Winners and Losers in a Major Price War

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ABSTRACT

Winners and Losers in a Major Price War

While retail price wars have received much business press and some research attention, it is unclear how they affect consumer purchase behavior. This paper studies an unprecedented price war in Dutch grocery retailing that started in the Fall of 2003, initiated by the market leader to halt its sliding market share. The authors investigate the short-term and long-term effects of the price war on store visits, spending and on the sensitivity of these decisions to weekly prices and price image. They use a unique data set with consumer hand scan and perceptual data for a national panel of 1821 households, covering approximately two years before and two years after the start of the price war. While the price war initially entails more shopping around and increased spending, spending per visit ultimately drops as consumers redistribute their purchases across stores. The price war makes consumers more sensitive to weekly prices and price image, which helps both the chain that shows an improvement in price image (the price war initiator) and the chains that already have a favorable price image (hard discounters). The price war initiator manages to halt the slide in its market share while its stock price improves. The losers are the rival mid- and high-end chains: unlike the initiator, their price image is hardly improved, and they suffer from the increased price image sensitivity. The authors provide managerial implications for firms that are (about to be) involved in a price war.

Keywords: price war, Tobit II model, grocery retailing, store visits, spending, price image, Bayesian estimation.

INTRODUCTION

"A price battle between large retailers is not uncommon. But the price war that rages now is entirely different. The price cuts encompass a much larger assortment, and the percentage price reductions are spectacular. More is going on here" (Newspaper NRC Handelsblad, November 17, 2003, p.1, on the unfolding price war in Dutch grocery retailing).

In the early 2000s, the leading Dutch supermarket chain Albert Heijn suffered from an unfavorable and deteriorating price image, which was especially troublesome in the light of the rise of hard discounters (Aldi and Lidl) and worsening economic conditions. Despite their continued belief in the retailer's quality and service, fewer and fewer shoppers could justify paying such higher prices. After several years of a sliding market share, Albert Heijn decided to slash its prices for more than 1000 products on October 20th, 2003. Using the headline "From now on, your daily groceries are much less expensive," its double-page color advertisements in all national and local newspapers made clear the chain was committed to decrease its prices systematically and permanently.[1]

The price reduction applied to many national brands from a wide variety of categories. For example, Figure 1 shows how the regular price for a 1.5 liter bottle of Coca Cola went down from €1.23 to €1.12 (–9%). While Albert Heijn's operation to decrease prices had been undertaken in complete secrecy, within 2 days all major competitors carrying this SKU (C1000, Edah, and Super de Boer), matched or even exceeded the price reductions, as Figure 1 illustrates.

[Insert Figure 1 and Table 1 about here]

A week later, Albert Heijn decreased prices for another 550 products. The price war that followed is unprecedented in Dutch retailing. As Table 1 shows, many more price cutting rounds occurred over the next years, up till October 31, 2005. These subsequent rounds involved different brands (national versus private label) and categories, resulting in negative retail margins for hundreds of products (Van Aalst et al. 2005, Holla and Koreman 2006). As for scope and depth, this national price war dwarfs both documented incidents in the grocery industry mentioned by Heil and Helsen (2001): the price cuts on private labels among UK retailers Tesco and Asda, and the 2% price drop in the Houston retailing market. In our case, the price war was

[1] Additional factors may have contributed to Albert Heijn's decision to initiate a major policy change. First, its holding company Ahold was involved in a major accounting scandal in 2002, which seriously affected its reputation as a reliable firm. Furthermore, in the weeks preceding the price war, the media and the general public had been stirred up by a payment bonus for Albert Heijn's CEO, which many considered excessive in a time of economic decline. Several customers even decided to participate in a boycott of Albert Heijn to express their disagreement.

nationwide, entailing an 8.2% reduction in food prices (Baltesen 2006), and resulting in the lowest inflation level in 15 years (Consumer report 2004). The loss in added value for the Dutch retailing industry is estimated to be €900M in one year, and over 30,000 employees in the grocery industry lost their jobs (Van Aalst et al. 2005).

This Dutch supermarket price war fits in with the trend that retail price competition has become increasingly vivid in recent years, reducing retailer profitability (Ailawadi 2001). Discounters such as Wal-Mart, Aldi and Lidl are challenging traditional retail formats on both sides of the Atlantic (Business Week October 6, 2003). In almost all Western markets, grocery discounters have captured market share from traditional supermarkets, and now occupy a prominent position (Cleeren et al. 2007). In the United States, Wal-Mart controls a large part of the retail market and is driving down prices at other retailers (Singh, Hansen, and Blattberg 2006). In the Netherlands, over 52% of households frequently shopped at hard discounters Aldi or Lidl in the Fall of 2003, up from 30% in 2001 (GfK 2003). The reaction of traditional retailers has varied from focusing on quality and service to engaging the challengers with substantial price reductions (Rogers 2001). However, these price reductions may trigger price wars, as in the case of Dutch supermarkets, which can last for a long time and strongly affect all market players (Rao, Bergen, and Davis 2000).

The literature is inconclusive about the consequences of price wars. While price wars are generally believed to hurt revenues and long-term prospects for the market players (Brandenburger and Nalebuff 1996), other studies suggest the impact depends on each player's price position and role in the price war (Busse 2002, Elzinga and Mills 1999, Rao et al. 2000). Although the antecedents of price wars have been well documented (see the next section), empirical research on their consequences is sparse. Indeed, a recent review concludes: “It is unclear what the overall effects of price wars are. Price wars are often assumed to lead to losses for the firms involved in the battle … It is, therefore, important to research how price wars affect firms in the industry, whether these effects are uniformly distributed, and how such effects persist in the long run through lower reference prices” (Heil and Helsen 2001, p.96).

To fill this gap in the literature, we study the consequences of the Dutch supermarket price war on consumer purchase behavior. We analyze how the price war affects two major components of purchase behavior (Singh, Hansen, and Blattberg 2006): store visits and spending (money spent per store per week). In particular, we investigate whether the price war leads to

more shopping around in the short term, and to decreased spending in the long term. Further, we test the hypothesis that the price war makes store visit- and spending decisions more sensitive to weekly prices and price image. To examine these issues, we use a unique data set that combines consumer hand scan and perceptual data for a national panel of 1821 households, covering a period of 90 weeks before and 114 weeks after the start of the price war. For the six largest national chains, we estimate a multivariate heterogeneous Tobit II model that includes the short-term and long-term effects of the price war on store visits, spending, and the sensitivity of these decisions to weekly prices and price image. To complement our analyses, we not only estimate competitive reaction functions, but also assess the effects of the price war on stock prices.

While the price war initially entails more shopping around and increased spending, spending per visit ultimately drops as consumers redistribute their purchases across stores. The price war makes consumers more sensitive to weekly prices and price image, which helps both the player that shows an improvement in price image (the price war initiator) and the players that already have a favorable price image (hard discounters). The price war initiator manages to halt the slide in its market share while its stock price improves. The losers are the rival mid- and high-end chains: unlike the initiator, their price image is hardly improved, and they suffer from the increased price image sensitivity. We expect these results to be generalizable since the Dutch grocery retail industry is representative for many Western markets on a number of key indicators (Steenkamp et al. 2005, p. 40). Moreover, a recent meta analysis conclude price elasticities do not differ significantly among developed countries (Bijmolt, Van Heerde, and Pieters 2005). Hence, the consequences of the Dutch price war may hold lessons for retailers in other countries facing a similar situation.

The remainder of this paper is organized as follows. The next section discusses the price war literature, focusing on the gaps this paper aims to address. Next, we discuss the model used to quantify price war effects on store visits and spending. The subsequent section describes the empirical setting, and details our data sets. The estimation outcomes are presented next, and we end by providing a discussion and limitations.

RESEARCH BACKGROUND AND HYPOTHESES

Price War: Definition and importance

Price wars are characterized by competing firms struggling to undercut each other's prices (Assael 1990). Urbany and Dickson (1991) refer to a "price-cutting momentum," the downward price pressure that drives other competitors to follow the initial move. Price is the logical weapon of choice: it is easy to change fast (Kalra, Raju, and Srinivasan 1998). Unlike typical intense price competition, price wars lead to prices that are not sustainable in the long term (Schunk 1999). Based on an extensive review of business press articles and academic literature, Heil and Helsen (2001) define a price war to require *one or more* of the following conditions: (1) a strong focus on competitors instead of on consumers, (2) the pricing interaction as a whole is undesirable to firms, (3) the competitors did neither intend nor expect to ignite a price war, (4) the competitive interaction violates industry norms, (5) the pricing interaction occurs at much faster rate than normal, (6) the direction of pricing is downward, and (7) the pricing interplay is not sustainable. We verify in the empirical data section that the Dutch price war meets most (if not all) of these conditions.

Price wars have become a fact of life in a wide range of industries (Rao, Bergen, and Davis 2000). Business press and academic papers report on price wars in industries ranging from electricity (Fabra and Toro 2005), oil (Slade 1992), telecom (Young 2004), cars (Breshnahan 1987), airlines (Busse 2002), and fast food (Gayatri 2004) to groceries (Barnes 2004). Price wars erupt at various levels in the distribution channel, and with growing frequency and intensity (Heil and Helsen 2001). This leads Rao et al. (2000, p. 116) to conclude that "If you're not in a battle currently, you probably will be fairly soon".

Literature on Price Wars

Academic literature on price wars can be classified into three research streams. A first set of papers are *game-theoretic* contributions, with a strong focus on price war *antecedents*. An important price war trigger revealed by these papers is competitive entry (Milgrom and Roberts 1982, Elzinga and Mills 1999). Other factors found inductive to price wars are declining economic conditions (Slade 1990, Eilon 1993) and – often related to this – consumers' low (and/or declining) brand loyalty and high (and/or increasing) price sensitivity (Sairamesh and Kephart 2000, Klemperer 1989).

A second stream of more *managerial* papers reflects on the link between price wars and *firm strategies and characteristics*. Companies with high exit barriers (Heil and Helsen 2001), and high stakes in the market or a worsened financial situation (Busse 2002) are more inclined to initiate a price war or enter an ongoing battle. In doing so, these firms hope to bring about a market clear-out and profit from reduced competition in the long term (Fudenberg and Tirole 1986, Klemperer 1989), or at least to halt the loss of customers and maybe even re-attract clientele (Elzinga and Mills 1999, Klemperer 1989). A widely advertised price cut may also establish a more favorable price image (Rao et al. 2000, Busse 2002).

A final stream consists of *empirical* papers documenting price war *consequences*. Unfortunately, despite the importance of price wars, such empirical contributions are extremely scarce, and suffer from some limitations. While the studies by Green and Porter (1984), Breshnahan (1987), Rotemberg and Saloner (1986) and Levenstein (1997) do provide a flavor for the nature and impact of price wars, the data set limitations of these studies do not allow to go beyond a rough empirical assessment. Heil and Helsen (2001) provide some preliminary evidence on overall price war effects for 15 case-studies in a diversity of industries - which include dwindling prices, declining image and revenues, and profit erosion for the parties involved. They also provide initial indications of increased shelf price elasticities for incumbent brands of a personal care product, following a price war. The authors conclude that, while their "…descriptive statistics illustrate the importance and scope of price war phenomena […], more rigorous empirical research is needed" (Heil and Helsen, 2001, p. 86). In this paper, we contribute to filling this gap by testing hypotheses on price war consequences with an empirical model, estimated on a unique and rich data set.

Price war effects on store visits, spending and price sensitivity: Hypotheses

Henderson (1997) suggests that, in the absence of a strong and sustainable cost advantage, price wars are "good for absolutely nothing" and may lead to dramatic losses for the market players involved. In this section, we develop a more refined picture of how price wars affect consumer spending, leading to negative impact of the price war on some market players and a positive impact for others.

Given our focus on a retail setting, we decompose this spending effect into its two major components: (i) store visits, and (ii) spending, once a consumer decides to buy in the store.

Moreover, we distinguish between the price war's (i) main effect on these performance measures and (ii) its moderating impact on consumers' sensitivity to weekly store prices and to overall store price image. Finally, we expect substantial differences in the price war's performance effects in the short term versus the long term. The latter is important from a managerial perspective, as great initial results may encourage retailers to further cut prices, even when the long-term effects of competitive escalation are disastrous (Dekimpe and Hanssens 1999, Ghemawat 1991). Figure 2 displays our conceptual framework and hypotheses.

[Insert Figure 2 about here]

Main effects of the price war on store visits and spending

Short-term effects

By definition, price wars constitute market disruptions: market players announce major strategy changes, and formulate unprecedented claims on reduced prices. For instance, the two major high-service/high price Dutch retailers stated that shopping in their chain allows for "dramatic savings" on grocery spending (Albert Heijn) and that "gigantic" benefits are to be reaped from permanent price reductions (Super de Boer). Such widely publicized claims may shake up consumers' former beliefs about the market, and lead them to reconsider their established purchase patterns, both in terms of store visits and spending.

In the short term, i.e., right after the start of the price war, consumers face increased uncertainty about which stores offer the best value for money. As a result, they are likely to adopt risk-reducing strategies (Blattberg and Neslin 1989), engaging in comparison shopping in order to update previous information (Mick and Fournier 1998). In other words, they will visit more chains, at least to check out the (new) prices in these stores. Therefore, we expect that:

H1: The price war leads to an overall *increase* in store visits in the short term.

At the same time, the price war's influence on spending is subject to three forces. First, the price war leads to lower prices, and as a result spending reduces even when quantities remain the same. In our approach we focus on the impact of the price war on spending controlling for these price-driven changes. This impact may be negative due to the second force: consistent with the argument on uncertainty, consumers may redistribute their purchases across stores, thereby reducing the probability of systematically getting the worst deal (Fox and Hoch 2005).

Conversely, the short-term impact of the price war on spending may be positive due to the third force: the sudden and heavily publicized price drop may create an unexpected "psychological income" or "windfall" effect. For instance, one field experiment found that, when given a monetary award before entering a store, shoppers spend more in the store – in excess of the monetary award (Heilman, Nakamoto, and Rao 2002). In a similar vein, the price war's sudden promise of "dramatic savings" may induce consumers to "burn a hole in their pockets," that is, to disproportionally increase their spending, as the savings enable them to afford better quality brands and to enjoy the transactional utility of getting a great deal (Chandon, Wansink, and Laurent 2000). Given these opposing forces, we investigate the price war's short-term effect on spending in an exploratory fashion.

Long-term effects

Compared to the short term, we see little reason for the price war to increase store visits in the long term. Indeed, consumers in mature markets tend to develop stable purchase patterns which are only temporarily disrupted by marketing activities (Ehrenberg 1988). While specific stores may benefit from increased visits in the long term (see below), consumers are unlikely to permanently increase the overall frequency of store visits.

In contrast, the price war is likely to *decrease* spending in the long term, even after controlling for the changes driven by price reductions. Analogous to our argument for the short-tem effect, we expect that a shopping environment characterized by an escalating price war induces consumers to redistribute their total grocery spending across the stores they visit. In contrast, the opposing force of a windfall effect is most likely only short-lived as families are unlikely to consume much more food overall – even when prices drop substantially. An analogous result holds at the category level: while weekly price promotions may expand the category substantially, they do so only temporarily (Pauwels, Hanssens, and Siddarth 2002, Van Heerde, Leeflang, and Wittink 2004. As we believe the negative force is present (splitting the grocery bill across stores) whereas the positive (windfall) effect is absent in the long term, we expect that the price war will reduce spending.

H2: The price war leads to an overall *decrease* in spending in the long term.

Moderating effects of a price war: consumer sensitivity to weekly prices and price image

One of the unique features of a price war is that pricing interactions occur at a much faster rate than previously (Heil and Helsen 2001). Intensive price interactions make price a more easily accessible attribute, which, as a result, increases its importance as a purchase criterion (Wänke, Bohner, and Jurkowitsch 1997). Lab experiments by Wathieu, Muthukrshnan, and Bronnenberg (2004) show strong evidence for this effect in a brand setting: offering and retracting discounts decreases the subsequent choice share for high-priced brands, while it increases the choice share of low-priced brands.

A price war between stores may enhance a consumer's reliance on two different types of price information. First, a consumer is confronted with *actual, objective* prices charged by stores, which may vary weekly as a result of regular price changes or promotional deals. These *weekly prices* determine how much the consumer will actually pay for a specific product basket, in a specific store and week. We define the store visit sensitivity to price as the response parameter of weekly store price in the model for store visit probability, and the spending sensitivity to price as the response parameter of weekly store price in the model for spending (for more details please refer to the model section). Consistent with a preference for lower prices, we expect that store visit sensitivity to price is negative, whereas the spending sensitivity to price is positive in case of price inelastic demand and negative in case of price elastic demand (see Figure 2).

Second, consumers also hold *subjective* summary views of the stores' overall price appeal. As shown by Mägi and Yulander (2005), these subjective price images constitute a separate price dimension that is at best moderately associated with actual objective prices and is more stable over time. *Price image* differentiates stores based on their perceived price positioning. This perceived price positioning has been found to exert an important influence on store selection (Arnold, Oum, and Tigert 1983, Severin, Louvière, and Finn 2001), over and above objective weekly store prices. We define the store visit sensitivity to price image [spending sensitivity to price image] as the response parameter of price image in the model for store visit probability [in the model for spending], and we expect both sensitivities to be positive (see Figure 2).

Consistent with this dual retail price construct, increased sensitivity to weekly prices and price image triggered by a price war may materialize in two ways (Lal and Rao 1997; Bell and Lattin 1998, Galata, Bucklin, and Hanssens 1999). First, the price war may stimulate more opportunistic buying behavior, consumers shopping around more to benefit from weekly deals on

prices (Bell and Lattin 1998; Fox and Hoch 2005). Hence consumers will be more responsive to stores' actual weekly prices (Fox and Hoch 2005, Drèze, Nisol, and Vilcassim 2004):

H3a: The price war increases the sensitivity of store visits to weekly prices (i.e., the price war makes the corresponding response parameter more negative);

H3b: The price war increases the sensitivity of spending to weekly prices (i.e., the price war makes the corresponding response parameter more negative).

Clearly, responding more strongly to weekly prices requires increased effort from consumers. They may also engage in other, more general-impression-based forms of price-oriented shopping. A consumer's enhanced focus on price then translates into systematically seeking out stores with a favorable overall price image (Bell, Ho, and Tang 1998; Galata, Bucklin, and Hanssens 1999; Rhee and Bell 2002), and allocating larger shares-of-wallet to these stores. This leads to two additional moderating price war influences:

H4a: The price war increases the sensitivity of store visits to price image (i.e., the price war makes the corresponding response parameter more positive);

H4b: The price war increases the sensitivity of spending to price image (i.e., the price war makes the corresponding response parameter more positive).

Since it is an empirical question whether H3a, H3b, H4a, and H4b imply sensitivity changes in the short- and/or long term, our tests allow for both possibilities. It is interesting to note that the hypothesized increase in price image sensitivity would entail a differential impact of the price war on different market players. This would be especially troublesome for high-end chains, while it might actually help low-end competitors in the long term (Boulding, Lee, and Staelin 1994). As such, the price war may make the price differences between stores more salient, leading stores with worse price images to suffer.

As price wars are very different from a period of intense price promotions (Heil and Helsen 2001), we test the price war hypotheses while controlling for price promotion intensive weeks (more details are provided in the section on independent variables).

To the best of our knowledge, not a single empirical paper has systematically distinguished the impact of a price war on consumers' store visits, spending, and weekly price and price image sensitivity. This is an important gap, since the net outcome for firms involved in a price war

hinges upon these (possibly countervailing) effects. Unfortunately, researchers used to lack the necessary data on consumer perceptions and behavior before and during the price war. Our data set on the recent Dutch retailing price war allows us to overcome this hurdle. Before we provide details on the data set, we outline the model in the next section.

MODEL

To study the consequences of the price war for national retail chains, we model purchase behavior of a national panel of Dutch households before and after the start of the price war. A household faces choices along two dimensions: *which* of the stores to visit (possibly more than one in a given week) and *how much* to spend at each store. We develop a model for the store visit decision and ln spending level of every household h (h=1, …, H), for every chain i (i=1, ..., S) in every week t (t= 1, …, T). Given that a household may visit multiple stores in one week, and given the left-censored nature of household spending, we specify a multivariate Tobit-II model (e.g., Fox, Montgomery, and Lodish 2004; Singh, Hansen, and Blattberg 2006). A store visit of household h for store i in week t (z_{hit}) is described by a multivariate probit model:

$$(1) \qquad z_{hit} = \begin{cases} 1 \text{ if } z_{hit}^{*} > 0 \\ 0 \text{ otherwise} \end{cases},$$

In a given week t, a household h may visit multiple stores. Hence z_{hit} equals one for those stores. The latent variable, z_{hit}^{*}, is modeled through a linear model:

$$(2) \qquad z_{hit}^{*} = \iota_{hi} + \mathbf{x}_{hit}^{'}\zeta_{h} + u_{hit}.$$

Conditional on a store visit (z_{hit}=1), we model y_{hit}, the ln of spending (in euro cents) by household h in store i in week t as:

$$(3) \qquad y_{hit} = \alpha_{hi} + \mathbf{v}_{hit}^{'}\boldsymbol{\omega}_{h} + \varepsilon_{hit}.$$

Consistent with the extant literature that uses Tobit models for store visits and spending (Fox et al. 2004; Singh, Hansen, and Blattberg 2006), we model the *logarithm* of spending (conditional on a store visit) since its distribution is closer to normal than the distribution of spending.

The independent variables in the store visit- ($\mathbf{x}_{hit}$) and spending equations ($\mathbf{v}_{hit}$) need not be the same. We specify the independent variables after we have given more details about the

data. The intercepts in equations (2) and (3) capture individual-specific store preferences. We assume that these intercepts are randomly distributed around store means:

(4) $\iota_{hi} = \psi_i + \tau_{hi}$

(5) $\alpha_{hi} = \delta_i + \xi_{hi}$.

Clearly, the stores visited and the amounts spent depend on consumers' time and budget constraints, and are interdependent between stores. Our model allows for this by embedding equations (2) and (3) in a multivariate framework. More specifically, we assume that the error vectors $\mathbf{u}_{ht} = (u_{h1t},...,u_{hSt})'$ and $\boldsymbol{\varepsilon}_{ht} = (\varepsilon_{h1t},...,\varepsilon_{hSt})'$ follow a joint multivariate normal distribution, with a full variance-covariance matrix: $(\boldsymbol{\varepsilon}'_{ht}, \mathbf{u}'_{ht})' \sim MVN(0, \boldsymbol{\Sigma})$. Intrinsic store preferences for visits and spending may also be correlated, leading to a joint multivariate normal distribution for the error terms in (4) and (5) as well: $(\boldsymbol{\xi}'_h, \boldsymbol{\tau}'_h)' \sim MVN(0, \mathbf{V})$. We also allow for unobserved heterogeneity in response coefficients. Specifically, we assume that the coefficients from the store visit- and spending equations are jointly distributed multivariate normal: $(\boldsymbol{\omega}'_h, \boldsymbol{\zeta}'_h)' \sim N\left((\overline{\boldsymbol{\omega}}', \overline{\boldsymbol{\zeta}}')', \boldsymbol{\Omega}\right)$. We estimate this multivariate heterogeneous Tobit-II model using MCMC procedures. Technical details are given in appendix A.

THE DUTCH PRICE WAR IN GROCERY RETAILING: SETTING AND DATA

Empirical setting

We have described the Dutch supermarket price war in some detail in the introduction. How does it compare to the definitional conditions of a price war in Heil and Helsen (2001)? First, as for the "strong focus on competitors instead of on consumers": rival chains Super de Boer, Edah and C1000 react within two days to Albert Heijn's initial move, which does not allow enough time to fully assess consumer responses. This fast competitive reaction may be provoked by the goal Albert Heijn stated at the beginning of the price war: "to become less expensive than the market average". To verify that competitive interactions intensified due to the price war, we estimate competitive reaction functions (Leeflang and Wittink 1996) before and after the price war start. The results reveal more (significant) reactions after the start of the price war for every retailer than before (see online appendix B for details).

Second, the "pricing interaction as a whole is undesirable to firms," as it places huge pressure on already tight margins (Van Aalst et al. 2005). Third, while we cannot peer into

managers' minds to assess whether "the competitors did neither intend nor expect to ignite a price war," there is no evidence of such intent (Baarsma and de Nooij 2005). Fourth, the claim that "the competitive interaction violates industry norms" is evident from lawsuits brought by large national brand suppliers against the price war initiator for selling far below the recommended price. In addition, smaller suppliers and grocery stores are facing bankruptcy (Van Aalst et al. 2005). As a result, the Dutch Ministry of Commerce opened an investigation to consider outlawing below-cost pricing (Baarsma and de Nooij 2005) [2]. Fifth, "the pricing interaction occurs at much faster rate than normal," i.e., days instead of weeks/months, and "the direction of pricing is downward", as Figure 1 illustrates. Finally, "the pricing interplay is not sustainable", as hundreds of items are now sold below cost in Dutch supermarkets (Van Aalst et al. 2005).

While most sources agree that the price war appears detrimental to grocery retailers on average, mixed signals are found when it comes to individual players – especially by the time the price war seems to have taken its full effect. While, by the end of 2005, after three years of price warfare, Laurus (holding company of Edah and Super de Boer) is on the edge of bankruptcy, Albert Heijn – in contrast - claims to have "attained its goals," reporting a revival of revenues, and profit (Baltesen 2006). In a similar vein, Figure 3, which displays market share for the six leading supermarkets in the period 2002 – 2005, indicates a strong post-price war decline for Edah, while the slide in Albert Heijn's market share prior to the price war is halted. A key question remains: what explains the difference in price war consequences between these key market players? Our model and empirical results, by disentangling the price war impact from that of other drivers of chain revenue, and by unraveling its effect on separate revenue components, sheds light on these issues.

[Insert Figure 3 about here]

Data Sources

Our dataset combines several sources. First, we use purchase records from the Dutch GfK consumer hand scan panel across a period of four and a half years (July 1, 2001-December 31, 2005). Panel members scan at home all their purchases at all Dutch grocery retailers, and the data are sent electronically to GfK Benelux. This GfK panel consists of 4400 households, which

[2] In Belgium, France, Greece, Ireland, Italy, Luxemburg, Portugal and Spain, law prohibits selling at a price below cost. Other European countries such as Denmark, Germany, Finland, Austria, Sweden and the UK are similar to the Netherlands in that they do not explicitly impose that selling prices must exceed costs (Baarsma and de Nooij 2005).

represents a stratified national sample. We use this source to operationalize our dependent variables (store visits and spending) and the household- and store specific weekly prices. A unique advantage of consumer hand scan data (over in-store scanned data via household ID cards) is that the market research agency does not need the permission for data collection from the retail chains. Such permission is increasingly problematic both in Europe (especially for the hard discounters) and the U.S. (Wal-Mart).

GfK also provided household perceptions of grocery retailing chains. Every six months, part of the panelists are surveyed on their perception of price image and produce quality. Based on these surveys, GfK prepares Christmas and Summer reports for the Dutch grocery industry. On top of these biyearly reports, GfK conducted an additional survey a few weeks after the start of the price war. We obtained the store image data at the individual household level for the same time period, and for each week *t* we assigned the perceptions from the measurement moment that is closest to week *t*. For the households that were not surveyed for a specific Christmas- or Summer report, we imputed image data using a two-way linear model - a typical and commonly used best-fit imputation approach (see Little and Rubin 1987, Chapter 2).

We obtained data from IRI and Publi Info (both in the Netherlands) on weekly feature and display for all items sold in Dutch grocery retailing chains across the same time period. We used these variables to operationalize household- and store-specific feature- and display variables. Finally, Reed Business provided us with the sizes (in square meters) and the locations (zip codes) for all Dutch grocery stores and each year in our data set. The store size data are a useful proxy for assortment size of each chain's store nearest to the household. We combined the store zip codes with the GfK household panelists' zip codes to compute the Euclidean distance between a household and the closest store from each chain.

Data selection

Since the panel composition changes over time, we decided to select the 1821 households that remained in the panel across the 4½ year period. We use the first 30 weeks (week 27 of 2001 till week 4 of 2002) as the initialization period for determining households' spending across categories and for the lagged store visit and spending variables. The remaining 204 weeks (week 5 of 2002 – week 52 of 2005) are used for model calibration. The price war started in week 43 of 2003, and hence we have 90 weeks before the price war start and 114 weeks afterwards. This

seems sufficient to measure long-term effects since by the end of 2005, the price war is in its aftermath (Van Aalst 2006). The full data set consists of 2,228,904 observations: purchases of 1821 households at 6 retail chains over 204 weeks.

We model store visit and spending at the six largest chains with national coverage, which jointly comprise 70% share of the 2002 market. To illustrate the positioning of these chains prior to the price war, Figure 4 summarizes the store perception data in two main dimensions (according to GfK): service and value for money. Albert Heijn is the market leader who initiated the price war. As illustrated by its scores on price image and produce quality (see Table 2), it is a high-price, high-service chain, which also applies to Super de Boer. The middle segment comprises two chains: C1000, with good scores for service and value, and Edah, with low ratings on both dimensions. The two hard discounters (low price, low service) are Aldi and Lidl. Interestingly, the price war leads to a strongly improved price image for Albert Heijn, as Figure 5 shows.

We note that actual weekly prices hardly decrease across the 4.5 years of data (Table 2), which may be surprising given the magnitude of the price war. Two comments are relevant here. First, the prices reported in Table 2 are nominal price indices. As pointed out by Baltesen (2006), the corresponding decline in real prices is much stronger: in the absence of the price war, Dutch food prices would have been 8.2% higher than they actually are. Second, while many items have been reduced in price, the majority of the stores' SKUs has not (and some prices of heavily featured SKUs have increased again after an initial advertised price drop), implying that price drops for the entire basket remain modest.

[Insert Table 2 and Figures 4 and 5 about here]

Independent variables

Store selection and spending depend on a trade-off between shopping benefits and costs (Bell, Ho, and Tang 1998; Tang, Bell, and Ho 2001), and Table 3 summarizes our corresponding independent variables. As store *benefits* variables we include store price image, produce quality (an indicator of general quality), store surface (indicator for assortment size), and feature and display variables[3] (Sirohi et al. 1998, Bell et al. 1998, Tang et al. 2001, Fox et al. 2004). Store

[3] We include feature in the store visit model but omit it from the spending equation since feature promotions represent out-of-store communication intended to enhance store visits. Similarly, we include display in the spending

familiarity or spending habits affect store visits and spending as well (Bell et al. 1998, Rhee and Bell 2002). Such state dependence can be captured using lagged purchase indicators (Ailawadi, Gedenk, and Neslin 1999, Seetharaman 2003). To capture a wide variety of shopping visit and spending patterns, we use four lagged variables representing past store visits and spending, one for each of the four preceding weeks.

[Insert Table 3 about here]

We include two independent variables for store *costs*: (i) store distance, representing fixed costs and (ii) weekly prices paid to acquire a basket of products[4], representing variable costs (Bawa and Ghosh 1999, Bell et al. 1998, Popkowski-Leszczyc, Sinha, and Sahgal 2004). Importantly, since we mean-center weekly prices for each store-household combination, they capture longitudinal variation only, whereas the (untransformed) price image variable captures both cross-sectional and longitudinal variation. Furthermore, we include *seasonal* dummies (weeks 1, 51, 52, and Easter).

To test the hypotheses, we include *price war variables,* based on the price war rounds outlined in Table 1. We define the step variable PWRound as the *cumulative* number of items that were reduced in price since the start of the price war. Its coefficient in the model for store visit and spending represents the price war's long-term (permanent) effect. We also use its first difference, the pulse variable Pulse_PWRound, representing the *extra* number of items reduced in price in a particular week. Its response coefficient represents the short-term effect of the price war on store visits and incidence. The use of step- and pulse variables combined with lagged endogenous variables captures a wide variety of dynamic effects (Hanssens, Parsons, and Schultz 2001, p. 295-296), while it is still parsimonious and tractable.[5] In both the store visit and spending equations, we also test whether the price war affects consumer's sensitivity to weekly prices and price image, both in the short- and the long term. To that end, we use the interactions

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model but exclude it from the store visit model, as this marketing instrument is only observed by shoppers inside the store. We verified both restrictions, and found that posterior interval for the display parameter includes zero in the store visit model, and the same applies for the feature parameter in the spending model.

[4] As we discussed in the hypotheses section, we need to include weekly price as an independent variable in the models for store incidence and spending. This allows the price war variable (to be discussed next) to capture the impact of the price war while controlling for mere price reductions. To avoid endogeneity issues, we use purchases from the initialization sample to define each household's basket of products, rather than the current week's basket.

[5] It is unlikely that retailers set basket prices, or decide on the number of items to reduce in price, as a function of same-week spending levels of individual households, especially in a competitor-centered price war setting. This justifies our choice of treating weekly price and price war variables as exogenous.

between these variables and the pulse- and step price war variables: Pulse_PWRound*lnPrice, Pulse_PWRound*PriceImage, PWRound*lnPrice, and PWRound*PriceImage.

Finally, consumers may not only become more price- and price image sensitive in the course of the price war, but also in other periods of intensified price promotions that supermarkets tend to engage in. To identify these periods we define a new dummy Promweek, which is 1 in promotion intensive weeks (average price index across stores 2.5% or more below the yearly average), and 0 otherwise. This operationalization identifies promotion-intense periods that make intuitive sense as they largely correspond to the periods when households are on tighter budgets (beginning of the year and end of summer). We include the main effect of Promweek as well as its interaction with weekly prices (Promweek*lnPrice) and price image (Promweek*PriceImage) in the models for store visits and spending. Our results are robust to alternative definitions of Promweek (based on price 2 or 3% lower than average).

Table 2 shows that the means of several store activities change between the periods before and after the price war starts. For example, the average distance to a Lidl store decreases from 7.0 to 5.3 kilometer, reflecting Lidl's increase in the number of outlets. In addition, the average store surface areas tend to increase over time (either due to remodeling or due to new stores). Moreover, the feature and display activities increase for Aldi and Lidl and decrease for some other players. Our model includes control (independent) variables for each of these changes to obtain unbiased estimates for the price war effects.

RESULTS

Store visits

We present the store visit results in the left-hand part of Table 4. All *benefit* variables (PriceImage, ProduceQuality, StoreSurface, Feature and LagVisit1-4) have positive effects on store visit probabilities (and their 95% posterior interval excludes zero). The positive impact of lnStoreSurface (.155) is consistent with store size being a proxy for assortment size. The coefficients of lagged visit (.235, .298, .283, and .264) indicate the expected positive state dependence. As for *costs*, we find that a higher distance between a household and a store (which means: more travel time and costs) has the expected negative effect on store visit probability (−.502). The effect of price is, as expected, negative (−.097). The *seasonal* effect estimates indicate a decreased propensity to visit grocery stores in the Christmas week (Week52: −.107)

and in the first week of the year (Week1: −.458), possibly because stores limit their opening hours (grocery stores are closed on December 25 and 26, and January 1), and consumers prefer to stay at home with family and friends. At Easter the store visit propensity goes up (.073), plausibly because consumers want to shop for holiday meals, and the longer opening hours (relative to Christmas) allow them to do so. We find that during promotion-intensive weeks, consumers go more often to stores (Promweek: 0.24). In addition, in these weeks their store visit decision is more sensitive to weekly prices (Promweek*lnPrice: −.350). Both effects make intuitive sense.

[Insert Table 4 about here]

Focusing on the impact of the *price war variables*, several interesting findings emerge (see also Figure 2). Consistent with H1, the overall store visit propensity temporarily increases due to the price war, as the coefficient for Pulse_PWRound is positive (.020). Yet, in line with expectations, this traffic increase does not persist. In the long term, the price war even reduces visits for the average store - the coefficient of PWRound is negative (−.011). This result has to be interpreted against the finding that, the price war makes the store visit decision more sensitive to weekly prices and price image, consistent with the prediction of Heil and Helsen (2001). Specifically, we find support for H3a in the short term (but not in the long term) as the sensitivity of store visits to weekly prices increases temporarily at each new price war round (Pulse_PwRound*lnPrice: −.058). For H4a we find support in the long term only (PWRound*PriceImage: .005), implying that price image becomes a more important criterion for store visit as the cumulative number of items reduced in price increases.

Spending

The estimates for the ln spending equation are given in the right-hand part of Table 4. All the *benefit* variables have the expected positive effects. Spending increases with PriceImage (.008), ProduceQuality (.010) and Display (.003). Moreover, it increases with lnStoreSurface (.098); consistent with the notion that larger assortments allow the fulfillment of more consumer needs, and with lagged spending (.002, .009, .010, .009); consistent with positive state dependence. On the *cost* side, a longer distance to the store leads to less spending (−.116). This may be true either because transportation from the store to home by foot or bike (which is very common in the Netherlands) becomes increasingly difficult when more groceries have to be

carried, or because consumers visit these far-away stores for fill-in trips on their way home from work. The elasticity of *spending* to weekly prices is positive (.282) but lower than one. This implies that, prior to the price war, the elasticity of *quantity* to price is negative but inelastic. As for *seasonalities*, the effects of the pre-Christmas-week (Week51: .127), the Christmas week (Week52: .025) and the Easter week (.128) on ln spending are positive, whereas the effect of the year's first week on spending is negative (Week1: −.217), possibly due to consumers using excessive stocks from the preceding holiday week, or due to economizing or dieting. During promotion-intensive weeks, the reduced prices allow consumers to spend less (Promweek: −0.07), and their store spending decision is more sensitive to weekly prices (Promweek*lnPrice: −.026) - effects that make sense intuitively.

Again, the *price war variables* reveal some interesting results (see also Figure 2). Consistent with H2, the price war causes decreases in ln spending in the long term (PWRound: −.004). However, the coefficient of Pulse_PWRound indicates that, after the start of the price war, consumers initially spend more per shopping trip (.008). This short-term phenomenon is consistent with a "temporary income" or "windfall" effect: consumers initially perceive the announced price reductions as a gain that triggers them to buy more, but then adjust spending downward again. Consistent with H3b we find that the price war makes spending more sensitive to weekly prices both in the short- (Pulse_PwRound*lnPrice:−.084) and in the long term (PWRound*lnPrice: −.026). Similar to the store visit results, for H4b we find support in the long term only (PWRound*PriceImage: .004), implying that price image becomes a more important criterion for spending as the cumulative number of items reduced in price goes up.

Decomposing the net impact of price war on store visits and spending

The price war affects the models for store visit and spending in multiple ways. First, the price war has an impact on independent variables that capture price aspects, i.e., weekly price and price image. Second, there is a direct effect of the price war on intercepts and response coefficients for the store visit and spending models. The intercept effect is captured by the cumulative price war variable, PWRound, whereas the moderating effect of response coefficients is manifested in the terms PWRound*lnPrice and PWRound*PriceImage. Since we want to focus on long-term changes, we exclude the temporary change captured by the pulse variable Pulse_PWRound.

To decompose the effect of the price war on store visit and spending, we proceed as follows. Since we calculate a *ceteris paribus* effect, we only vary the price-related variables (price image, basket price and the PWRound variables), and keep the other variables (e.g., distance to store, store surface, feature and display) constant. This avoids confounding these variables and price war variables. Specifically, we consider the quarter before the price war start as the pre-war period (2003, weeks 30-42). Vectors $\mathbf{v}_{hi0}$ (expenditure equation) and $\mathbf{x}_{hi0}$ (store visit equation) include the price and price image values in the pre-war period for household *h* and store *i*. They also include other independent variables such as distance to a store, which are kept at their means across the pre- and post-start periods to isolate the price war effect. The corresponding response coefficients are $\boldsymbol{\omega}_{h0}$ (expenditure equation) and $\boldsymbol{\zeta}_{h0}$ (store visit equation). For the post-start period, we take the last quarter of the data (fourth quarter of 2005), and the variables and parameters are $\mathbf{v}_{hi1}, \mathbf{x}_{hi1}$ (again, all non-price war variables are kept at their means across pre and post-start periods), $\boldsymbol{\omega}_{h1}$, and $\boldsymbol{\zeta}_{h1}$.[6] The price-war induced change in a household's expenditure at a store, $\Delta E(R_{hi}) = E(R_{hi1}) - E(R_{hi0})$, can (as shown in online appendix C) be decomposed into five components:

(6) $\Delta E(R_{hi})$

$$= \underbrace{\Pr(z^*_{hi0}=1)\Delta E(y^*_{hi} \mid \Delta\mathbf{v}_{hi}, \boldsymbol{\omega}_{h0})}_{\text{(a) Expenditure change due to changed independent variables}} + \underbrace{\Pr(z^*_{hi0}=1)\Delta E(y^*_{hi} \mid \Delta\boldsymbol{\omega}_{h}, \mathbf{v}_{hi1})}_{\text{(b) Expenditure change due to changed coefficients}} + \underbrace{\Pr(z^*_{hi0}=1)o(n^2)}_{\text{(c) Expenditure approximation error}}$$

$$+ \underbrace{\Delta\Pr(z^*_{hi}=1 \mid \Delta\mathbf{x}_{hi}, \boldsymbol{\zeta}_{h0})E(y^*_{hi1})}_{\text{(d) Incidence change due to change independent variables}} + \underbrace{\Delta\Pr(z^*_{hi}=1 \mid \mathbf{x}_{hi1}, \Delta\boldsymbol{\zeta}_{h})E(y^*_{hi1})}_{\text{(e) Incidence change dueto changed coefficients}}$$

Since parts (a) and (b) capture expenditure changes multiplied by pre-price war store visit probabilities, these parts can be interpreted as changes in spending at the existing store visit propensity (which we may interpret as "the existing customer base"). Conversely, as parts (d) and (e) capture store visit changes multiplied by post-price war spending, they represent the effect of the changed store visit propensity at the new expenditure level. Part (c) is an approximation term that is due to a Taylor series expansion (see online appendix C for details). We find this term to be negligible in all the calculations below.

[6] We also tested a few alternative post-price war periods, and found that the substantive outcomes remain the same.

We calculate decomposition (6) at the household level (using the households-specific parameters), and next take the average across households.[7] Table 5 shows the results for each of the 6 chains. For Albert Heijn average spending decreases by €1.09, which is a reduction of 10.3%. However, since the six chains together also lose 10.3%, Albert Heijn's market share is preserved (consistent with Table 2 and Figure 3). Albert Heijn's spending loss is primarily due to a strong decrease in current customers' conditional spending (−.72), largely due to the effect of the price war rounds on the intercept (−.61). On the positive side, Albert Heijn – as the price war pioneer – enjoys an improvement in overall price image (see Figure 5), which somewhat enhances conditional spending (+.01). However, consumers' increased sensitivity to store price image, combined with the fact that Albert Heijn's *relative* price image in the market remains unfavorable[8], more than offsets this effect (−.16). Albert Heijn also experiences a net decrease in store patronage (−.38), caused primarily by an intercept driven down by the price war rounds (−.41).

[Insert Table 5 about here]

Ironically, the two hard discounters, Aldi and Lidl, remain largely unaffected. While the price war somewhat reduces the intercept part of store visit probability (−.23 and −.14 for Aldi and Lidl, respectively), consumers' increased sensitivity to their still favorable price image (Figure 5) enhances store visits (+.25 and +.11, respectively). The other three chains (C1000, Edah and Super de Boer) all experience net losses in average spending (−.85, −.32 and −.56, respectively). Table 5 shows that the increased sensitivity of spending and store visits to C1000's favorable price image (+0.10 and +0.09, respectively) is not enough to compensate major intercept losses (−.51 for both store visits and spending). Edah faces a whole array of problems: both spending (−.16) and visits (−.16) are down, in each case driven by price-war induced intercept losses and an increased sensitivity to its unfavorable price image. Finally, Super De Boer's loss in spending are driven by intercept reductions and reduced spending of the existing customer base due the chain's increase vulnerability to its weak price image (−.11).

[7] In these calculations, we use all parameters irrespective of whether or not their posterior intervals exclude zero.
[8] As Price Image enters the interaction term after mean centering, it reflects the chain's price position compared with the market average. Thus, it takes on negative values for stores with a worse-than-average price image. Hence an increased price image coefficient leads to negative store visit and spending effects for such stores.

The impact of the price war on profitability and share values

Our core analysis deals with changes in purchase behavior due to the price war. One may argue that purchase behavior, and the associated revenue implications, are mediators for ultimate performance measures such as profitability and stock market performance. Whereas detailed and reliable figures on national chain-specific margins are lacking (in particular for Aldi and Lidl), the retailers' annual reports do unveil some important insights. Ahold – the holding company of Albert Heijn- indicates that "Albert Heijn's ongoing price repositioning strategy resulted in fierce price competition in the Dutch food retail market. This made it more difficult to maintain gross profit margins, and this pressure on gross profit margins is expected to continue in 2005. Albert Heijn was able to compensate for part of the impact of lower prices by reducing the cost of goods, largely as a result of negotiations with vendors as well as increased vendor allowances. The cost reduction program at Albert Heijn is focused on lowering logistic and distribution expenses." (Ahold Annual report 2004, p. 64). Clearly, Albert Heijn's dominant retail market position allowed it to recoup much of the price drop at the expense of manufacturers, whose profit margins, according to some industry sources, have decreased by 80% after three years of Dutch price warfare (Baltesen 2006). Together with a massive effort to improve the efficiency of its operations, this appears to have prevented huge downturns in Albert Heijn's profitability.

In contrast, for Laurus (owning chains Edah and Super De Boer) net sales (=revenues times gross margin) decline sharply in three successive years (Laurus Annual Reports 2003-2005): –26% (in 2002-2003), –14% (in 2003-2004) and –10% (in 2004-2005), leading to the statement: "As a result of the price war […] hundreds of products are sold below cost. Combined with a lower sales volume, this has had a significant negative impact on our bottom line. Given the financial position of Laurus, there was no other option but to sell Edah" (Laurus Annual Report 2005 p.3). Lacking the deep pockets and market power of Albert Heijn/Ahold, the Edah chain is a primary casualty of the price war. For C1000, net sales initially keep on increasing (+ 8.1% in 2002-2003), +3.2 % in 2003-2004), but start to tumble as the price war lingers on (–1.6 % in 2004-2005) (Schuitema Annual Reports 2003-2005).

Interestingly, similar patterns are observed in the share values (see online appendix B). Structural break analyses of the retail companies' weekly stock price indices (own stock price divided by the total market price) on the Amsterdam Stock Exchange, reveal that the price war, while not significantly altering the share notation of Schuitema (C1000), goes along with a

downward slope shift for Laurus (Edah, Super de Boer, Konmar), yet with an upward slope shift for Ahold that almost nullifies the pre-war downward trend. It appears that the improved price image of Albert Heijn, together with its no longer declining market share and pursuit of massive efficiency improvement operations, has outweighed the harmful store visit and spending implications of the price war, thereby restoring the shareholders' faith.

DISCUSSION

Summary

This paper has studied the impact of a major price war on consumer purchase behavior. We find that the price war that has been raging in Dutch grocery retailing since October 2003 impacts both store visit probabilities and spending. Based on a national household panel providing hand scan data and perceptual measures of store image across a nearly four-year time period, we estimate a multivariate Tobit-II model for store visits and spending. The model allows for household heterogeneity and a full covariance structure (across store visits and spending) for the errors, for the random store intercepts, and for response coefficients. Based on a decomposition of price war-induced changes in spending patterns, we show that these changes are not merely induced by a shift in weekly prices and price image (independent variables in our model), but also by changes in household shopping behavior (model coefficients). As hypothesized, we find that the price war induces consumers to shop around more – entailing a temporary increase in store visit across-the-board. Moreover, while the price war initially creates a "windfall' effect that triggers temporarily increased spending, spending levels shrink in the long term as consumers redistribute their purchases across the stores they visit. At the same time, the price war enhances consumers' sensitivity to both weekly store prices and chain price image, confirming predictions in the literature (Heil and Helsen 2001) as well as lab experiment findings (Wathieu et al. 2004). Hence, consistent with the Lucas critique, we find that the initiator's major policy change affects response parameters (Van Heerde, Dekimpe, and Putsis, Jr. 2005). Importantly, we distill these price-war based effects while controlling for price promotion intensive weeks. Our decomposition of the spending change reveals differential consequences for key retail chains depending on (i) their overall (perceived) price position and (ii) their ability to improve price image through the price war.

Price war, what is it good for?

Our answer to the question "the price war, what is it good for?" has five aspects. First, the Dutch supermarket price war is good for the price image of its initiator: Albert Heijn *succeeds* to improve it without significant harm to its quality and service image[9]. Other retailers, who follow Albert Heijn's move within days, do not obtain such price image gains. This first-mover advantage in a price war (Busse 2002, Elzinga and Mills 1999, Rao et al. 2000) confirms several business anecdotes (Simon 1997, Pauwels et al. 2004). If the price war initiator specifically aimed to improve its price image, the price war appears successful.

Second, this price war is good for the initiator's market share: the slide in its market share comes to a screeching halt (Figure 3). However, our analysis shows that this holds because the price war *decreases* spending at Albert Heijn at the same rate as at the market average (minus 10.3%). In that sense, Albert Heijn's "price war victory" as reported in the business press (Baltesen 2006) is somewhat bittersweet. Still, investors reward the price war initiator by neutralizing the downward trend in its stock price, consistent with the halt in its market share decline and with its improved price image among consumers.

Third, focusing on competitors, the price war is bad for the high-service follower (Super de Boer) and the middle-service followers (C1000 and Edah), as they also get hit with smaller spending. Moreover, they hardly enjoy an improved price image, like the pioneer does. Their lower prices appear simply to subsidize existing customers. Ironically, however, the price war is good for the hard discounters. While spending is hardly affected, their market shares increase because their competitors' revenues contract. The hard discounters benefit from an increase in store visit propensity triggered by consumers' enhanced sensitivity to price image.

Fourth and finally, from a broader perspective, the upside of the price war for consumers is that they pay lower prices. Downsides are less obvious, but the lower manufacturer and retailer margins harm the industry as a whole. One likely consequence is a reduction in resources for Research & Development, which, in the longer run, harms product quality and, thus, will hurt consumers. Another downside is that the price war may reduce the focus on important marketing variables such as service and assortment. Finally, firms may go bankrupt, which reduces

[9] We fail to reject the null hypothesis of no change in these components after the start of the price war.

consumer choice. For example, the Dutch price war forced the Edah supermarket chain to go out of business.

External validity

While our findings are based on a unique dataset and a new methodology, it is interesting to observe their consistency with trends reported by external sources. The increased consumer sensitivity to weekly prices is reflected in the nation-wide Consumer Trends survey by EFMI (2002, 2004, 2005), which reports that low prices became the major consumer decision criterion in store choice (46% of respondents naming it within their top three criteria, up from 35%). This high sensitivity to price/promotions appears to be maintained in 2005.

Because our findings relate to the weekly household level for a representative sample, they have to be projected to aggregate levels (whole population for a full year) to grasp their relevance to the retailer's overall performance. For instance, the total per-household spending change of €−1.09 for Albert Heijn (Table 5) translates into an annual €369 million revenue loss across the 6.5 million Dutch households (www.cbs.nl). Thus the magnitude of the price war effects is managerially substantial, as compared to the 5.6 billion revenue of Albert Heijn in 2003 (Ahold Annual Report 2003, p. 61). Our estimated total loss among the 6 largest Dutch retailers amounts to €972 million, which is in the same ballpark as industry estimates that put the loss at €900 million (Van Aalst et al. 2005).

Managerial implications

While our findings relate to the specific consequences of this particular price war, we may speculate on recommendations for retail and brand managers who either intend to start a price war, or who are, perhaps unintentionally, involved in one:

1. If the competitive situation is such that a price war is very likely anyhow (based, e.g., on the early warning signals identified in Heil and Helsen 2001), it is desirable to make the first strike as it may bring a first mover advantage in price image improvement. This price war benefit is especially relevant for market players with a price image problem, as was the case for the Dutch price war initiator.

2. We caution high-end market players for the risk of using price as a competitive weapon as it may increase price (image) sensitivity, which may backfire if the high-end player's price remains relatively high due to competitive reactions.
3. Discounters may actually benefit from a price war. They can advertise their very low price levels, for which there may be increased consumer attention and sensitivity, leading to more store visits and expenditures. If there remains a substantial price gap with the middle- and high-end players (as is the case for Aldi and Lidl in the Dutch price war, see Table 2), low-end players seem to have little reason to further reduce prices during a price war.
4. Managers should not be too encouraged if a price war initially brings more visitors to their stores or buyers to their brands. A price move may re-engage customers (Chen and McMillan 1992) to compare prices in the short run, but in the long term they are expected to return to their usual shopping frequencies. In this study we find that especially those stores with an unfavorable price image lose store visitors in the long term.
5. To prevent a price war escalation, it may be a good idea to first analyze consumer responses when one market player starts to cut prices. If purchase behavior only changes modestly or temporarily, it may be better to focus on other marketing mix instruments than price to win back customers. If the changes are strong, there seems little other resort than to respond by offering price reductions as well, possibly spiraling down to a price war.
6. Channel power is a major asset when one is involved in a price war. In the Dutch price war, Albert Heijn initiated the price war when it still had market leadership and was widely regarded at offering superior service and quality. In this regard, our situation is consistent with the power transition paradigm (Organski 1968): the market leader launches a pre-emptive strike while it is still powerful, i.e., before most shoppers have lost interest. Since the chain had and has the highest market share, it represents a major outlet for many manufacturers, which they cannot afford to lose. As result, Albert Heijn could divert a major part of its loss in margin (due to reduced consumer prices) to its suppliers. Edah, a price war casualty, probably suffered from both low channel power and a lack of cost leadership (Rao et al. 2000).
7. It seems particularly unwise to provoke competitors with a competitor-focused goal such as "to become less expensive than the market average," as Albert Heijn did at the beginning of the price war. Instead, it seems better to focus on the savings for consumers.

8. Our final recommendation is to consider market characteristics that may moderate the findings of the supermarket price war considered in this study. The negative market-level consequences of the price war may be related to the grocery category, whose primary demand appeared to be price inelastic. Overall spending in the category may increase when the price war brings the product within the reach of large new consumer segments (e.g., when air travel, then computers and later printers became inexpensive enough for most Western individuals).

Policy implications

The scope of price war consequences clearly differentiates them from periods of intense price promotions (Heil and Helsen 2001). The Dutch supermarket price war has incited a nationwide discussion on setting minimum prices and competitive regulations, right up to the Dutch parliament (Baarsma and de Nooij 2005). Such a public debate is rather new to antitrust legislation, which focuses largely on a lack of competition and mostly ignores "too much competition," e.g., in the form of price wars. For instance, in defense of laissez-faire, Baarsma and de Nooij (2005) argue that law enforcers cannot evoke article 2 of the European Treaty, which prohibits the use of unreasonably low prices in order to drive out competition, because there is no evidence of intent to achieve this (although in reality, the Dutch supermarket price war did drive out one chain, Edah). Such arguments reflect a strong belief in the economic rationality and foresight of managers, which may not be supported by the growing literature on managerial biases in pricing (e.g. Nijs et al. 2007), on competitive overreaction (Leeflang and Wittink 1996) and escalation of commitment (Ghemawat 1991). However, in the Dutch situation, there was no political majority to implement legislation to prevent price wars.

Limitations and future research

This study has several limitations, providing leads for future research. First, our data come from one price war in one country, and further studies are needed to establish whether our findings generalize to other price war situations. For one, how would spending respond in a more price-elastic market? Second, we model cross-chain effects via the correlated intercepts and error terms in the multivariate store visit and spending models. While future research may analyze how each competitor's marketing mix instrument price has a different impact, incorporating explicit

cross-instrument effects would greatly complicate the already strenuous model estimation. Third, in the computation of weekly prices the household-specific basket weights are the same across stores. However, a household may buy a specific subset of the basket in one store, and another subset in another store. Hence one may be tempted to use store-specific weights. The reason that we chose not to follow this route is that it would lead to an endogeneity problem: the dependent variable (choice) is used to construct the independent variable. Yet, in relation to this point, another interesting avenue for future research is a detailed investigation of differences across households in terms of changes in basket content. Furthermore, we specify interactions for the moderating effects of the price war on price (image) sensitivity. An extension to stochastic time-varying parameters (e.g., Van Heerde, Mela, and Manchanda 2004) is a worthwhile future research endeavor (although it would also severely stretch model estimation). Finally, we model prices as exogenous vis-à-vis household decisions on store visits and spending, as it seems much more likely that chains base their prices on competition than on unobserved individual-level demand shocks (see Erdem, Imai, and Keane 2003 for a similar argument). Incorporating endogenous prices and complicated feedback loops, would allow quantitative analysis of the antecedents and momentum of a price war, a fascinating topic for future research.

Despite these limitations, our analysis of the Dutch supermarket price war generates interesting insights into an important and timely marketing phenomenon, and points to exciting future research possibilities.

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Table 1
Overview of price war rounds

Date	Initiator	Number of products (approx.)	Emphasis on
October 20, 2003	Albert Heijn	1000	A-brands
October 27, 2003	Albert Heijn	550	A-brands
November 10, 2003	Albert Heijn	300	A-brands and Dairy
January 19, 2004	Albert Heijn	500	A-brands and Produce
March 8, 2004	Albert Heijn	100	Meat
May 10, 2004	Albert Heijn	100	Cheese
September 20, 2004	Albert Heijn	1000	Private Labels
November 13, 2004	Albert Heijn	2000	A-brands
January 30, 2005	Albert Heijn	1000	A-brands, Cleaning and Personal Care
February 21, 2005	Albert Heijn	100	Prepared Meat/Cheese
March, 7 2005	Edah	250	A-brands and Private Labels
April 4, 2005	Edah	250	A-brands and Private Labels
July, 28 2005	Vomar	1000	n.a.
August 23, 2005	Super de Boer	600	A-brands
September 12, 2005	Albert Heijn	100	Cleaning and Personal Care
October 31, 2005	Albert Heijn	1000	A-brands

Sources: van Aalst et al (2005), Holla and Koreman (2006).

Table 2
Descriptive statistics of the six chains before (pre) and after (post) the start of the Price War

	Albert Heijn		Super de Boer		C1000		Edah		Aldi		Lidl	
Positioning (GfK 2003)	Service		Service		Middle		Middle		Discount		Discount	
Pre- or Post Price War period[a]	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
Market share	32%	31%	14%	13%	24%	24%	10%	8%	16%	18%	4%	7%
Weekly store visits	.36	.35	.16	.15	.27	.27	.14	.11	.24	.25	.08	.12
Weekly spending given spending > 0	28.92	27.12	27.74	26.03	28.03	27.57	24.07	22.17	20.66	21.70	15.96	17.14
Price image (1=lowest, 7 = highest)	5.1	5.5	5.4	5.4	6.0	6.1	5.8	5.8	6.9	6.7	6.7	6.7
Produce quality (1=lowest, 7 = highest)	6.4	6.5	6.2	6.1	6.2	6.2	5.5	5.5	4.3	4.5	4.7	5.0
Distance to panelists (km)	2.3	2.3	4.0	4.0	3.1	3.0	5.1	5.2	3.2	3.2	7.0	5.3
Store surface (m^2)	1326	1385	867	979	838	927	1008	1024	421	428	613	622
Price (Index)	1.19	1.20	1.11	1.12	.98	.96	1.01	1.01	.60	.58	.59	.59
Feature[b]	3.09	2.67	3.45	2.97	1.46	1.45	4.05	2.40	.31	3.5	1.68	3.45
Display[b]	2.37	2.69	2.81	2.56	1.40	1.41	3.20	2.82	.31	3.5	1.68	3.45

a. The pre-Price War period runs from January 2002 till October 19, 2003, the post-Price War period from October 20, 2003 till the end of 2005.
b. This variable is the product of the percentage of stores carrying the promotion times the percentage of products that are promoted. It varies from 0 (no activity whatsoever) to 10,000 (100% of the products in 100% of the stores are promoted).

Table 3
Overview of independent variables in the store visit and spending models

Variable	Operationalization
Store benefits	
$PriceImage_{hit}$	Price image of store *i* for household *h* in week *t* measured on a ten-point scale (1=worst, 10=best)[a]
$ProduceQuality_{hit}$	Produce quality image of store *i* for household *h* in week *t* measured on a ten-point scale (1=worst, 10=best)[a]. This is an important indicator for perceived chain quality.
$lnStoreSurface_{hit}$	ln Floor surface of closest store of chain *i* to household *h* in week *t*[a]. This variable is an important indicator for assortment size.
$Feature_{hit}$	Feature activity of store *i* in week *t* for household *h*: weighted average of store *i*'s feature activities in category *c* in week *t* with household *h*'s category shares as weights[a,b] (only in store visit model)
$Display_{hit}$	Display activity of store *i* in week *t* for household *h*: weighted average of store *i*'s display activities in category *c* in week *t* with household *h*'s category shares as weights[a,b,c] (only in spending model)
$LagVisit l_{hit}$	Indicator for store visit (store *i*) by household *h* in week *t-l*, *l*=1,2,3,4
$LaglnExpend l_{hit}$	ln spending for household *h* in store *i* in week *t-l*, *l*=1,2,3,4
Store costs	
$lnDistance_{hit}$	ln Distance (km) between household *h* and store *i* in week *t*[a]
$lnPrice_{hit}$	ln weekly price of store *i* for household *h* in week *t*, i.e., a weighted average of store *i*'s price in category *c* in week *t* (P_{hit}^{c}), with household *h*'s category shares as weights. [b,d,e]
Seasonalities	
$Week1_t$; $Week51_t$; $Week52_t$, Easter	Dummy variables for week 1, week 51, week 52, and Easter, respectively.
Price war variables	
$PWRound_t$	Cumulative Price war round variable for permanent effects, 0 before start price war, and equal to the cumulative number of items reduced in price up to time *t* (see Table 1); scaled by dividing by 1,000
$Pulse\_PWRound_t$	Pulse Price war round variable for temporary effects, 0 before start price war, and equal to the number of items reduced in price at time *t* (see Table 1); scaled by dividing by 1,000
$PWRound_t * lnPrice_{hit}$	Interaction between cumulative Price war round variable and ln price
$PWRound_t * PriceImage_{hit}$	Interaction between cumulative Price war round variable and price image
$Pulse\_PWRound_t * lnPrice_{hit}$	Interaction between Pulse Price war round variable and ln weekly price
$Pulse\_PWRound_t * PriceImage_{hit}$	Interaction between Pulse Price war round variable and price image
Promotion week variables	
$Promweek_t$	Dummy for price promotion intensive week: 1 if average price across chains is 2.5% or more below average, 0 else
$Promweek_t * lnPrice_{hit}$	Interaction between Promweek and ln weekly price
$Promweek_t *$ PriceImage	Interaction between Promweek and price image

a: obtained from the measurement moment that is closest to week *t*.
b: this variable has been mean-centered for each household-store combination to use longitudinal information only to assess its effect.
c. This variable is the product of the percentage of stores carrying the promotion times the percentage of products that are promoted. It varies from 0 (no activity) to 10,000 (100% of the products in 100% of the stores are promoted).
d: a benefit of mean-centering described at footnote b is that lnPrice is only weakly correlated with PriceImage: $\rho = -.015$.
e: to allow for meaningful aggregation across categories with different units (e.g. ounces, liters) into a weekly store price, category prices P_{hit}^{c} are expressed as an index by dividing them by the across-store average unit price for the category in the initialization period.

Table 4
Posterior distributions of response parameters[a]

	Model for store visit				Model for ln spending			
	Percentiles of $\bar{\zeta}$			Stdv. across households	Percentiles of $\bar{\omega}$			Stdv. across households
	2.5	50	97.5	(based on Ω)	2.5	50	97.5	(based on Ω)
PriceImage	.000	.009 *	.018	.078	.002	.008*	.014	.069
ProduceQuality	.003	.011 *	.017	.033	.006	.010*	.014	.040
lnStoreSurface	.139	.155 *	.171	.108	.089	.098*	.105	.102
Feature	.001	.002 *	.003	.006				
Display					.002	.003*	.004	.006
LagVisit1	.220	.235 *	.250	.269				
LagVisit2	.287	.298 *	.312	.168				
LagVisit3	.273	.283 *	.292	.148				
LagVisit4	.251	.264 *	.273	.139				
LaglnExpend1					.001	.002*	.003	.018
LaglnExpend2					.008	.009*	.010	.013
LaglnExpend3					.009	.010*	.011	.012
LaglnExpend4					.008	.009*	.010	.010
lnDistance	-.526	-502 *	-.476	.321	-.142	-.116*	-.100	.175
lnPrice	-.107	-.097 *	-.082	.075	.269	.282*	.323	.092
Week1	-.478	-.458 *	-.443	.133	-.227	-.217*	-.205	.070
Week51	.019	.040 *	.060	.065	.115	.127*	.140	.046
Week52	-.122	-.107 *	-.089	.065	.014	.025*	.037	.060
Easter	.062	.073 *	.083	.060	.119	.128*	.134	.049
PWRound	-.013	-.011 *	-.009	.034	-.005	-.004*	-.002	.029
Pulse_PWRound	.008	.020 *	.030	.030	.000	.008*	.014	.021
PWRound *lnPrice	-.005	.009	.026	.045	-.035	-.026*	-.018	.047
PWRound *PriceImage	.003	.005 *	.007	.029	.002	.004*	.005	.019
Pulse_PWRound*lnPrice	-.086	-.058 *	-.021	.108	-.099	-.084*	-.062	.036
Pulse_PWRound*PriceImage	-.009	.004	.016	.024	-.008	-.002	.005	.019
Promweek	.013	.024 *	.032	.029	-.013	-.007*	-.002	.026
Promweek* lnPrice	-.364	-.350 *	-.338	.055	-.034	-.026*	-.016	.067
Promweek* PriceImage	-.001	.009	.016	.040	-.004	.002	.009	.023

* the 95% posterior interval excludes 0.
[a] Store-specific moderators (intercepts) of the random household effects are not reported to preserve space.

Table 5
Decomposition of the net effect of the price war on store visits and spending

				Part due to changed conditional spending						Part due to changed store visit probability					
				Subtotal	Part due to changed variables		Part due to changed coefficients			Subtotal	Part due to changed variables		Part due to changed coefficients		
	Spending before price war	Spending after price war	Total change		Part due to changed weekly price	Part due to changed price image	Part due to intercept change	Part due to changed weekly price coefficient	Part due to changed price image coefficient		Part due to changed weekly price	Part due to changed price image	Part due to intercept change	Part due to changed weekly price coefficient	Part due to changed price image coefficient
Albert Heijn	10.64	9.54	-1.09	-0.72	0.05	0.01	-0.61	-0.07	-0.16	-0.38	-0.01	0.01	-0.41	0.01	0.03
Aldi	4.55	4.57	0.02	0.02	-0.02	-0.02	-0.10	0.01	0.14	0.00	0.01	-0.02	-0.23	0.00	0.25
C1000	6.80	5.96	-0.85	-0.43	-0.04	0.00	-0.51	0.00	0.10	-0.41	0.01	0.00	-0.51	0.00	0.09
Edah	2.01	1.69	-0.32	-0.16	-0.01	0.01	-0.09	0.00	-0.09	-0.16	0.00	0.01	-0.13	0.00	-0.03
Lidl	1.20	1.12	-0.08	-0.05	0.01	0.00	-0.04	-0.01	0.00	-0.03	0.00	-0.01	-0.14	0.00	0.11
Super de Boer	2.70	2.13	-0.56	-0.38	0.01	0.00	-0.29	0.00	-0.11	-0.18	0.00	-0.01	-0.19	0.00	0.01

The table shows the decomposition of spending for each chain (in euro), averaged across all households based on equation (6). We use equilibrium estimates for conditional spending and store visit by repeated substitution. In particular, in the spending model we use four lags of the predicted unconditional spending (product of store visit probability and conditional spending) on the right hand side to predict for period t, t+1, etcetera, until convergence. In the store visit probability model we repeatedly use lagged predicted store visit probabilities as independent variables, until convergence. We contrast the quarter just preceding the price war (2003, weeks 30- 42) with the final quarter in the data set (2005, weeks 40-52). The approximation error (term (c) in eq. (6)) is .06 for Albert Heijn but does not exceed .02 for the other chains, and it is therefore omitted from the table.

Figure 1
Prices of Coca Cola 1.5 liter at four leading chains over time

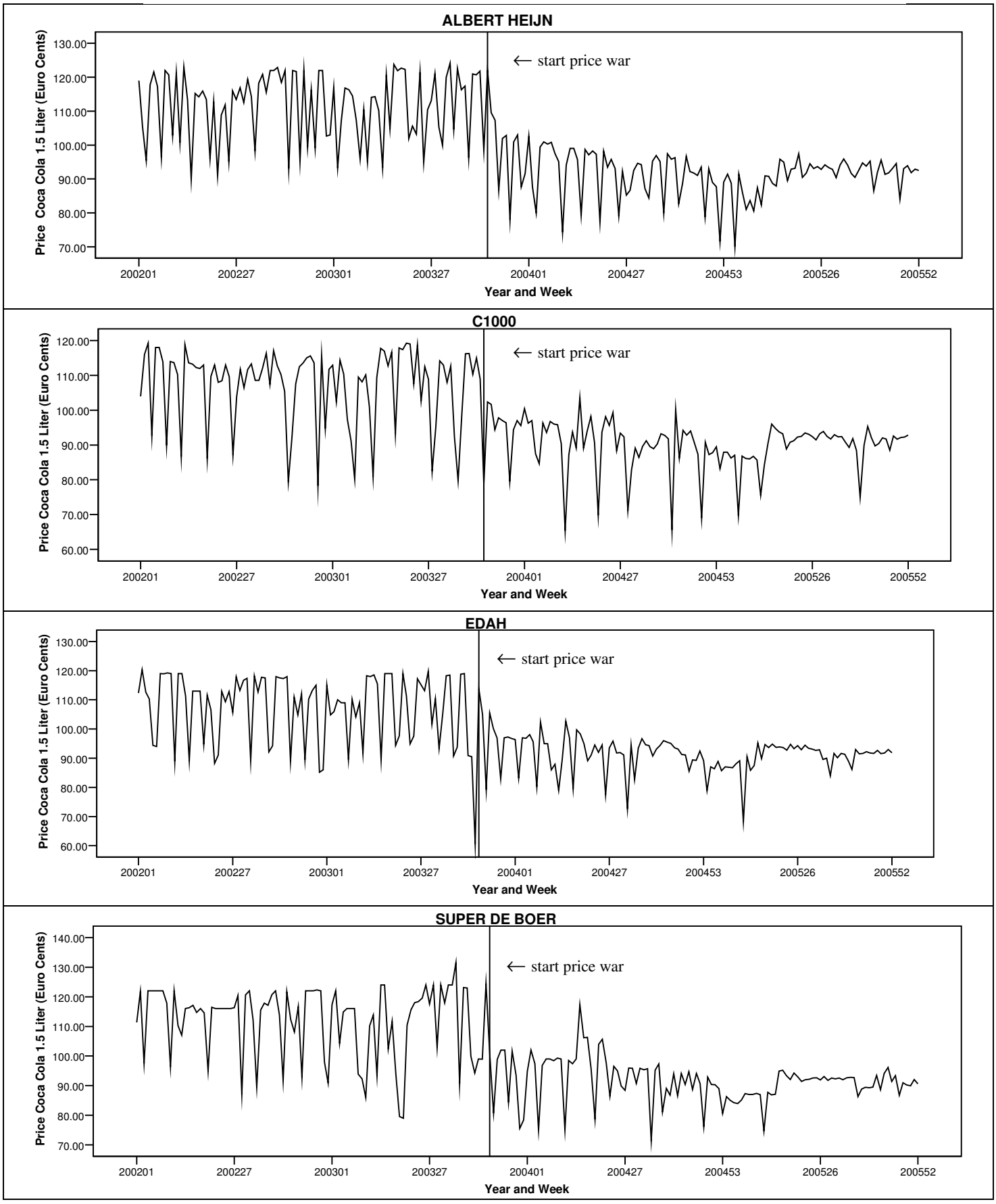
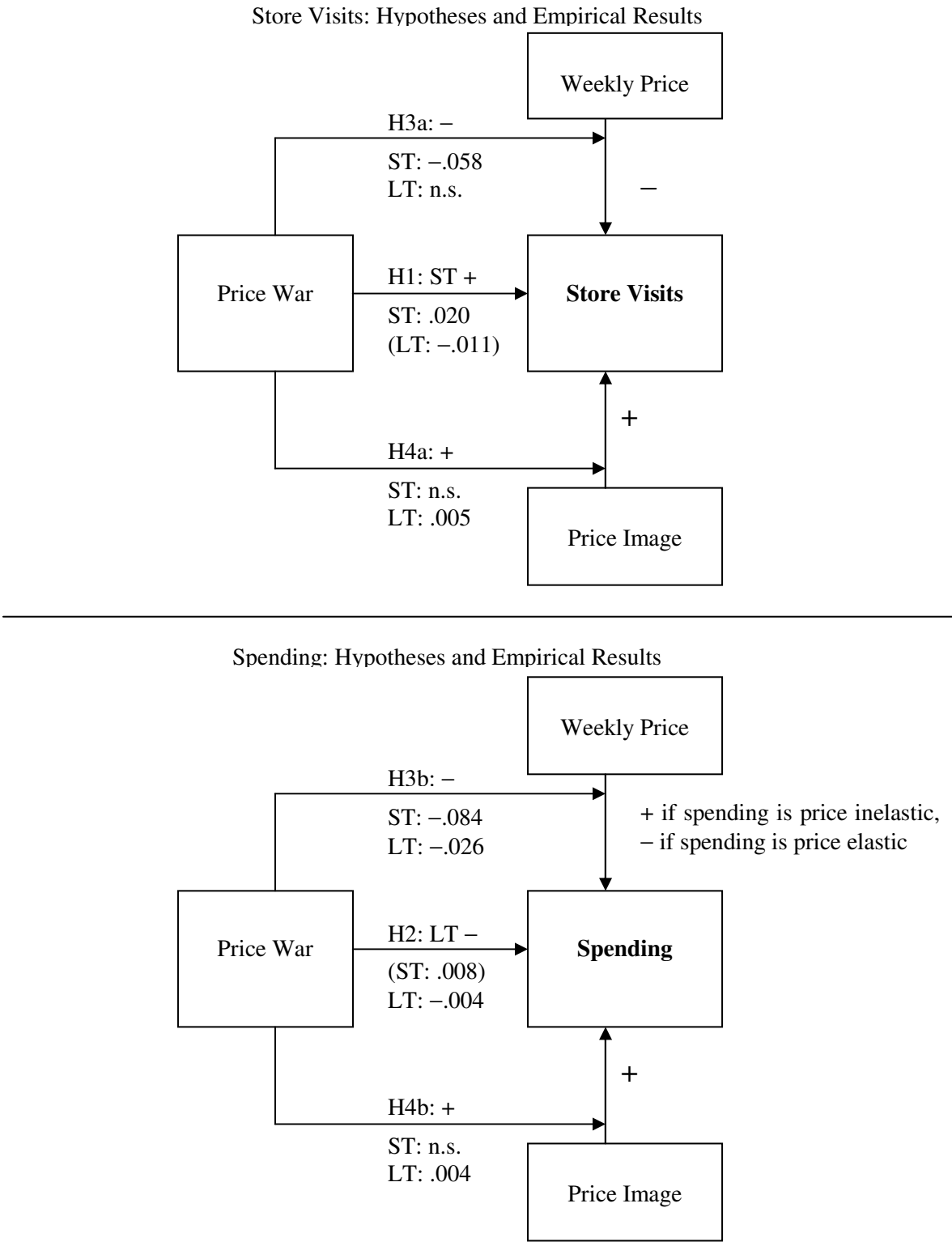
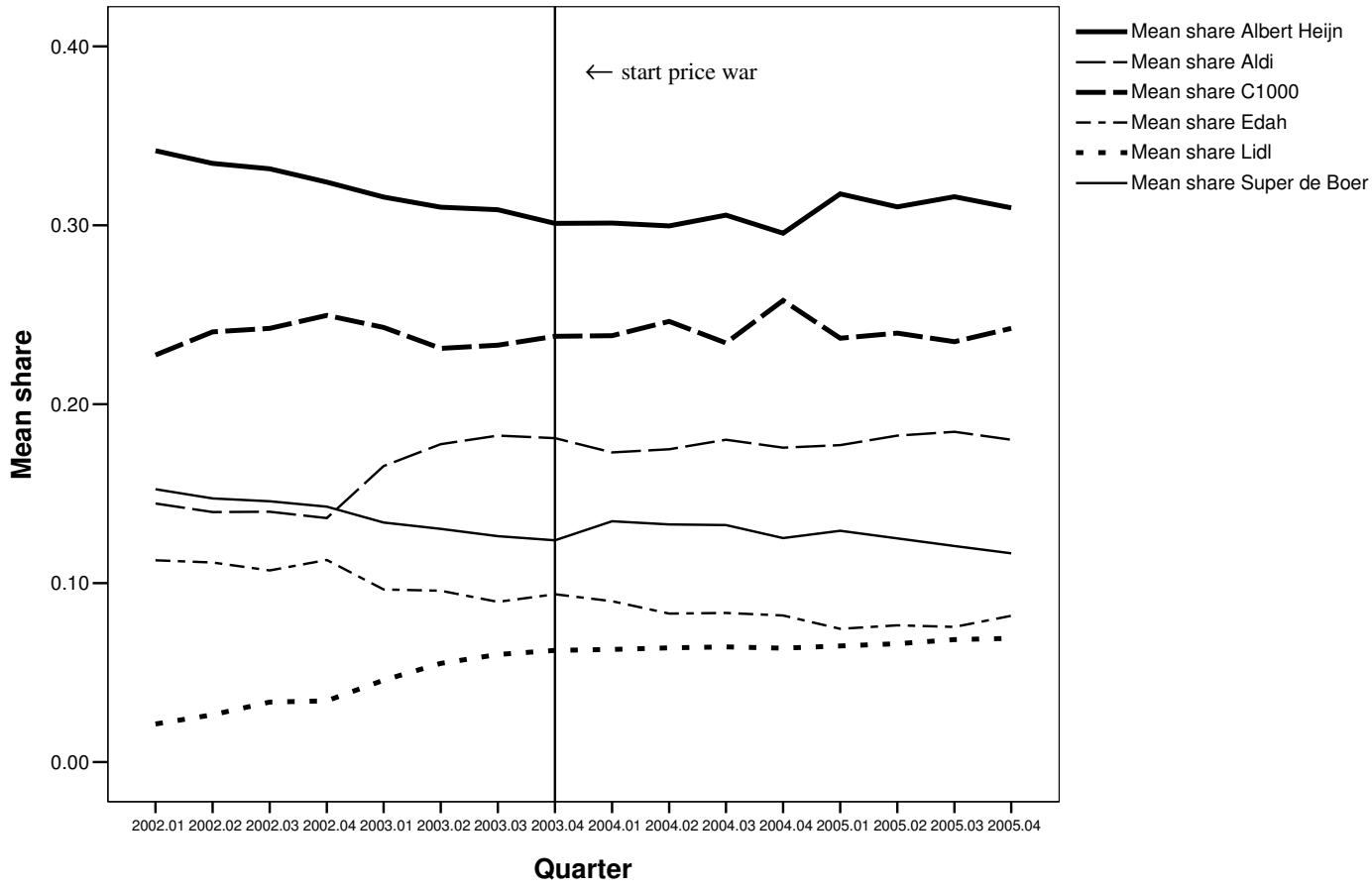


Figure 2
The effects of a price war on (1) store visit and spending and (2) sensitivities to weekly price and price image



ST = Short Term; LT = Long Term.

Figure 3
Quarterly market shares of the six national chains (within the submarket of the six chains)



These market shares are based on the representative sample of 1821 households used in the analyses.

Figure 4
Positioning of the six major Dutch retail chains in Summer 2002 (Source: GfK 2003)

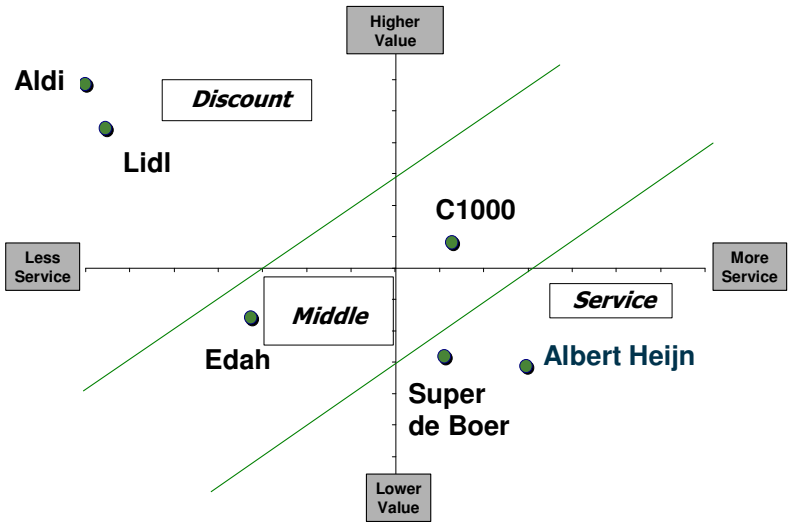


Figure 5
Price image for the six chains over time