mathbf{DDPMI}^{TE-KW}_{UNB,POST}$ and $\mathbf{DDPMI}^{TE-KW}_{NOUNB,PRE} \approx \mathbf{DDPMI}^{TE-KW}_{NOUNB,POST}$ are rejected). The fact that average price coordination in the post-guarantee period is higher both for the products included and not included in the LPG rises doubts about the LPG as the factor causing the observed increase in price coordination. The analysis of Kwik Save price trends in the next section will confirm this intuition.

The final step of the analysis of price coordination consists in checking how the observed price coordination changes have modified the pre-guarantee status of no difference in the degree of between-retailers price coordination of **UNB** and **NOUNB**. We carry out this test using a one-sided Mann-Whitney test with the following null and alternative hypotheses:

H_0 :*On average, in the post-guarantee period there is no difference in the degree of price coordination between Tesco and Sainsbury (Kwik Save) for* **UNB** *and* **NOUNB**, *i.e. on average there is no difference between* $\mathbf{DDPMI}^{TE-J}_{UNB,POST}$ *and* $\mathbf{DDPMI}^{TE-J}_{NOUNB,POST}$ (for $J = SA, KW$).

H_1 :*On average, in the post-guarantee period the degree of price coordination between Tesco and Sainsbury (Kwik Save) is higher for* **UNB** *than for* **NOUNB**, *i.e. on average* $\mathbf{DDPMI}^{TE-J}_{UNB,POST}$ *is higher than* $\mathbf{DDPMI}^{TE-J}_{NOUNB,POST}$ (for $J = SA, KW$).

The results of this test shown in Table 7.6 reveal that in the post guarantee period price coordination TE-SA is higher for **UNB** than for **NOUNB** products. The higher degree of price coordination TE-KW for **UNB** and **NOUNB** products in the post guarantee period does not change the pre-guarantee balance: both in the pre and post-guarantee periods the degree of price coordination TE-KW is similar for UNB and NOUNB products.

Table 7.6: Mann-Whitney Test for differences in average DDPMI.UNB-NOUNB

Post-Guarantee		Value of the test (U)	Critical Value 5%
	TE-SA	182.5	188.88
	TE-KW	237	188.77

Rejection of H_0 if $U \leq CV$ 5%

To sum up, the analysis of the implications of Tesco's LPG over the patterns of between-retailers price coordination sheds light about the influence of the service quality differential on the effects of the LPG over Sainsbury and Kwik Save. As result of the LPG price coordination between the two food retailers offering the same level of service quality becomes higher for the products included in the LPG than for the products not included. However, the pre-guarantee status of similar levels of price coordination between Tesco and the low service quality retailer (Kwik Save) for **UNB** and **NOUNB** products is not altered by the LPG. The next step is to analyse if the LPG had any effect over retailer price trends and if it is possible to detect any differential effect linked to differences in service quality.

7.5.3 Low price guarantees and price trends

In order to analyse the effect of *Unbeatable Value* LPG over the level of prices at each one of the supermarkets, we follow a two stage procedure. In the first stage, we compare the evolution of the prices of the baskets of **UNB** and **NOUNB** products at each one of the food-retailers by means of a regression analysis of the **RELPRI** index described in the next paragraph. Once we know if the price of the basket of **UNB** products is increasing or decreasing with respect to the price of the basket of **NOUNB** products, we analyse separately the effects of the LPG over the evolution of the prices of the basket of **UNB** and **NOUNB** at each one of the food-retailers.

We define the **RELPRI** index as,

$$\mathbf{RELPRI}_t^J = \frac{\text{PUNB}_t^J}{\text{PNOUNB}_t^J}$$

where:

$$\mathbf{PUNB}_t^J = \text{Unbeatable Products Basket Price}_t^J = \sum_{i=1}^{22} p_{it}^{UNB_J}$$

$$\mathbf{PNOUNB}_t^J = \text{No Unbeatable Products Basket Market Price}_t^J = \sum_{i=1}^{24} p_{it}^{NOUNB_J}$$

for $J = TE, SA, KW$.

This relative price index for each one of the food retailers ($\mathbf{RELPRI}_t^J$)[20] can be used as dependent variable of the following regression model:

$$\mathbf{RELPRI}_t^J = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

where:

$$D_1 = \begin{cases} 0 \text{ from } t = 1 \text{ to } t = 15 \\ 1 \text{ otherwise} \end{cases} \quad \text{and } T \text{ is a time trend}$$

The results of the OLS regressions for each supermarket are shown in Table 7.7. Actual and fitted values of the relative price index for each one of the supermarkets are shown in Figures 7.2 to 7.4 of Appendix D. Observation of these figures suggests to

[20] An ideal construction of the baskets of UNB and NOUNB products will weight the products according to their weight in the representative consumer budget. Hess and Gerstner[1991] used as weights those of the consumer price index, however these weights are not available in the UK with the required disaggregation. With the aim of showing that the results obtained are robust to the set of products included in the sample, in Appendix E we replicate the analysis excluding from the sample the alcohol and toiletries categories.

focus our attention on the analysis of the trend followed for $\mathbf{RELPRI}_t^J$ at each one of the food-retailers in the pre and post-guarantee periods. Any change in trend caused by *Unbeatable Value* LPG will be caught by the coefficient of the slope dummy (β_2).

Table 7.7: RELPRI Regression Analysis by store

Dep. Var: $\mathbf{RELPRI}_t^{TE}$			Dep. Var: $\mathbf{RELPRI}_t^{SA}$			Dep. Var: $\mathbf{RELPRI}_t^{KW}$		
	R^2=60.23	$\bar{R}^2$=55.04		R^2=85.19	$\bar{R}^2$=83.26		R^2=72.74	$\bar{R}^2$=69.:
	Coeff.	Std. Error[1]		Coeff.	Std. Error[1]		Coeff.	Std. Er
α_1	0.4257**	0.0032	α_1	0.4219**	0.0028	α_1	0.5212**	0.0075
α_2	0.0313**	0.0058	α_2	0.0723**	0.0049	α_2	-0.0998**	0.0106
β_1	0.0012**	0.0004	β_1	0.0020**	0.0002	β_1	-0.0032**	0.0009
β_2	-0.0018**	0.0005	β_2	-0.0043**	0.0003	β_2	0.0075**	0.0010
α_{post}	0.4570**	0.0047	α_{post}	0.4943**	0.0041	α_{post}	0.4213**	0.0073
β_{post}	-0.0006**	0.0002	β_{post}	-0.0023**	0.0002	β_{post}	0.0044**	0.0003
Norm.	1.3583 (0.507)		*Norm.*	0.9264 (0.629)		*Norm.*	0.3325(0.847)	

$\alpha_{post} = \alpha_1 + \alpha_2; \beta_{post} = \beta_1 + \beta_2$

[1]Newey-West standard errors,** Significant at 5% level; *Significant at 10% level

Both for Tesco (supermarket offering the LPG) and Sainsbury (supermarket affected for the LPG) $\hat{\beta}_2$ is negative and significant. As it is possible to observe in Figures 7.2 and 7.3 and in Table 7.7, the effect of the LPG for the two food-retailers offering high service quality is to invert the trend of $\mathbf{RELPRI}_t^J$ from increasing to decreasing. Nevertheless, in absolute value $\hat{\beta}_2$ is higher for Sainsbury (-0.0043) than for Tesco (-0.0018) with the result of a steeper negative slope for Sainsbury in the second period.

In contrast to the supermarkets' regressions, for the Kwik Save regression $\hat{\beta}_{post}$ is positive and significant. However, observation of Figure 7.4 reveals clearly that the increasing trend of $\mathbf{RELPRI}^{KW}$ does not start with Tesco's LPG but as soon as in Fortnight 9 of the sample. Therefore, the regression analysis of **RELPRI** for each one of the food-retailers is providing evidence about a differential effect of Tesco's LPG over Sainsbury and Kwik Save. Whilst for both high quality service food-retailers (Tesco and Sainsbury) **RELPRI** shows a decreasing trend in the post-guarantee period, this trend is increasing for the low service quality food-retailer (Kwik Save). Therefore, whereas in the post-guarantee both in Tesco and Sainsbury the price of the basket of **UNB** products was decreasing with respect to the price of the basket **NOUNB** products, for Kwik Save the opposite is true. With the aim of confirming whether the trends observed for **RELPRI** for each one of the food-retailers can be imputed to the LPG, the next step will be to check if these trends are the result of changes in the prices of the products included in the LPG, or in the products excluded.

In order to analyse the evolution of the price of the basket of **NOUNB** and **UNB** at each one of the food-retailers, we use the $\mathbf{PNOUNB}_t^J$ and PUNB_t^J indexes (described above) as dependent variables of the following regression models:

$$\mathbf{PNOUNB}_t^J = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

$$\mathbf{PUNB}_t^J = \alpha_1 + \alpha_2 D_1 + \beta_1 T + \beta_2 (T \times D_1)$$

Let us start by analysing the trends followed by the prices of the baskets of **UNB** and **NOUNB** at Tesco (the food-retailer offering the LPG) in the pre and post-guarantee periods (Figures 7.5 and 7.6). As it is possible to observe in Table 7.8 the estimated coefficient of the trend dummy in the $\mathbf{PUNB}_t^{TE}$ regression model is not significant. This clearly signals that the trend followed by the price of the basket of **UNB** products at Tesco although negative in both periods is not modified by the LPG. With respect to the trend dummy in the regression analysis of $\mathbf{PNOUNB}_t^{TE}$, this is positive (6.1886) and significant. The LPG changes the trend of $\mathbf{PNOUNB}_t^{TE}$ from negative (-6.3512) and significant in the pre-guarantee period to negative (-0.1626) but no significant in the post-policy period.

We can observe in Figure 7.7 that Sainsbury's reaction to Tesco's LPG is a continuous reduction of the price of the basket of **UNB** products that changes the trend of $\mathbf{PUNB}_t^{SA}$ from increasing to decreasing. The results of the regression analysis for

$\mathbf{PUNB}_t^{SA}$ confirm this change in trend: whereas in the pre-guarantee period the trend coefficient is 3.1494, in the post-guarantee period the trend coefficient is -5.5770 . It seems that Sainsbury interpreted *Unbeatable Value* as a threat to its custom and reacted reducing the prices of the products included in the LPG. This Sainsbury's price reduction lead to a process of convergence (Figure 7.9) between the prices of Sainsbury and Tesco for the basket of **UNB** products, that reduced the price difference between the basket of **UNB** in Tesco and Sainsbury from fifty pence at Fortnight 16 to eight pence at Fortnight 27 (in Table 7.9 we show the difference in the prices of the basket of **UNB** products in the fortnight of the start of the LPG and at the end of the sample). This evidence about the process of price reduction is sustained by the declarations of a Sainbury's representative shortly after the start of Tesco's LPG: " *When we launch Unbeatable Autumn, we said that we would undercut the competitors and that is just what we have done with this offer".* In contrast to the observed change in trend detected for $\mathbf{PUNB}_t^{SA}$, it is possible to observe in Table 7.8 that the trend dummy in the regression analysis of $\mathbf{PNOUNB}_t^{SA}$ is not significant. This is signalling that Tesco's LPG did not affect significantly Sainsbury's price setting for the products not included in the LPG[21].

With respect to the reaction of Kwik Save to Tesco's LPG, we can observe in Figures 7.10 and 7.11 the trends followed by the prices of the baskets of **UNB** and **NOUNB** products at the low service quality food-retailer. The regression analysis for $\mathbf{PUNB}_t^{KW}$ provides us with positive estimations[22] of the trend coefficients both for the pre and post-guarantee periods with a trend coefficient that is significantly higher in the post guarantee period. Furthermore, the opposite trends observed for

[21]The fact that the LPG affected only to Sainsbury price setting for the UNB group of products (and no to the price setting for the NOUNB group of products) confirms that the cause of the change is Tesco's LPG.

[22]The trend coeffcient is not significant in the pre-guarantee period.

Table 7.8: Table PUNB Regression Analysis by store

Dep. Var: $\mathbf{PUNB}_t^{TE}$			Dep. Var: $\mathbf{PNOUNB}_t^{TE}$		
	R^2=25.00	$\bar{R}^2$=15.12		R^2=87.58	$\bar{R}^2$=85.97
	Coeff.	Std. Error		Coeff.	Std. Error
α_1	834.1658**	4.7166	α_1	1958.3**	7.4250
α_2	14.5131	8.5111	α_2	-101.024**	26.0618
β_1	-0.5718	0.6965	β_1	-6.3512**	0.8196
β_2	-0.6310	0.7662	β_2	6.1886**	1.4096
α_{post}	848.6789**	6.9152	α_{post}	1857.3**	24.9737
β_{post}	-1.2028**	0.2883	β_{post}	-0.1626	1.1469
Norm.	3.0903 (0.213)		*Norm.*	0.2792 (0.870)	
Dep. Var: $\mathbf{PUNB}_t^{SA}$			Dep. Var: $\mathbf{PNOUNB}_t^{SA}$		
	R^2=88.68	$\bar{R}^2$=87.21		R^2=84.17	$\bar{R}^2$=82.11
	Coeff.	Std. Error		Coeff.	Std. Error
α_1	840.7180**	5.1178	α_1	1992.2**	7.3128
α_2	132.8139**	8.1861	α_2	-17.5134	25.5751
β_1	3.1494**	0.4235	β_1	-1.8536**	0.8043
β_2	-8.7264**	0.5256	β_2	-0.5904	1.3833
α_{post}	973.5319**	6.3962	α_{post}	1974.6**	24.5073
β_{post}	-5.5770**	0.3125	β_{post}	-2.4441**	-1.1255
Norm.	0.0585 (0.971)		*Norm.*	0.5347 (0.765)	
Dep. Var: $\mathbf{PUNB}_t^{KW}$				Dep. Var: $\mathbf{PNOUNB}_t^{KW}$	
	R^2=70.84	$\bar{R}^2$=66.63		R^2=84.73	$\bar{R}^2$=82.74
	Coeff.	Std. Error		Coeff.	Std. Error
α_1	820.3921**	7.4935	α_1	1573.2**	10.5324
α_2	-34.1381**	16.8939	α_2	257.2708**	36.8348
β_1	0.7784	0.9496	β_1	11.7652**	1.1584
β_2	2.5204**	1.2097	β_2	-19.6611**	1.9923
α_{post}	786.254**	14.4636	α_{post}	1830.4**	35.2969
β_{post}	3.2988**	0.6348	β_{post}	-7.8959**	1.6210
Norm.	0.3901 (0.823)		*Norm*	1.0454 (0.593)	

$\alpha_{post} = \alpha_1 + \alpha_2; \beta_{post} = \beta_1 + \beta_2$

[1]Newey-West standard errors,** Significant at 5% level; *Significant at 10% level

Table 7.9: Differences in the prices of the basket of UNB products

	Fortnight 16	Fortnight 27
$\mathbf{PUNB}_t^{SA} - \mathbf{PUNB}_t^{TE}$	50	8
$\mathbf{PUNB}_t^{KW} - \mathbf{PUNB}_t^{TE}$	16	64

the prices of the basket of **UNB** at Tesco and Kwik Save has as a result a process of increasing divergence between the prices of the **UNB** basket at these two food-retailers (Figure 7.9). This process of continuous price divergence contrasts with the process of price convergence observed between Tesco and Sainsbury for the prices of the basket of **UNB**.

The results of the regression analysis for $\mathbf{PNOUNB}_t^{KW}$ indicate that whereas in the pre-guarantee period it follows a positive trend (11.7652) its trend in the post-guarantee period is negative (-7.8959). However, the simple consideration of this regression results can be misleading. Figure 7.11 indicates that the start of the change in trend detected happened in Fortnight 13, well before the start of the LPG. Hence, it seems that to attribute the change observed in $\mathbf{PNOUNB}_t^{KW}$ to the start of Tesco's LPG is not adequate.

7.5.4 Summing up

Tesco's LPG has an undoubted effect over the patterns of price setting of Sainsbury. As a consequence of the LPG, price coordination between the two retailers providing high service quality increases and Sainsbury starts a process of reduction of the prices of the products included in the LPG that makes the price of the basket of **UNB** products at Sainsbury to converge towards the price of this basket at Tesco. However, the LPG does not seem to affect the price setting of the low service quality food-retailer (Kwik Save). Furthermore, in the post-guarantee period the gap (higher price at Kwik Save than at Tesco) between the prices of the basket of **UNB** products at Tesco and Kwik

Save grows instead of shrinking. Hence, the difference in service quality provided by each one of the food-retailers is an important factor when analysing the effects of the LPG.

The absence of a reaction by Kwik Save to Tesco's LPG seems to indicate that the difference in service quality observed is actually segmenting the market. Likely, Kwik Save price setting can be explained calling at a reputation issue: the belief that loyal consumers will trust its reputation of low-price retailer and will not be attracted by the LPG of a higher price-higher quality reputation supermarket as Tesco, allows Kwik Save to face Tesco' LPG without modifying substantially its pricing behaviour.

If we accept that service quality is segmenting the market, then the analysis of the LPG should focus on analysing the effect of this over the relevant price for the market segment served by the supermarkets. In this line it was shown in Chapter 6 that the increase in between-supermarket price coordination, and the fall in the market price of the basket of UNB (Tesco and Sainsbury prices fall in the post-guarantee period) observed could be part of loss-leaders strategy advertised by Tesco as a LPG. Tesco, aware of the fact that is setting lower prices than the other supermarkets for a subset of products, uses these products as part of an advertising strategy addressed to lure consumers. Sainsbury takes this action as a threat to its custom and reacts reducing the prices of the same group of products.

7.6 Concluding remarks

The results obtained in this paper shed light about the ability of service quality differentials to segment the market. From the analysis carried out in the first part of the paper, it is clear that the main element determining patterns of price setting for the BPs is the differential in service quality between supermarkets and retailers. For the LQs, both service quality differentials and locational asymmetries seem to play a role in determining food-retailers price setting. This is signalling that for the LQs service quality differentials could be losing part of their segmentation ability.

The exploration of the effects of Tesco's LPG offered us the opportunity of going deeper in the analysis of the competition between supermarkets and discounter for the LQ variant. The reaction of Sainsbury to Tesco's LPG (continuous reduction of the price of the basket of the products included in the guarantee) resulted in an increase of the degree of price coordination between the two food-retailers offering the same level of service quality. However, Kwik Save does not seem to react to Tesco's LPG. Furthermore, whereas after the start of the LPG the price of the basket of products included in the guarantee follows a decreasing trend at Tesco, for Kwik Save it shows an increasing trend. The result of these opposite trends in the post-guarantee period is an increase of the divergence between the prices of the basket of products included in the guarantee. This result clearly indicates that service quality is actually segmenting the market and that even for LQs and independently of location, competition is much more intense between food-retailers offering the same level of service quality than between food-retailers offering different levels of service quality.

These findings result of great importance to define the relevant market to analyse food-retailer competition. Although service quality seems to be more determinant to segment the market for BPs than for LQs, the analysis of the differential effects of the LPGs rises serious doubts about the convenience of considering supermarkets and discounter as forming part of a unique food-retailers relevant market. Likely supermarkets and discounters compete in two markets with different levels of service quality. Furthermore, the results suggest that the common custom to this two markets is quite small.

7.7 Appendices

A. Variables description and Descriptive Statistics for the LPG Analysis

DS.1 Variables Used in the Price Coordination Analysis

Variable	Description	Sample	Observations	Period	Mean	Std. Dev.
$DDPMI^{TE-SA}_{ALL,PRE}$	Price Coordination TE-SA	All Products	46	Pre-Guarantee period	0.6539	0.2243
$DDPMI^{TE-SA}_{NOUNB,PRE}$	Price Coordination TE-SA	No Unbeatables	24	Pre-Guarantee period	0.6877	0.2296
$DDPMI^{TE-SA}_{UNB,PRE}$	Price Coordination TE-SA	Unbeatables	22	Pre-Guarantee period	0.6169	0.2245
$DDPMI^{TE-KW}_{ALL,PRE}$	Price Coordination TE-KW	All Products	46	Pre-Guarantee period	0.6234	0.2170
$DDPMI^{TE-KW}_{NOUNB,PRE}$	Price Coordination TE-KW	No Unbeatables	24	Pre-Guarantee period	0.6203	0.2305
$DDPMI^{TE-KW}_{UNB,PRE}$	Price Coordination TE-KW	Unbeatables	22	Pre-Guarantee period	0.6268	0.2084
$DDPMI^{TE-SA}_{ALL,POST}$	Price Coordination TE-SA	All Products	46	Post-Guarantee period	0.7980	0.1641
$DDPMI^{TE-SA}_{NOUNB,POST}$	Price Coordination TE-SA	No Unbeatables	24	Post-Guarantee period	0.7583	0.1601
$DDPMI^{TE-SA}_{UNB,POST}$	Price Coordination TE-SA	Unbeatables	22	Post-Guarantee period	0.8413	0.1172
$DDPMI^{TE-KW}_{ALL,POST}$	Price Coordination TE-KW	All Products	46	Post-Guarantee period	0.7808	0.1781
$DDPMI^{TE-KW}_{NOUNB,POST}$	Price Coordination TE-KW	No Unbeatables	24	Post-Guarantee period	0.7622	0.1874
$DDPMI^{TE-KW}_{UNB,POST}$	Price Coordination TE-KW	Unbeatables	22	Post-Guarantee period	0.8011	0.1285

DS.2 Variables used in the Price Trends Analysis

Variable	Description	Observations	Mean	Std. Deviation
$RELPRI_t^{TE}$	Price Index for Tesco	27	0.4389	0.0078
$RELPRI_t^{SA}$	Price Index for Sainsbury	27	0.4407	0.0099
$RELPRI_t^{KW}$	Price Index for Kwik Save	27	0.5053	0.0212
$PUNB_t^{TE}$	Price of the Basket of Unbeatable Products at Tesco	27	826.5814	9.6413
$PUNB_t^{SA}$	Price of the Basket of Unbeatable Products at Sainsbury	27	860.4520	18.8940
$PUNB_t^{KW}$	Price of the Basket of Unbeatable Products at Kwik Save	27	840.2016	21.3883
$PNOUNB_t^{TE}$	Price of the Basket of No Unbeatable Products at Tesco	27	1883.6674	36.6148
$PNOUNB_t^{SA}$	Price of the Basket of No Unbeatable Products at Sainsbury	27	1952.7778	31.8244
$PNOUNB_t^{KW}$	Price of the Basket of No Unbeatable Products at Kwik Save	27	1664.3524	46.6602

B. Testing Proposition 1

This appendix consists of two parts. In the first part we describe the Friedman test and give the reasons to use it. In the second part, we explain the complete testing procedure for Proposition 1. We carry out this testing procedure for each one of the products of the sample both for BPs and LQs.

1. Description of the Friedman Test

This non-parametric test should be used to detect differences in average between more than two samples when observations are related in some way across the samples. In our particular case, we have 27 fortnightly observations for the price of product j at three food-retailers. The observations in the three samples are not independent, but are related by a common feature: the fortnight in which they were taken.

For the Friedman test we consider each one of the K samples as a column with the related observations located in the same row of each one of the columns (in our case, the price samples of product j for each one of the three food-retailers should be considered as a column, with the observations corresponding to a given fortnight t located in the same row of each one of the three columns). Then, the observations within each row are ranked from 1 to K. The M statistic can be obtained as

$$M = \frac{12}{NK(K+1)} \sum_{j=1}^{K} R_j^2 - 3N(K+1)$$

where:

R_j is the sum of ranks in column j and N is the number of observations (the number of observations is equal in each one of the columns). The null hypothesis of no difference in the average level of the variable under analysis is rejected if $M \geq \chi^2_{k-1}$. Some correction is needed in presence of ties. A full description of the test can be found in Neave and Worthington [1988]

2. Testing procedure for Proposition 1

This testing procedure consists of two parts:

Step 1: Friedman Test

In this first step, we use the Friedman test for more than two related samples to test if there is any difference between the average prices set by Tesco, Sainsbury and Kwik Save for each one of the products of the sample. Formally, the null and alternative hypotheses of this test for product i are:

H_0: *There is no difference in the average prices set by Sainsbury, Tesco and Kwik Save for the quality variant k of product i.*

H_1: *There are some differences in the average prices set by Sainsbury, Tesco and Kwik Save for the quality variant k of product i.*

For those products for which the null hypothesis is not rejected, we conclude that on average there is no difference between the prices set at the three food-retailers and halt the testing sequence. For those products for which the null hypothesis is rejected, we proceed to the second step of the testing procedure to establish a rank of food-retailers prices.

Step 2: Dunn's multiple comparisons technique

The next step for those products for which the Friedman test led to reject the null hypothesis of no difference between the average prices set by the three food retailers is to check using as basis food-retailers pairs which food-retailer price is different from which. We perform this analysis by means of the Dunn´s multiple comparisons procedure.

The three sets of hypotheses for this multiple comparisons test are:

$H_0^{(J,K)}$: *Food-retailers J and K set the same average price for the quality variant k of product i*

$H_1^{(J,K)}$: *Food-retailers **J** and **K** set different average price for the quality variant k of product i*

with $(J, K) = (KW, SA)$, (KW, TE), (TE, SA).

With the results of this multiple comparisons test and the sum of ranks for each one of the food-retailers obtained as an intermediate output of this test, we can establish a rank of supermarket prices

Let us use as an example the results of the test that correspond to the BP Cola to illustrate the procedure. The results of the test for BP Cola are summarized in the Table below as:

	M	CV 5%	R_{KW}	R_{SA}	R_{TE}	T_{KW-SA}	T_{KW-TE}	T_{SA-TE}	CV 30
BP COLA	49.368	6.4	29	67	66	5.171	5.035	0.136	1.645

For the BP Cola the value of the Friedman statistic (M) leads to reject the null hypothesis of equal prices on average for the three supermarkets (even at 1% level) and it is evidence of some difference in the average price set by BP Cola at the three food-retailers. Therefore the next step is to check by means of the Dunn´s procedure which food-retailer average price is different from which. The joint consideration of the values of the sums of ranks R_{KW}, R_{SA} and R_{TE} and the statistics $T_{KW\text{-}SA}$, $T_{KW\text{-}TE}$ and $T_{SA\text{-}TE}$ are evidence of similar average prices for the BP Cola at Tesco and Sainsbury that are significantly higher than the price at Kwik Save (the null hypothesis of each one of the comparisons is rejected if T_{J-K} is greater than the critical value).

Although the reasons to use a 30% significance level were already described in Appendix B of Chapter 4 (when the Dunn's procedure was explained), we briefly remember them here. If we were carrying a single test, the probability would be $\frac{1}{2}\alpha$, however with the Dunn's procedure we are performing $\frac{1}{2}k(k-1)$ tests. In order to share out the risk equally between these tests the appropriate probability is $\frac{1}{2}\alpha/\frac{1}{2}k(k-1) = \alpha/k\,(k-1)$.

On the basis of this rule with $k = 3$, we choose an $\alpha = 30\%$. The z that corresponds to an upper probability $\alpha/k\,(k-1) = 0.05$ is 1.645 . Therefore, we will reject the null hypothesis when $|T_{ij}| \geq 1.645$.

In Table A1 and A2 we show the results of the Friedman test and the Dunn's multiple comparisons procedure both for BPs and LQs.

Table A1: Friedman Test and Dunn's Multiple Comparisons Test. BP. Full sample.

	M	Signif	KW	SA	TE	T_{KW-SA}	T_{KW-TE}	T_{SA-TE}	CV 30%
BB	45,750	0,000	29	67	66	5,171	5,035	0,136	1,645
BEER	22,463	0,000	39	66,5	56,5	3,742	2,381	1,360	1,645
BLE	22,533	0,000	67	47,5	47,5	2,653	2,653	0,000	1,645
BRE	18,420	0,000	36,5	63,5	62	3,674	3,470	0,204	1,645
CAT	53,365	0,000	27	67	68	5,443	5,779	0,136	1,645
COC	49,368	0,000	29	67	66	5,171	5,035	0,136	1,645
COF	30,687	0,000	33,5	66,5	62	4,491	3,878	0,612	1,645
CON	35,473	0,000	33	62	67	3,946	4,627	0,680	1,645
CORN	19,419	0,000	44	58,5	59,5	1,973	2,109	0,136	1,645
CP	16,000	0,000	46	60	58	2,177	1,905	0,272	1,645
CS	49,560	0,000	28	66	68	5,171	5,443	0,272	1,645
CS1	53,355	0,000	81	40	41	5,579	5,443	0,136	1,645
CT	33,363	0,000	32	67	63	4,762	4,218	0,544	1,645
DE	44,355	0,000	29	72	61	5,851	4,354	1,496	1,645
DO	38,847	0,000	31	61,5	69,5	4,151	5,239	1,088	1,645
FIS	48,667	0,000	28	65	69	5,035	5,579	0,544	1,645
FLO	39,511	0,000	30,5	62,5	69	4,354	5,239	0,885	1,645
FRO	14,000	0,001	48	66,5	47,5	2,517	0,068	2,585	1,645
GEL	24,796	0,000	34,5	65,5	62	4,219	3,742	0,476	1,645
ICE	28,451	0,000	33	64,5	64,5	4,287	4,287	0,000	1,645
KET	54,000	0,000	27	67,5	67,5	5,511	5,511	0,000	1,645
KITC	50,273	0,000	27	65	70	5,171	5,851	0,680	1,645
KIT	27,846	0,000	37	52,75	72,5	2,109	4,830	2,722	1,645
MAR	39,102	0,000	31,5	64,5	66,5	4,422	4,762	0,340	1,645
MAY	47,929	0,000	28	65,5	68,5	5,103	5,511	0,408	1,645
ORA	41,247	0,000	30	63,5	68,5	4,550	5,239	0,680	1,645
OVE	4,261	0,119	49	62	51				
PAS	31,659	0,000	32	62	68	4,0824	4,899	0,816	1,645
PEA	49,235	0,000	81	41,5	39,5	5,375	5,647	0,2721	1,645
RIC	0,626	0,731	53	53	52,5				
SAL	32,830	0,000	32	66,5	63,5	4,694	4,286	0,4082	1,645
SAN	39,783	0,000	31	61,5	69,5	4,15	5,239	1,088	1,645
SHA	33,300	0,000	33	66	63	4,49	4,082	0,408	1,645
SMO	51,441	0,000	27	65	70	5,171	5,854	0,68	1,645
SOAP	52,795	0,000	27	66,5	68,5	5,375	5,647	0,272	1,645
SPA	45,358	0,000	29	78	55	6,668	3,538	3,129	1,645
STRA	40,085	0,000	29	68	65	5,3072	4,899	0,4028	1,645
TEA	53,365	0,000	27	68	67	5,5793	5,443	0,136	1,645
TIS	54,000	0,000	27	67,5	67,5	5,5511	5,511	2,394	1,645
TOI	38,000	0,000	31,5	63	67,5	4,286	4,898	0,162	1,645
TO	20,583	0,000	36	65	61	3,946	3,402	0,544	1,645
TU	31,431	0,000	31	67,5	63,5	4,967	4,422	0,544	1,645
WAL	16,701	0,000	70,5	41	50,5	4,014	2,721	1,2927	1,645
WU	26,380	0,000	35	61	66	3,538	4,128	0,68	1,645
WP	39,747	0,000	30	66,5	65,5	4,967	4,83	0,136	1,645
YO	34,879	0,000	31	65,5	65,5	4,694	4,694	0	1,645

Table A2: Friedman Test and Dunn's Multiple Comparisons Test. LQ. Full sample

	M	Sign	KW	SA	TE	T_{KW-SA}	T_{KW-TE}	T_{SA-TE}	CV 30%
BB	12,400	0,002	50	62,5	49,5	1,701	0,068	1,769	1,645
BEER	50,296	0,000	27	56	79	3,946	7,076	3,130	1,645
BLE	42,522	0,000	29	62	71	4,491	5,715	1,225	1,645
BRE	28,744	0,000	34	67	61	4,491	3,674	0,816	1,645
CAT	32,667	0,000	33	64,5	64,5	4,287	4,287	0,000	1,645
COC	23,918	0,000	37,5	66	58,5	3,878	2,858	1,021	1,645
COF	50,818	0,000	27	71	64	5,988	5,035	0,953	1,645
CON	44,963	0,000	77	57	28	2,722	6,668	3,946	1,645
CORN	52,095	0,000	27	67	68	5,443	5,579	0,136	1,645
CP	20,000	0,000	64	49	49	2,041	2,041	0,000	1,645
CS	39,402	0,000	44,5	79	38,5	4,695	0,816	5,511	1,645
CS1	27,724	0,000	43	70	49	3,674	0,816	2,858	1,645
CT	17,526	0,000	48	64,5	49,5	2,245	0,204	2,041	1,645
DE	1,212	0,546	55,5	49,5	57				
DO	16,286	0,000	39	60	63	2,858	3,266	0,408	1,645
FIS	1,153	0,562							
FLO	9,892	0,007	47	60,5	54,5	1,837	1,021	0,816	1,645
FRO	4,598	0,100	45,5	59,5	57				
GEL	52,095	0,000	27	68	67	5,579	5,443	0,136	1,645
ICE	13,634	0,001	40,5	62,5	59	2,994	2,518	0,476	1,645
KET	41,152	0,000	28	65,5	68,5	5,103	5,511	0,408	1,645
KITC	2,154	0,341	58	49	55				
KIT	29,936	0,000	62,5	67	32,5	0,612	4,082	4,695	1,645
MAR	8,361	0,015	48,5	64	49,5	2,109	0,136	1,973	1,645
MAY	1,238	0,538	57	50	55				
ORA	4,542	0,103	50,5	60	51,5				
OVE	37,514	0,000	37,5	79,5	45	5,715	1,021	4,695	1,645
PAS	44,408	0,000	27	62,5	72,5	4,831	6,192	1,361	1,645
PEA	21,765	0,000	64	61,5	36,5	0,340	3,742	3,402	1,645
RIC	38,273	0,000	33,5	65	63,5	4,287	4,082	0,204	1,645
SAL	40,821	0,000	29	70,5	62,5	5,647	4,559	1,089	1,645
SAN	2,508	0,285	57,5	55,5	49				
SHA	13,127	0,001	64,5	51,5	46	1,769	2,518	0,748	1,645
SMO	13,127	0,001	64,5	51,5	46	1,769	2,518	0,748	1,645
SOAP	43,600	0,000	34,5	79	48,5	6,056	1,905	4,151	1,645
SPA	15,500	0,000	43	61	58	2,449	2,041	0,408	1,645
STRA	5,702	0,058	47	63	52				
TEA	49,279	0,000	39	80,5	42,5	5,647	0,476	5,171	1,645
TIS	44,000	0,000	32	65	65	4,491	4,491	0,000	1,645
TOI	52,699	0,000	81	40,5	40,5	5,511	5,511	0,000	1,645
TO	48,667	0,000	27	78	57	6,940	4,082	2,858	1,645
TU	28,778	0,000	38	60,5	63,5	3,062	3,470	0,408	1,645
WAL	25,387	0,000	39,5	67,5	55	3,810	2,109	1,701	1,645
WU	15,846	0,000	61,5	62	38,5	0,068	3,130	3,198	1,645
WP	50,400	0,000	27	72	63	6,124	4,899	1,225	1,645
YO	23,565	0,000	39,5	68	54,5	3,878	2,041	1,837	1,645

C. Testing Proposition 1 for the period before the LPG

With the aim of showing that the results obtained when testing Proposition 1 are not a consequence of the LPG offered by Tesco from Fortnight 16 onwards, we replicate the empirical analysis of Proposition 1 using as sample period the 15 fortnights before the start of the LPG.

The results obtained can be summarized in the following table[23]

Table 7.1a: Testing Proposition 1 in the Pre-guarantee period. Summary Table

	BPs	LQs
$p_{SA} > p_{TE} > p_{KW}$	1	2
$p_{SA} \approx p_{TE} > p_{KW}$	34	19
$p_{SA} \approx p_{TE} \approx p_{KW}$	5	6
$p_{SA} > p_{TE} \approx p_{KW}$	1	9
$p_{TE} > p_{SA} > p_{KW}$	1	2
$p_{KW} > p_{SA} > p_{TE}$	0	0
$p_{KW} \approx p_{SA} > p_{TE}$	0	5
$p_{KW} > p_{SA} \approx p_{TE}$	4	2
$p_{TE} > p_{SA} \approx p_{KW}$	0	1

In order to show that the results do not depend on the sample period analysed, we check if there is any association between distribution of supermarket price ranks and period of analysis. In order to do this, we build two contingency tables, one for the BPs and another one for the LQs. The rows of the BPs contingency table are the distributions of supermarkets price ranks of the BPs for the full period and the period before the start of the LPG. By analogy, the rows of the LQs contingency table are the distributions of supermarket price ranks for the LQs for the full period and the period before the start of the LPG. In these two contingency tables, we test the null hypothesis of no association between period of analysis and distribution of supermarket price ranks.

[23]The numbering of the tables correpond to that of the general body of the paper, we have added an "a" to the number to mean an Appendix table.

Table: 7.1b[24] Contingency table association test. Full vs pre-guarantee sample period

		Pearson-χ^2	D. of F.	Significance
BPs	Full vs. Pre-guarantee samples	1.418	5	0.922
LQs	Full vs. Pre-guarantee samples	3.795	8	0.875

As it is possible to observe in Table 7.1b, in both cases the null hypothesis of no association is not rejected. Therefore, it is evidence (both for the BPs and LQs) in favour of a common distribution of price ranks for the full and pre-guarantee periods.

We use also a contingency table to check, as we did for the full period sample, the null hypothesis of no association between quality variant and distribution of supermarket price ranks. The rows of this contingency table correspond to the columns of Table 7.1a.

Table 7.2a: Contingency Table Association test

	Pearson-χ^2	D. of F.	Significance
BPs-LQs	18.070	7	0.012

As for the full period, for the period before the start of LPG the test of association leads to reject the null hypothesis of no association between quality variant and distribution of supermarket price ranks. Therefore, the results obtained using the pre-guarantee period sample are identical to those obtained using the full-period sample.

The results of the battery of Friedman and Dunn's multiple comparisons tests for BPs and LQs for the period before the start of the LPG are shown in Tables A3 to A4.

[24] As this table does not appear on the main body of the paper we number the table as the one before but we add the "b" to distinguish it from 7.1a.

Table A3: Friedman Test and Dunn's Multiple Comparisons Test. BP. Fortnights 1-15

	M	CV 5%	R_{KW}	R_{SA}	R_{TE}	T_{KW-SA}	T_{KW-TE}	T_{SA-TE}	CV 30%
BB	19.455	6.4	17	37	36	3.651	3.469	0.183	1.645
BEER	9.991	6.4	21	35.5	33.5	2.647	2.282	0.365	1.645
BLE	7.056	6.4	37	26.5	26.5	1.917	1.917	0.000	1.645
BRE	11.359	6.4	20	32.5	37.5	2.282	3.195	0.913	1.645
CAT	25.889	6.4	15	37	38	4.017	4.199	0.183	1.645
COC	25.889	6.4	15	38	37	4.199	4.017	0.183	1.645
COF	14.832	6.4	19	39	32	3.651	2.373	1.278	1.645
CON	14.860	6.4	19	33	38	2.556	3.469	0.913	1.645
CORN	0.851	6.4	28	30.5	31.5				
CP	11.548	6.4	21	35.5	33.5	2.647	2.282	0.365	1.645
CS	22.672	6.4	16	36	38	3.651	4.017	0.365	1.645
CS1	25.889	6.4	45	22	23	4.199	4.017	0.183	1.645
CT	18.582	6.4	17	37.5	35.5	3.743	3.378	0.365	1.645
DE	23.846	6.4	16	41.5	32.5	4.656	3.012	1.643	1.645
DO	21.409	6.4	16.5	35	38.5	3.378	4.017	0.639	1.645
FIS	22.672	6.4	16	36	38	3.651	4.017	0.365	1.645
FLO	21.179	6.4	16.5	35.5	38	3.469	3.925	0.456	1.645
FRO	11.115	6.4	26.5	39	24.5	2.282	0.365	2.647	1.645
GEL	7.584	6.4	21.5	34.5	34	2.373	2.282	0.091	1.645
ICE	22.623	6.4	16	38.5	35.5	4.108	3.560	0.548	1.645
KET	26.129	6.4	15	37.5	37.5	4.108	4.108	0.000	1.645
KITC	26.129	6.4	15	37.5	37.5	4.108	4.108	0.000	1.645
KIT	14.694	6.4	20	30	40	1.826	3.651	1.826	1.645
MAR	13.874	6.4	19.5	33.5	37	2.556	3.195	0.639	1.645
MAY	*25.889*	*6.4*	*15*	*37*	*38*	*4.017*	*4.199*	0.183	1.645
ORA	19.364	6.4	17	35.5	37.5	3.378	3.743	0.365	1.645
OVE	1.029	6.4	29	33	28				
PAS	21.312	6.4	16	36	38	3.651	4.017	0.365	1.645
PEA	24.202	6.4	45	23.5	21.5	3.925	4.290	0.365	1.645
RIC	4.420	6.4	34	24.5	31.5				
SAL	*13.782*	*6.4*	19	37.5	33.5	3.378	2.647	0.730	1.645
SAN	16.181	6.4	19	31.5	39.5	2.282	3.743	1.461	1.645
SHA	11.285	6.4	21	37.5	31.5	3.012	1.917	1.095	1.645
SMO	25.645	6.4	15	35.5	39.5	3.743	4.473	0.730	1.645
SOAP	26.129	6.4	15	37.5	37.5	4.108	4.108	0.000	1.645
SPA	23.652	6.4	17	43.5	29.5	4.838	2.282	2.556	1.645
STRA	26.682	6.4	15	42	33	4.930	3.286	1.643	1.645
TEA	25.889	6.4	15	38	37	4.199	4.017	0.183	1.645
TIS	26.129	6.4	15	37.5	37.5	4.108	4.108	0.000	1.645
TOI	20.949	6.4	16.5	36.5	37	3.651	3.743	0.091	1.645
TO	5.400	6.4	23	35	32				
TU	26.169	6.4	15	33	42	3.286	4.930	1.643	1.645
WAL	15.092	6.4	42	25	23	3.104	3.469	0.365	1.645
WU	6.177	6.4	23	31.5	35.5				
WP	19.050	6.4	17	36	37	3.469	3.651	0.183	1.645
YO	12.847	6.4	19	36	35	3.104	2.921	0.183	1.645

Table A4: Friedman Test and Dunn's Multiple Comparisons Test. LQ. Fortnights 1-15

	M	CV 5%	R_{KW}	R_{SA}	R_{TE}	T_{KW-SA}	T_{KW-TE}	T_{SA-TE}	CV 30%
BB	8.820	6.4	27	38	25	2.008	0.365	2.373	1.645
BEER	30.000	6.4	15	30	45	2.739	5.477	2.739	1.645
BLE	22.165	6.4	17	0	42	2.556	4.564	2.008	1.645
BRE	7.635	6.4	22	33.5	34.5	2.100	2.282	0.183	1.645
CAT	14.052	6.4	19	35.5	35.5	3.012	3.012	0.000	1.645
COC	7.577	6.4	24.5	37.5	28	2.373	0.639	1.734	1.645
COF	26.129	6.4	15	37.5	37.5	4.108	4.108	0.000	1.645
CON	21.733	6.4	41	33	16	1.461	4.564	3.104	1.645
CORN	25.350	6.4	15	37	38	4.017	4.199	0.183	1.645
CP	8.862	6.4	38	26	26	2.191	2.191	0.000	1.645
CS	18.415	6.4	26	43	21	3.104	0.913	4.017	1.645
CS1	21.174	6.4	23	43.5	23.5	3.743	0.091	3.651	1.645
CT	6.419	6.4	27	37	26	1.826	0.183	2.008	1.645
DE	0.707	6.4	32	30.5	27.5				
DO	1.072	6.4	27	31	32				
FIS	17.157	6.4	18	38	34	3.651	2.921	0.730	1.645
FLO	14.115	6.4	21.5	37.5	31.5	2.921	1.826	1.095	1.645
FRO	18.489	6.4	18.5	30	41.5	2.100	4.199	2.100	1.645
GEL	25.350	6.4	15	38	37	4.199	4.017	0.183	1.645
ICE	14.863	6.4	18.5	38	33.5	3.560	2.739	0.822	1.645
KET	22.291	6.4	16	39.5	34.5	4.290	3.378	0.913	1.645
KITC	13.855	6.4	29.5	20.5	40	1.643	1.917	3.560	1.645
KIT	13.826	6.4	32.5	38	19.5	1.004	2.373	3.378	1.645
MAR	19.350	6.4	21.5	43.5	25	4.017	0.639	3.378	1.645
MAY	19.410	6.4	34.5	17	38.5	3.195	0.730	3.925	1.645
ORA	2.352	6.4	31.5	32.5	26				
OVE	20.133	6.4	21	44	25	4.199	0.730	3.469	1.645
AS	24.850	6.4	15	34.5	40.5	3.560	4.656	1.095	1.645
PEA	20.016	6.4	40	33	17	1.278	4.199	2.921	1.645
RIC	13.846	6.4	20	35	35	2.739	2.739		1.645
SAL	18.965	6.4	17	35.5	37.5	3.378	3.743	0.365	1.645
SAN	6.028	6.4	36	24	30				
SHA	0.720	6.4	29	29	32				
SMO	14.837	6.4	18	37.5	34.5	3.560	3.012	0.548	1.645
SOAP	21.738	6.4	18	43	29	4.564	2.008	2.556	1.645
SPA	0.720	6.4	29	32	29				
STRA	9.459	6.4	21	37	32	2.921	2.008	0.913	1.645
TEA	25.714	6.4	20	45	25	4.564	0.913	3.651	1.645
TIS	23.520	6.4	16	37	37	3.834	3.834	0.000	1.645
TOI	25.579	6.4	45	22.5	22.5	4.108	4.108	0.000	1.645
TO	25.200	6.4	15	42	33	4.930	3.286	1.643	1.645
TU	23.520	6.4	16	37	37	3.834	3.834	0.000	1.645
WAL	19.029	6.4	18	39.5	32.5	3.925	2.647	1.278	1.645
WO	9.232	6.4	32.5	36.5	21	0.730	2.100	2.830	1.645
WP	26.129	6.4	15	37.5	37.5	4.108	4.108	0.000	1.645
YO	20.329	6.4	18	42	30	4.382	2.191	2.191	1.645

D: Figures of the LPG analysis

Figure 7.2: RELPRI (TE) Actual and Fitted Values

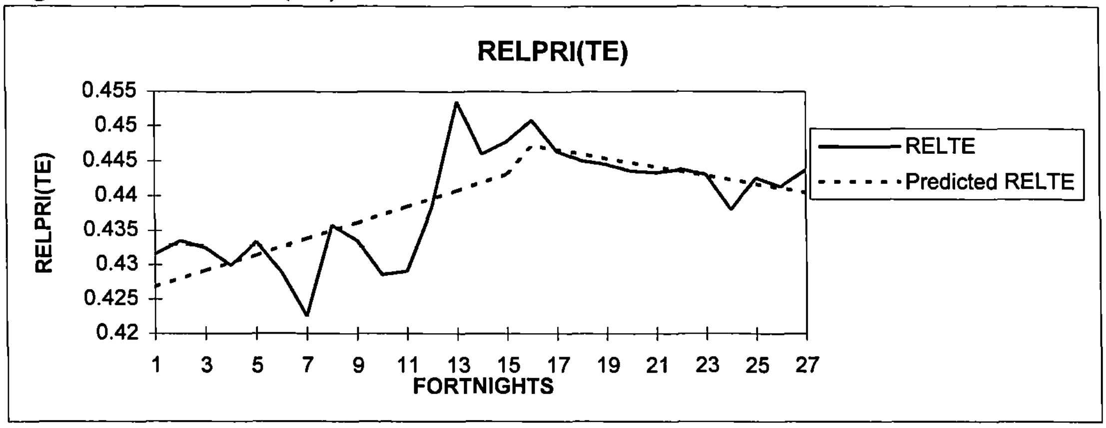


Figure 7.3: RELPRI (SA) Actual and Fitted Values

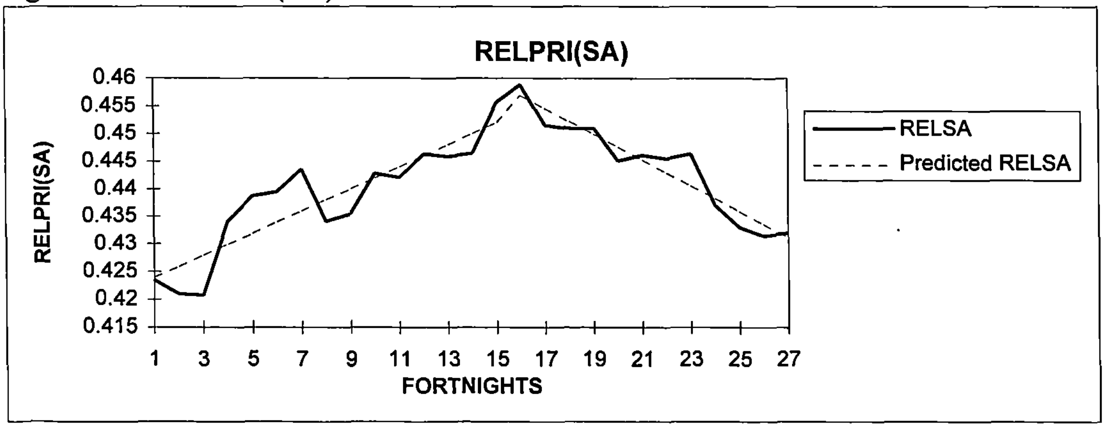


Figure 7.4: RELPRI(KW) Actual and Fitted Values

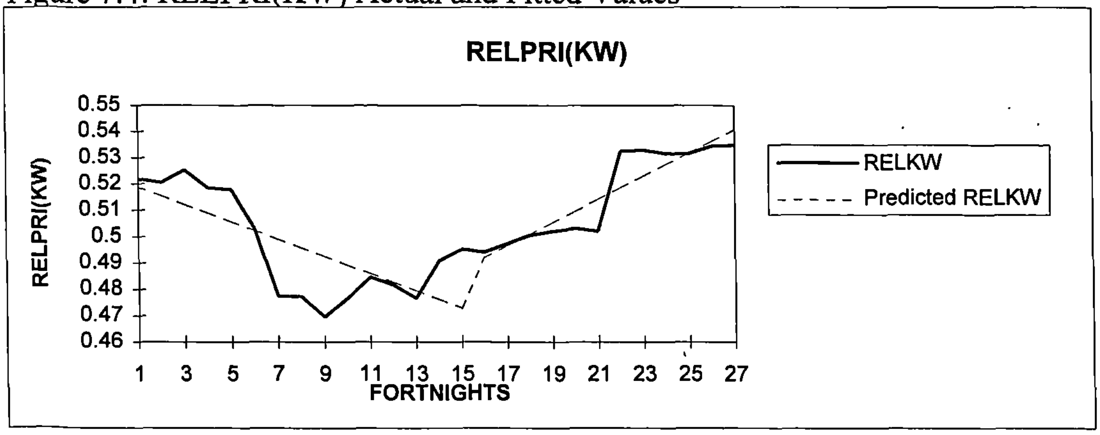


Figure 7.5 : PUNB(TE) Actual and Fitted Values

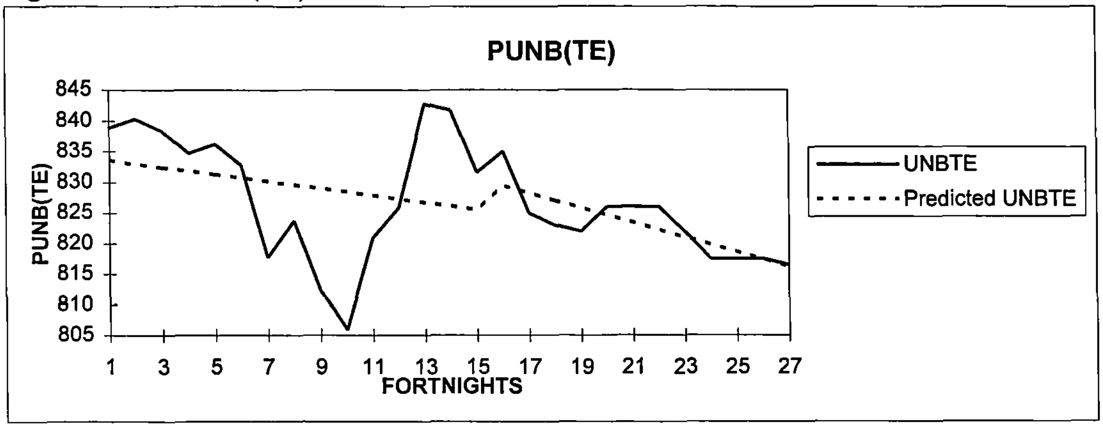


Figure 7.6: PNOUNB(TE) Actual and Fitted Values

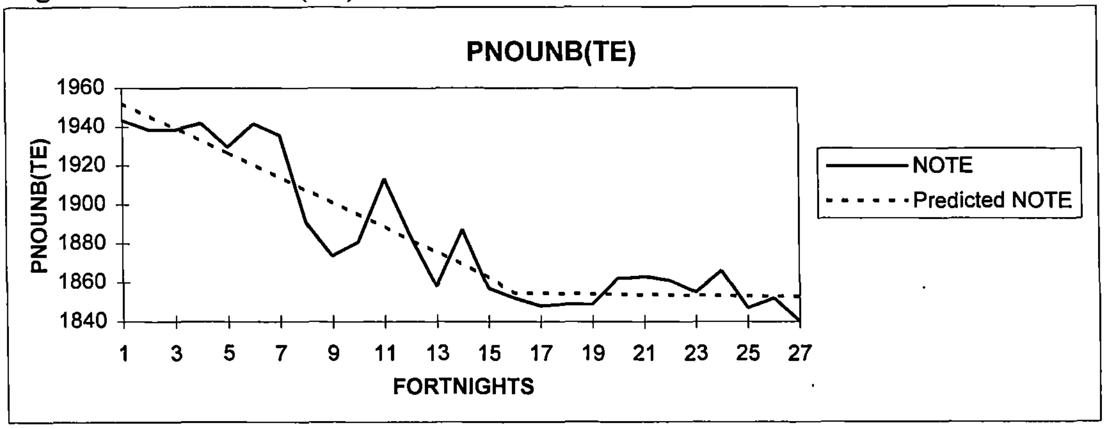


Figure 7.7: PUNB(SA) Actual and Fitted Values

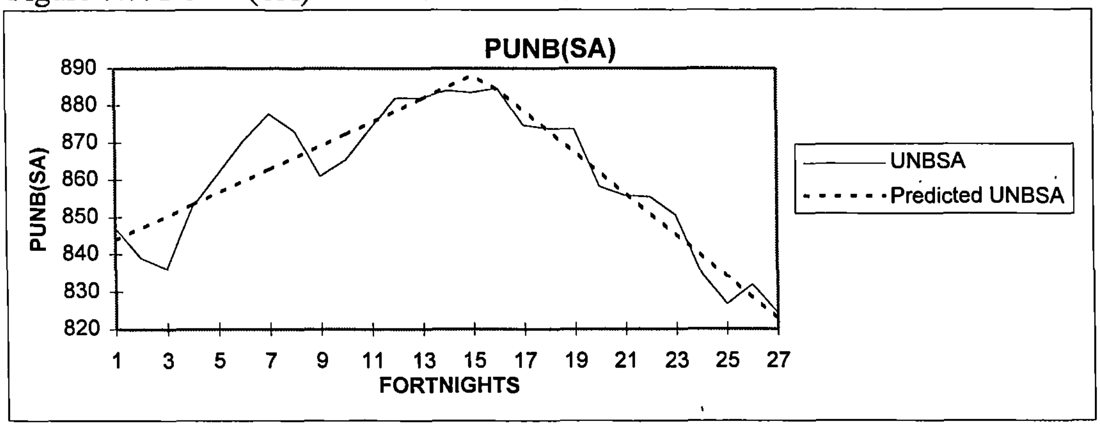


Figure 7.8: PNOUNB(SA) Actual and Fitted Values

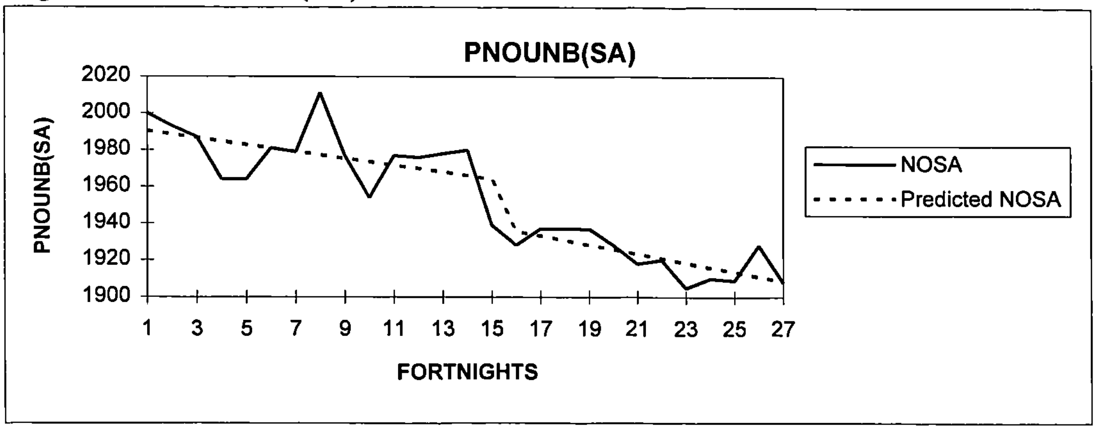


Figure 7.9: Evolution of the price of the basket of UNB products

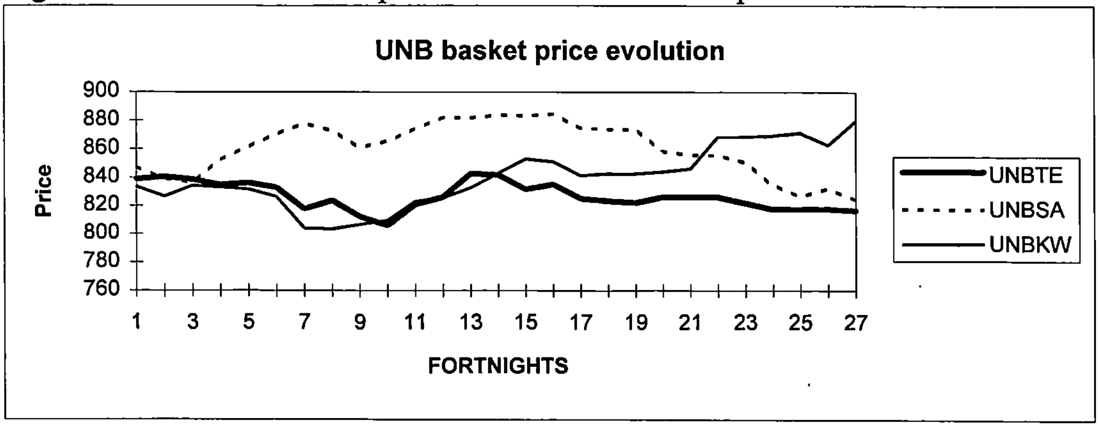


Figure 7.10: UNB(KW) Actual and Fitted values

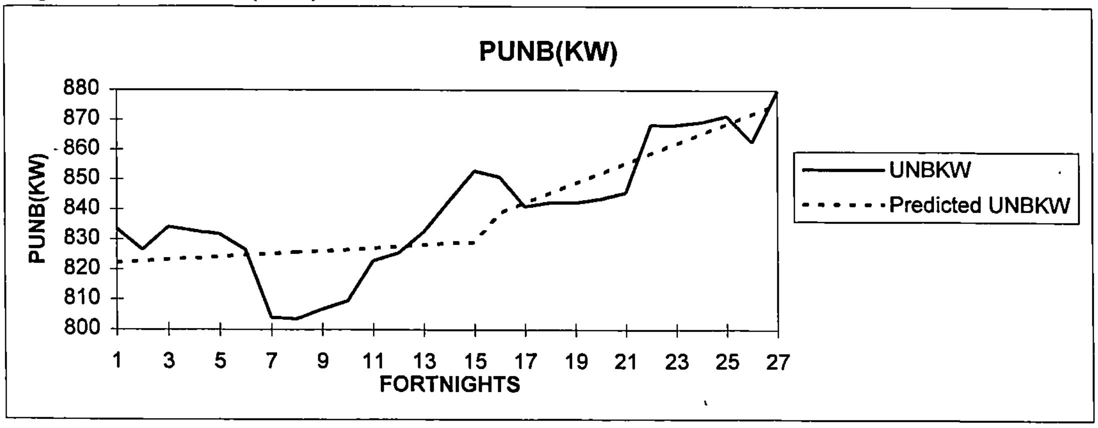
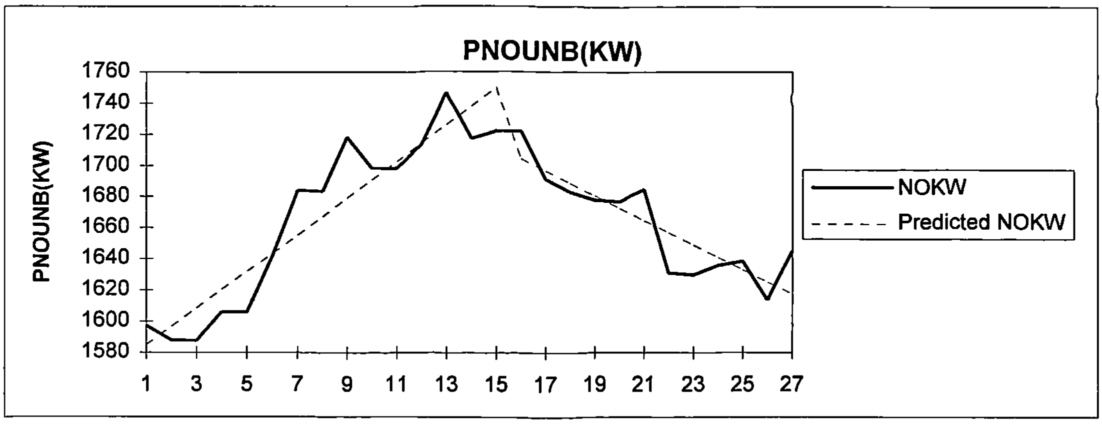


Figure 7.11: PNOUNB(KW) Actual and Fitted Values



E. Reduced Sample Analysis

Motivated by the lack of weights when building the basket of products included (**UNB**) and not included in the LPG (**NOUNB**), the aim of this Appendix is to show the robustness of the results to the subset of products included in the sample. With respect to the sample used in the general body of the paper (full sample), we exclude here the categories of alcoholic products (beer) and toiletries (deodorant, hair shampoo, shower gel, toothpaste, sanitary towels, soap). The reason for this exclusion is that this is the subset of products for which interpurchase time is longer and/or tastes more important in the buying decision.

The numbering of the Tables in this Appendix corresponds to that of the general body of the paper and an *a* is added to distinguish them.

Table 7.4a: Mann-Whitney Test for differences on average DDPMI. UNB-NOUNB

Pre-guarantee		Value of the test (U)	Critical Value 5%	One/Two Sided
	TE-SA	179	120.07	Two
	TE-KW	158.5	119.83	Two

Rejection of the H_0 if $U \leq CV5\%$

It is possible to observe in Table 7.4a that the results obtained do not differ from the results obtained with the full sample. For the retailer pair TE-SA, in the pre-guarantee period there is no significant difference between the average **DDPMI** of **UNB** and **NOUNB** (the null hypothesis is not rejected). Also for the retailer pair TE-KW the null hypothesis of no difference on average between the **DDPMI** of **UNB** and **NOUNB** is not rejected for the pre-guarantee period.

Table 7.5a: Wilconxon Test for differences on average DDPMI. Pre-post guarantee

NOUNB		T	C.V. 5%	CSS	One/Two Sided
	TE-SA	47	41	17	One
	TE-KW	43	47	18	One
UNB		T	C.V. 5%		
	TE-SA	8	47	18	One
	TE-KW	37	60	20	One

T: value of the test; CV 5%: Critical Value at 5% significance level ;

Rejection of H_0 if T≤CV 5%; Corrected Sample Size = Sample Size − Number of Zero Differences

As for the full sample, the results shown in Table 7.5a for the retailer pair TE-SA suggest that while for the **NOUNB** there is no difference in the average **DDPMI** between the pre and post-guarantee period, for the **UNB** the **DDPMI** is higher in the post-guarantee period. However, for the retailer pair TE-KW both for **UNB** and **NOUNB** products average **DDPMI** is higher in the post than in the pre-guarantee period. As we say in the main text, the fact that average price coordination in the post-guarantee period is higher both for the products included and not included in the LPG rises doubts about the LPG as the factor causing the observed increase in price coordination.

Table 7.6a: Mann-Whitney Test for differences on average DDPMI.UNB-NOUNB

Post-guarantee		Value of the test (U)	Critical Value 5%	One/Two Sided
	TE-SA	105.5	131	One
	TE-KW	141	130.94	One

Rejection of the H_0 if U≤ $CV5\%$

With respect to the situation in the post-guarantee period (Table 7.6a), on average **DDPMI** between TE and SA is higher for UNB than for NOUNB products. However, for the retailer pair TE-KW the situation does not change from the pre to the post-guarantee periods: there is no difference in the degree of price coordination of UNB and NOUNB.

Table7.7a: Regression Analysis by store

Dependent Variable: $\mathbf{RELPRI}_t^{TE}$		
$R^2 = 62.10$	$\bar{R}^2 = 57.15$	
	Coefficient	Std. Error[1]
α_1	0.5364**	0.0058
α_2	0.0466**	0.0086
β_1	0.0008	0.0008
β_2	-0.0017*	0.0009
α_{post}	0.5830**	0.0060
β_{post}	-0.0010**	0.0003
Norm.	0.7105 (0.701)	
Dependent Variable: $\mathbf{RELPRI}_t^{SA}$		
$R^2 = 72.99$	$\bar{R}^2 = 69.47$	
	Coefficient	Std. Error[1]
α_1	0.5149**	0.0067
α_2	0.0739**	0.0089
β_1	0.0027**	0.0005
β_2	-0.0047**	0.0006
α_{post}	0.5888**	0.0059
β_{post}	-0.0020**	0.0003
Norm.	1.5773 (0.454)	
Dependent Variable: $\mathbf{RELPRI}_t^{KW}$		
$R^2 = 66.86$	$\bar{R}^2 = 62.54$	
	Coefficient	Std. Error[1]
α_1	0.6025**	0.0109
α_2	-0.0780**	0.0117
β_1	-0.0033**	0.0014
β_2	0.0072**	0.0014
α_{post}	0.5245**	0.0044
β_{post}	0.0039**	0.0002
Norm.	0.1799 (0.914)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$
[1]Newey-West Standard Errors;** significant at 5% level; * significant at 10% level.

With respect to the analysis of **RELPRI** trends for each one of the food retailers, observation of Table 7.7a reveals that all the results obtained with the full sample are confirmed when using the reduced sample. On the one hand the effect of Tesco's LPG is to invert the trend of **RELPRI** (from increasing to decreasing) at each one of the two high service quality retailers (supermarkets) considered in the analysis. On the other hand as for the full sample, $\mathbf{RELPRI}_t^{KW}$ shows an increasing trend in the post-guarantee period. This increasing trend starts as soon as Fortnight 9-10 of the sample (Figure 7.4a).

Table 7.8a: $PUNB_t$ and $PNOUNB_t$ Regression Analysis by store

Dep. Var: $\mathbf{PUNB}_t^{TE}$			Dep. Var: $PNOUNB_t^{TE}$		
	R^2=25.32	$\bar{R}^2$=15.58		R^2=83.16	$\bar{R}^2$=80.97
	Coeff.	Std. Error		Coeff.	Std. Error
α_1	773.8801**	6.9511	α_1	1442.1**	8.2317
α_2	2.9779	9.1278	α_2	-110.2637**	28.7886
β_1	-1.1111	0.9493	β_1	-3.7548**	0.9053
β_2	0.3278	1.0097	β_2	4.8159**	1.5571
α_{post}	776.8579**	5.1050	α_{post}	1131.8**	27.5867
β_{post}	-0.7832**	0.2178	β_{post}	1.0621	1.2669
Norm.	3.0419 (0.219)		*Norm*	0.2471 (0.884)	
Dep. Var: $\mathbf{PUNB}_t^{SA}$			Dep. Var: $\mathbf{PNOUNB}_t^{SA}$		
	R^2=83.02	$\bar{R}^2$=80.81		R^2=84.26	$\bar{R}^2$=82.21
	Coeff.	Std. Error		Coeff.	Std. Error
α_1	779.6818**	6.6892	α_1	1514.0**	12.7747
α_2	105.813**3	10.7207	α_2	-3.7358	22.0380
β_1	2.0822**	0.6062	β_1	-3.3607**	1.2486
β_2	-7.1893**	0.7505	β_2	-0.5036	1.5808
α_{post}	885.4951**	7.8052	α_{post}	1510.3**	16.4999
β_{post}	-5.1071**	0.3503	β_{post}	-4.1643**	0.7380
Norm.	0.6868 (0.709)		*Norm.*	1.9621 (0.375)	
Dep. Var: $\mathbf{PUNB}_t^{KW}$			Dep. Var: $PNOUNB_t^{KW}$		
	R^2=67.43	$\bar{R}^2$=63.19		R^2=71.57	$\bar{R}^2$=67.86
	Coeff.	Std. Error		Coeff.	Std. Error
α_1	759.4740**	7.7628	α_1	1260.8**	11.2543
α_2	-37.8345**	16.2673	α_2	106.0333**	27.8508
β_1	0.5599	1.0623	β_1	8.3902**	1.5046
β_2	2.8613**	1.2778	β_2	-11.2022**	1.8678
α_{post}	721.6395**	13.6821	α_{post}	1366.8**	25.4756
β_{post}	3.4212**	0.06069	β_{post}	-2.8120**	1.1068
Norm.	0.2310 (0.891)		*Norm.*	0.22612 (0.893)	

$\alpha_{post} = \alpha_1 + \alpha_2$; $\beta_{post} = \beta_1 + \beta_2$

[1]Newey-West Standard Errors;** significant at 5% level; * significant at 10% level.

We show the results of the regression analysis of **PUNB** and **PNOUNB** for each one of the food-retailers using the reduced sample in Table 7.8a. We start analysing the trends followed by the prices of the baskets of **UNB** and **NOUNB** products at the food-retailer offering the LPG. The analysis of these trends using the reduced sample confirms that the trend followed by the price of the basket of **UNB** products at Tesco is not modified by the LPG (the trend dummy of $\mathbf{PUNB}_t^{TE}$ is not significant). With respect to the trend dummy in the regression analysis of $\mathbf{PNOUNB}_t^{TE}$ it is positive and significant. The LPG changes the slope of $\mathbf{PNOUNB}_t^{TE}$ from negative and significant in the pre-policy period to negative but not significant in the post policy period.

As regards the results in the regression analysis of $\mathbf{PUNB}_t^{SA}$ and $\mathbf{PNOUNB}_t^{SA}$, the results obtained using the reduced sample confirm the results obtained when using the full sample. First, $\mathbf{PUNB}_t^{SA}$ changes trend: from increasing in the pre-guarantee period to decreasing in the post guarantee period. Second, the coefficient of the trend dummy in the regression analysis of $\mathbf{PNOUNB}_t^{SA}$ is not significant confirming that Tesco's LPG did not affect significantly Sainsbury's price setting for the products not included in the LPG.

As it is possible observe in Table 7.8a, the results obtained in the regression analysis of $\mathbf{PUNB}_t^{KW}$ and $\mathbf{PNOUNB}_t^{KW}$ just confirm the results obtained when using the full sample. The trend coefficient of $\mathbf{PUNB}_t^{KW}$ is positive in both pre and post-guarantee periods. The trend coefficient of $\mathbf{PNOUNB}_t^{KW}$ is positive in the pre-guarantee period and negative in the post-guarantee period, but again this change in trend seems to happen in Fortnight 13, well before the start of the LPG (Figure 7.11a)

Figures reduced sample analysis

Figure 7.4a: RELPRI (KW) Actual and Fitted Values

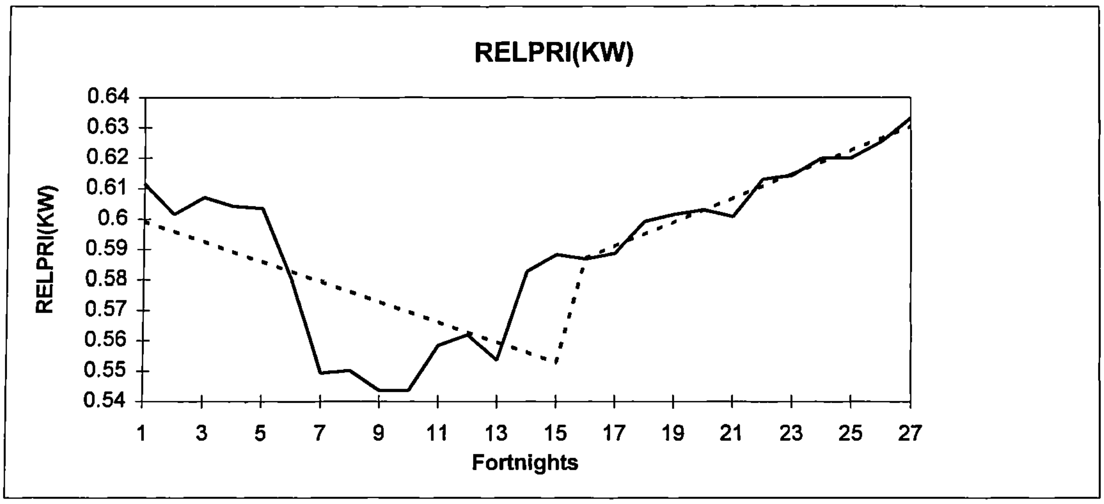
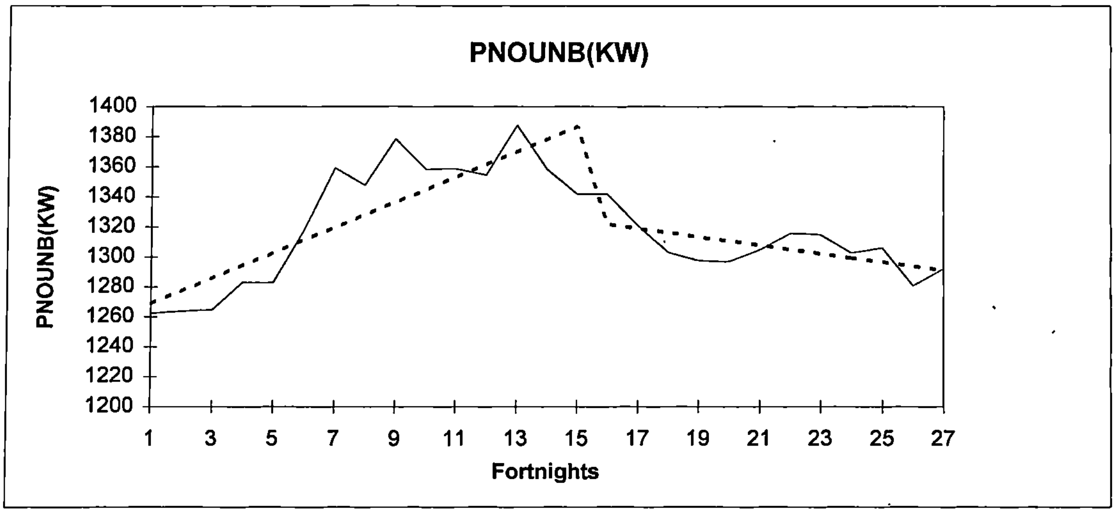


Figure 7.11a: PNOUNB(KW) Actual and Fitted Values



F	Products Included in the Sample	
LPG	PRODUCT	
NO UNBEATABLES	Canned Sweet Corn (Green Giant 340grs)	CS1
	Bleach (Domestos Bleach 2l)	BLE
	Conditioner (Lenor Ultra Plus Fabric Conditioner 2l)	CON
	Kitchen Foil (Bacofoil 450mm x5m)	KITC
	Washing Powder (Ariel Future 2kgs)	WP
	Washing Up Liquid (Fairy Excel Plus 500ml)	WU
	Beer (Heineken 330 ml)	BEER
	Bread (Mighty White. 800 grs)	BRE
	Cat Food (Whiskas 400grs)	CAT
	Coffee (Nescafe Gold 200grs)	COF
	Dog Food (Chum Original Large 400gr)	DO
	Frozen Peas (Birds Eye 340 grs)	FRO
	Ice Cream (Walls Vanilla 750grs)	ICE
	Oven Chips (McCain 1810 grs)	OVE
	Pasta Sauce (Dolmio Pasta sauce Original 475 grs)	PAS
	Salad Dressing (Heinz Salad Dressing 285 grs)	SAL
	Tea (PG Tips 250 grs)	TEA
	Tuna in Oil (John West 200grs)	TU
	Yogourth (Muller Strawberry 200 grs)	YO
	Orange Juice (Del Monte 1 L)	ORA
	Deodorant (Sure 24 hours Apa 150 ml)	DE
	Hair Shampoo (Timotei Herbs Shampoo 400grs)	SHA
	Shower Gel (Imperial Leather 500ml)	GEL
	Toothpaste (Colgate Total 100ml)	TO
UNBEATABLE	Baked Beans in Tomato Sauce (Heinz 425 grs)	BB
	Canned Peas (Hartley's Garden Peas)	CP
	Canned Spaghetti (Heinz 200 grs)	CS
	Canned Tomatoes (Napolina Chopped Tomatoes 400grs)	CT
	Kitchen Towel (Sterling Luxury Kitchen Towel Twin Pa)	KIT
	Tissues (Ultra 90. Kleenex)	TIS
	Toilet Roll (Twin Andrex 4)	TOI
	Cornflakes (Kellogs Cornflakes 500grs)	CORN
	Fish Fingers (10 Birds Eye)	FIS
	Flour (Homepride Flour 1,5kgs)	FLO
	Ketchup (Heinz 340grs)	KET
	Margarine (Flora 500 grs)	MAR
	Mayonneise (Hellmans, 400 grs)	MAY
	Peach Halves in Natural Juice (Del Monte 415 grs)	PEA
	Rice (Uncle Ben Long Grain Rice 1 kg)	RIC
	Smoked Back (Danepack 8s)	SMO
	Spaghetti (Buitoni 500grs)	SPA
	Strawberry Jam (Robertson 454 grs)	STRA
	Walkers Crisps (Variety Multipack. 6 packs)	WAL
	Coca-Cola (2 l)	COC
	Sanitary towels (Always 16)	SAN
	Soap (Dove 250 grs)	SOAP

Chapter 8

Concluding Remarks

Food-retailing competition is a hot regulatory topic in the UK The aim of this PhD dissertation has been to analyse the patterns of food retailing price setting and its implications over competition.

Our work sheds light about the importance of considering the UK supermarkets not only as a multiproduct firm but also as a multiquality firm. Ignoring that supermarkets offer three quality variants for most of their products can be the cause of misleading results when analysing competition.

Possibilities of product differentiation are not homogeneous across quality variants. These differences in product differentiation possibilities arise as a key factor to determine supermarket patterns of price setting. Supermarket price competition seems to be inversely related to product differentiation possibilities. It is in this context that the successful development of a wide line of high quality own brand products provides a determinant element to explain the high profitability of the UK supermarkets. Whereas branded products and low-quality own brand products are almost homogeneous across supermarkets, high quality own brand products offer a big scope for product differentiation.

Supermarkets can use these greater possibilities of product differentiation for the high-quality own brand products to create loyalty. If customer perceive the high-quality own brand products of each one of the supermarkets as different products, they will not be indifferent between buying a given high quality own brand product in any supermarket. They will systematically buy in the supermarket selling the own brand product they prefer. Once in the supermarket, the consumers will buy a whole assortment of goods (one stop shopping is predominant in modern societies) very likely consisting of branded products, high and low-quality own brand products. Therefore, differentiation of the high-quality own brand product can relax between supermarket competition not only for the own variant but also for the other variants the supermarket sells.

UK supermarkets ability to develop a successful line of high-quality own brand products has clear implication on the current debate about the high profitability of the UK supermarkets in comparison with their continental counterparts. It seems quite evident that the UK supermarkets enjoy significant buyer power (specially in their bargaining with the own brand product producers). But it also should be considered that the characteristics of the UK own brand product phenomenon have no parallel in the Continent where most of the supermarket chains have followed a low quality approach for their own brand product programmes. Therefore, not only the exercise of buyer power but also the ability of developing a highly successful own brand product programme should be factors taken into account when analysing the high profits of the UK supermarkets.

The multiproduct nature of the UK supermarkets should be carefully considered when analysing the possible effects of low-price guarantees over competition. When low-price guarantees are offered by multiproduct firms, as UK supermarkets, they are not necessarily an instrument addressed to ease tacit collusion. Multiproduct firms can use these guarantees as low-price signalling devices forming part of advertising strategies. The results obtained when analysing Tesco's Unbeatable Value low-price guarantee suggested a possible association between this low-price guarantee and a loss-leaders strategy. This is just a clear example of how the multiproduct character of supermarket chains increases dramatically the complexity of the analysis of price competition for regulatory authorities.

The definition of the relevant market is of crucial importance when analysing competition. In UK food retailing the determination of the relevant market implies to analyse if supermarkets compete with discounters. The main element that distinguishes supermarkets and discounters is the different level of service quality provided. This differential in service quality arises in our analysis as an element segmenting the market. The high service quality provided by supermarkets isolates them from the competition of the low service quality discounters. Very likely, UK competition authorities when analysing competition in food retailing should carefully consider the ability of service quality differentials to segment the market before considering supermarkets and discounters as forming part of a unique relevant market.

Finally, let me mention one shortcoming of this PhD dissertation and point to future lines of analysis. This research has been carried out with a reduced database of prices for a particular local area. Future research of competition in food retailing should be performed using databases providing data both about prices and quantities. Likely the use of scanner data would provide us with a much clear understanding of competition in food retailing. The use of scanner data including information about prices and quantities would make possible to carry out studies using as basis the discrete choice models of product differentiation already used in the car or the computer markets. However, scanner data is expensive and difficult to get. Supermarkets aware of its value sell them to a few consultancies imposing restrictive conditions of use and resale.

With respect to the analysis of low-price guarantees I am already involved in a project aimed to check the predictions of the different theoretical models making use of experiments. Although not analysed in this paper, there is a large stream of literature that considers the possibility of using low-price guarantees as a price discrimination device. Low price guarantees could allow firms to discriminate between informed and uninformed consumers. The main aim of this project is to test by means of experiments the ability of low price guarantees to price discriminate between informed and uninformed consumers and its impact over retailer prices and profits.

Bibliography

[1] ANDERSON, S.P., DE PALMA, A. AND J.F. THISSE, 1992, *Discrete Choice Theory of Product Differentiation,* MIT Press, Cambridge, MA.

[2] BALTAGI, B.H., 1995, *Econometric Analysis of Panel Data,* John Wiley and Sons Ltd.

[3] BAYE, M. AND D. KOVENOCK, 1994, "How to Sell a Pickup Truck: 'Beat-or Pay' Advertisement as Facilitating Devices", *International Journal of Industrial Organization,* 12, pp. 21-33.

[4] BEATH, J. AND Y. KATSOULACOS, 1991, *The Economic Theory of Product Differentiation,* Cambridge University Press.

[5] BELTON, M., 1987, "A Model of Doupoly and Meeting or Beating the Competition", *International Journal of Industrial Organization,* 5, pp.399-417.

[6] BERRY, S.T., 1994,"Estimating Discrete-Choice Models of Product Differentiation", *RAND Journal of Economics,* 25, pp. 242-262.

[7] BERRY, S.T., GRILLI,V. AND F. LOPEZ DE SILANES, 1992, "The Automobile Industry and the Mexico-US Free Trade Agreement", *NBER Working Paper* 4152.

[8] BERRY, S.T., LEVINSOHN, J. AND A. PAKES, 1995a, "Automobile Prices in Market Equilibrium", *Econometrica,* 63, pp. 841-890.

[9] BERRY, S.T., LEVINSOHN, J. AND A. PAKES, 1995b, "Voluntary Export Restraints on Automobiles: Evaluating a Strategic Trade Policy", *NBER Working Paper* 5435.

[10] BERRY, S.T., SPILLER, P. AND M. CARNALL, 1996, "Airline Hubs: Costs, Markups and the Implications of Consumers Hetereogeneity", *NBER Working Paper* 5561.

[11] BLISS, C. , 1988, "A Theory of Retail Pricing", *Journal of Industrial Economics,* 36, pp. 375-391.

[12] BORENSTEIN, S. AND N.L. ROSE, 1994, "Competition and Price Dispersion in the US Airline Industry", *Journal of Political Economy,* 104, pp. 653-683.

[13] BRANDER, J. A. AND J. EATON, 1984, "Product Line Rivalry", *American Economic Review,* 74, pp. 323-334.

[14] BRESNAHAN, T.F., 1987, "Competition and Collusion in the American Automobile Industry", *Journal of Industrial Economics*, 35, pp. 457-482.

[15] CAPLIN, A. AND B. NALEBUFF, 1991, "Aggregation and Imperfect Competition: on the Existence of Equilibrium", *Econometrica*, 59, pp. 25-29.

[16] CANOY, M. AND M. PEITZ, 1997, "The Differentiation Triangle", *Journal of Industrial Economics*, 45, pp. 305-324.

[17] CHAMPSAUR, P. AND J.C. ROCHET, 1989, "Multiproduct Duopolists", *Econometrica*, 57, pp. 533-557.

[18] CHEN, Z., 1995, "How Low is a Guaranteed-Lowest-Price", *Canadian Journal of Economics* 28, pp. 683-701.

[19] CORTSJENS, J. and M. CORSTJENS, 1995, *Store Wars. The Battle for Selfspace and Mindspace.* John Wiley and Sons Ltd.

[20] CORSTJENS, J., CORSTJENS, M. and R. LAL, 1995, "Retail Competition in the Fast-Moving Consumer Good Industry: The case of France and the UK", *European Management Journal*, 13, pp. 336-373.

[21] CORTS, K. S., 1995, "On the Robustness of the Argument that Price Matching is Anti-competitive", *Economic Letters*, 47, pp. 417-421.

[22] CORTS, K.S., 1996, "On the Competitive Effects of Price Matching Policies", *International Journal of Industrial Organization*, 15, pp. 283-299.

[23] COTTERILL, R.W., 1997 : "The Food Distribution System of the Future: Convergence Towards the US or the UK system", *Agribusiness*, 13, pp.123-135.

[24] DEGRYSE, H., 1996, "On the Interaction between Vertical and Horizontal Product Differentiation: an Application to Banking", *Journal of Industrial Economics*, 44, pp. 169-186.

[25] DIXIT A. AND B. NALEBUFF ,1991, *Thinking Strategically*, W.W. Norten & Company, Inc., New York, N.Y.

[26] DOBSON, P. AND M. WATERSON, 1996, "Product Range and Interfirm Competition, *Journal of Economics and Mangament Strategies*, 35, pp. 317-341.

[27] DOBSON, P. 1997, "The Economic Welfare Implications of Own Label Goods", Mimeo.

[28] DOYLE, C. , 1988, "Different Selling Strategies in Bertrand Oligopoly", *Economic Letters*, 28, pp. 387-390.

[29] EATON, B.C. AND R.G. LIPSEY, 1979, "The Theory of Market Pre-emption: the Persistence of Excess capacity and Monopoly in Growing Spacial Markets", *Economica*, 46, pp.149-158.

[30] EATON, B.C. AND R.G. LIPSEY, 1989, "Product Differentiation", in R. Schmalensee and R.D. Willig (eds.), *Handbook of Industrial Organization,* Vol. 1, North Holland, Amsterdam, pp. 723-763.

[31] THE ECONOMIST, 1995, *The Retailing Survey,* 4th March.

[32] EDLIN A.,1997, "Do Guaranteed-Low Price Policies Guarantee High Prices, and Can Antitrust Rise to the Challenge?, *Harvard Law Review,* 111, pp. 528-575.

[33] FEENSTRA R. C. AND J. A. LEVINSOHN, 1995, "Estimating Markups and Market Conduct with Multidimensional Produc Attributes", *Review of Economic Studies,* pp. 19-52.

[34] GABSZEWICZ, J.J, A. SHAKED, J. SUTTON and J.F. THISSE, 1986, "Segmenting the Market: The Monopolist's Optimal Product Mix", *Journal of Economic Theory,* 39, pp. 273-289.

[35] GARCIA A., GEORGANTZIS N. AND M.V. PETIT, 1998, "Competition Intensity vs. Service Quality: On the Distribution of Para-pharmaceutical products in Spain" in S. Martin (ed), *Competition Policies in Europe.* Elsevier Science B.V.

[36] GILBERT, R.J. AND C. MATUTES, 1993, "Product Line Rivalry with Brand Differentiation", *Journal of Industrial Economics,* 41, pp. 223-240.

[37] GIULETTI, M. , 1996, "Price-Cost Margins in the Italian Grocery Trade: an Empirical Analysis", University of Exeter. Discussion Paper in Economics 96/13.

[38] GIULETTI, M. AND M. WATERSON, 1997, "Multiproduct firms' Pricing Behaviour in the Italian Grocery Trade", *Review of Industrial Organization,* 12, pp. 817-832.

[39] GOLDBERG, P.K., 1995, "Product Differentiation and Oligopoly in International Markets: The Case of the US Automobile Industry", *Econometrica,* 63, pp. 891-951.

[40] GREENE, W. H., 1996, *Econometric Analysis. Third Edition,* MacMillan Publishing Company.

[41] HESS, J. AND E. GERSTNER, 1987, "Loss Leader Pricing and Rain Check Policy", *Marketing Science,* pp. 358-374.

[42] HESS, J. AND E. GERSTNER, 1991 "Price Matching Policies: an Empirical Case", *Managerial and Decision Economics,* 12, pp. 305-315.

[43] HOCH, S. J., 1996, "How Should National Brands to Think about Private Labels", *Sloan Managament Review,* pp. 89-101.

[44] HOLMES, T.J., 1989, "The Effects of Third Degree Price Discrimination in Oligopoly", *American Economic Review,* 79, pp. 244-250.

[45] HSIAO, C., 1986, *Analysis of Panel Data,* Cambridge University Press

[46] HVIID, M. AND G. SHAFFER , 1994, "Do Low Price Guarantees Facilitate Tacit Collusion", University of Michigan working paper, 94-02.

[47] HVIID, M. AND G. SHAFFER, 1998, "Hassle Costs and Price Beating Guarantees", Mimeo, University of Warwick.

[48] HVIID, M. AND G. SHAFFER, 1999, "Hassle Costs: the Achilles' Heel of Price Matching Guarantees", *Journal of Economics and Management Strategies*, forthcoming.

[49] IRELAND, N.J., 1987, "*Product Differentiation & Non-Price Competition*", Basil Blackwell Ltd.

[50] JUDD, K., 1985, "Credible Spatial Pre-emption", *RAND Journal of Economics,* 16, pp.153-166.

[51] KATZ, M., 1984, "Firm Specific Differentiation and Competition among Multiproduct Firms", *Journal of Business*, 56, S149-166.

[52] KEYNOTE, 1997: "Own Brands", Keynote Publications.

[53] KLEMPERER, P., 1992, "Equilibrium Product Lines: Competing Head-to-Head may be less competitive", *American Economic Review,* 82, pp. 741-755.

[54] LAL, R. AND C. MATUTES, 1989, "Price Competition in Multiproduct Duopolies", *RAND Journal of Economics*, 20, pp: 516-537.

[55] LAL, R. AND C. MATUTES, 1994, "Retail Pricing and Advertising Strategies", *Journal of Business,* 67, pp. 345-370.

[56] LOGAN, J. AND R. LUTTER, 1989, "Guaranteed Lowest Prices: Do they facilitate collusion?", *Economics Letters*, 31, pp. 189-192.

[57] MILLS, D.E. , 1995, "Why Retailers sell Private Labels", *Journal of Economics and Management Studies,* 4, pp. 509-528.

[58] MUSSA, M. AND ROSEN, S., 1978, "Monopoly and Product Quality", *Journal of Economic Theory,* 18, pp. 301-317.

[59] MOORTHY, K.S., 1988, "Product and Price Competition in a Duopoly", *Marketing Science*, 7, pp. 141-168.

[60] NEAVE H. R. AND P.L. WORTHINGTON, 1988, *Distribution-Free Tests.* Unwin-Hyman Ltd.

[61] NEVEN, D. AND J.F. THISSE, 1990, "On Quality and Variety Competition", In J.J. Gabszewicz, J. F. Richard and L. Wolsey (eds.), *Economics Decision Making: Games, Econometrics and Optimization. Contributions in Honour of Jacques Dreze,* North-Holland, Amsterdam, pp. 175-199.

[62] OFFICE OF FAIR TRADING, 1997, "Competition in Retailing", Research Paper 13, prepared by London Economics.

[63] OFFICE OF FAIR TRADING, 1998, "The Welfare Consequences of the Exercise of Buyer Power", Research Paper 16, prepared by P. Dobson, M. Waterson and A. Chu.

[64] PESARAN M.H AND B. PESARAN, 1997, *Working with Microfit 4.0*, Oxford University Press.

[65] PNG, I.P.L. AND D. HIRSCHLEIFER, 1987, "Price Discrimination Through Offers to Match Price", *Journal of Business,* 60, pp. 365-383

[66] RAO R.C., 1991, "Pricing and Promotions in Asymetric Duopolies", *Marketing Science*, 10, pp.131-144.

[67] SALOP, S. , 1986, "Practices that (Credibly) Facilitate Oligopoly Coordination", in J.Stiglitz and F. Mathewson (eds), *New Developments in the Analysis of Market Structure,* MIT Press, Cambridge, MA

[68] SARGENT, M. , 1993, "Economics Upside-Down: Low Price Guarantees as Mechanism for Facilitating Tacit Collusion", *University of Pennsilvania Law Review,* 141, pp. 2055-2118.

[69] SCHMALENSEE, R., 1978, "Entry Deterrence in the RTE Cereal Industry", *Bell Journal of Economics,* 9, pp. 305-327.

[70] SHAKED, A. AND J. SUTTON, 1982, "Relaxing Price Competition through Product Differentiation", *Review of Economic Studies,* 49, pp. 3-14.

[71] SHAKED, A. AND J. SUTTON, 1983, "Natural Oligopolies", *Econometrica,* 51, pp. 1469-1483.

[72] SHAKED, A. AND J. SUTTON, 1987, "Product Differentiation and Industrial Structure", *Journal of Industrial Economics,* 36, pp. 131-146.

[73] SHAKED, A. AND J. SUTTON, 1990, "Multiproduct Firms and Market Structure", *RAND Journal of Economics,* 21, pp. 45-62.

[74] SHEPARD, A., 1991, " Price Discrimination and Retailing Configuration", *Journal of Political Economy*, 99, pp. 30-53.

[75] SMITH, H. AND D. HAY, 1997, "Competition in Retailing: One Stop Shopping", University of Oxford. Applied Economics Discussion Paper Series, No. 189.

[76] SUTTON, J., 1986, "Vertical product differentiation: some basic themes", *American Economic Review* (Papers and proceedings), 76, pp. 393-398.

[77] TIROLE, J., 1988, *The Theory of Industrial Organization,* MIT Press, Cambridge, MA.

[78] VANDENBOSCH, M AND C. WEINBERG, 1995, "Product and Price Competition in Two-Dimensional Vertical Product Differentiation Model", *Marketing Science,* 14, pp. 224-249.

[79] VERBOVEN, F., 1996, "International Price Discrimination in the European Car Market", *Rand Journal of Economics,* 27, pp. 240-268.

[80] WALSH, P. AND C. WHELAN, 1999, "Modelling Price Dispersion as an Outcome of Competition in the Irish Grocery Market", *Journal of Industrial Economics,* 47, pp. 325-343.

[81] WATERSON, M., 1989, "Models of Product Differentiation", *Bulletin of Economic Research,* 41, pp. 1-24.

[82] ANDERSON, S.P., DE PALMA, A. AND J.F. THISSE, 1992, *Discrete Choice Theory of Product Differentiation,* MIT Press, Cambridge, MA.

[83] WRIGLEY, N., 1997, "Exporting the British Model of Food Retailing to the US: Implications for the EU-US Food Systems Convergence Debate", *Agribusiness,* 13, pp. 137-152.

[84] ZHANG, J., 1995, "Price-matching Policy and the Principle of Minimum Differentiation", *Journal of Industrial Economics,* 43, pp. 287-299.

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