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Identifying and characterising price leadership in British supermarkets ☆☆☆



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ABSTRACT

Price leadership is a concept that lacks precision. We propose a deliberately narrow, falsifiable, definition then develop it, illustrate its feasibility and test it using the two leading British supermarket chains. We find both firms engaging in leading prices upward over a range of products, with the larger being initially more dominant but the smaller increasing leadership activity to take overall leadership over time. However, more price leadership events are price reductions than price increases, consistently led by the smaller firm. Nevertheless, the increases are of larger monetary amounts than the falls, so average basket price increases over time.

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1. Introduction

The concept of price leadership lacks precision in existing literature. We aim to improve precision in what is meant by leadership, and then illustrate this using price data on the two leading British supermarkets. In our view, precision requires a careful and *falsifiable* definition of the concept. Unfortunately, this is more difficult than it might seem. To illustrate, the OECD definition “Price leadership refers to a situation where prices and price changes established by a dominant firm, or a firm accepted by others as the leader, and which other firms in the industry adopt and follow”¹ seems rather circular.

Similarly, characterising three types of price leadership, Dominant firm, Collusive and Barometric, Scherer and Ross (1990, p.249) suggest as distinguishing characteristics for the last of these “occasional changes in the identity of the price leader ... the absence of leader power to coerce others into accepting its price; a tendency for the leader formally to validate price reductions that other sellers have already initiated ...”. Since this well-established text is a common reference source for subsequent work, the situation remains confused. Some analyses have argued from effect to attribution of leadership, for example the limited analysis in Competition Commission (hereafter CC, 2000, ch. 7), rather than from an exogenous starting point to investigation of leadership. Finally, we need to accommodate multi-product firms.

We propose a new *falsifiable definition* of what constitutes price leadership (and, by implication, what does not):

Price leadership occurs when one firm makes a change in a *price* (or set of prices) that is followed within a *predetermined short period* by the other (more generally, another) firm making a *price* change of exactly the same monetary amount in the same direction on the *same product(s)*, and doing so *significantly more often than would be expected by chance*.

In our definition, the italicised elements are to be particularised to the specific circumstance or industry. Thus what we propose is a potentially general definition, illustrated using a specific case study of considerable interest.

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¹ See <http://stats.oecd.org/glossary/detail.asp?ID=3285>.

This definition necessarily excludes: simultaneous price changes, those followed with a long lag, price changes of similar monetary amounts, or on a similar but not the same product. It is clearly falsifiable since it may not occur. More positively, the definition identifies candidate cases of which firm is engaging in leadership on which products when. Leadership is deliberately defined narrowly, choosing a specific interval to reduce the possibility that chance movements are included, but allowing time for reaction, so the bias if any is towards not observing it when it occurs. Moreover, by maintaining a tight definition of candidate cases, robust testing against the alternative of chance observation can be performed, thereby sifting from candidate cases those that occur significantly more often than expected by chance. These become our clear cases of leadership.

As an empirical case study, we examine leadership behaviour in the British supermarket industry, a significant market and one which has the useful institutional feature of national pricing. Here, for reasons spelt out below in describing the industry, there are two clear leadership candidates, Tesco and Asda. We examine their pricing behaviour using our new leadership concept. Significant features of the industry lead us to particularise the proposed definition. Specifically, we define what we mean by price and by product and starting point, choose the short period of response by the follower, develop and employ a test of whether leadership happens more often than may be expected, and define sub-types of leadership.

Previewing results, we find considerable evidence that leadership exists. Most strikingly, we find that whilst Tesco appears commonly to lead prices upward in the first four years of our sample, there is a clear switch whereby over the last three years Asda comes to dominate leads upward. However, we observe significantly more leadership in price reductions than in price rises. Asda is more involved in reductions than Tesco, but both are extremely active in leading reductions, particularly in our later years. These results bring out certain features that theoretical models have suggested, most obviously the switch of leadership between firms and the smaller firm being more involved in leading falls.

Our plan is as follows. We outline the analytical literature in [Section 2](#). We then describe the industry ([Section 3](#)), the nature of our sample data ([Section 4](#)) and general features of pricing behaviour in the industry ([Section 5](#)). [Section 6](#) particularises the definition above to the British supermarket industry. Our characterisation of leadership and our analysis of overall leadership, including distinguishing it from random behaviour, is carried out in [Section 7](#), the core of the paper. We move on in [Section 8](#) to looking at more disaggregated levels of price leadership. Finally, [Section 9](#) offers a brief conclusion relating the findings to the theory. We do not draw normative conclusions.

2. The analytical literature on price leadership

Amongst the main contributions to the modern literature on price leadership are [Rotemberg and Saloner \(1990\)](#), [Deneckere and Kovenock \(1992\)](#), [Deneckere et al. \(1992\)](#), [Pastine and Pastine \(2004\)](#), also [Maskin and Tirole \(1988\)](#), [Eckert \(2003\)](#) and [Noel \(2008\)](#). These papers' main focus is on all (both) firms in the market being strategic players, rather than one main actor together with a raft of passive firms, which was common in the more traditional literature.

Rotemberg and Saloner have a collusive story underlying their model; price leadership facilitates tacit collusion by one firm signalling to others that prices should rise. One firm raises its price and the other decides non-cooperatively whether to follow – this involves the usual tradeoff between the immediate benefits of deviating from this strategy against the longer-term benefits of holding to it. They show existence but go beyond this to characterise the equilibrium. The leader earns higher profit but leadership may emerge endogenously with the less informed firm wishing to follow the better informed. Interestingly,

leadership may be characterised by extensive periods of static prices after a leadership move upwards, because the follower benefits from rigid prices.

Again, endogenous leadership is an outcome of the Deneckere papers, although the underlying models differ. The Deneckere and Kovenock paper criticises the dominant firm pricing model, which comes from an earlier less rigorous tradition, under which a large firm with significant market share is assumed to take on the leadership role, the others being passive. In their duopoly game, when firms' capacities are in the range where the simultaneous game leads to mixed strategy solutions, a game of timing emerges with the high capacity player becoming the price leader. Deneckere et al. has firms who cannot discriminate between loyal consumers and others. The firm with the smaller loyal segment strictly prefers to be a price follower. Thus here consumer behaviour significantly influences the identity of the price leader, the firm with the larger loyal consumer base taking on the leadership role. Pastine and Pastine add to this analysis by noting two things. First, there should arguably be a cost of delay, however small, in making a later price announcement. Second, they allow firms to make price announcements at any time. This allows firms to mix over the timing of their pricing moves. Hence, occasional changes in the identity of the price leader will occur. Amir and Stepanova have a model where one firm enjoys lower costs than the other. Despite endogenous timing, in equilibrium a firm with sufficiently lower costs adopts the leadership role; that is it has a first-mover advantage.

In sum, our reading of this branch of the literature leads to several key conclusions. First, the identity of the leader is not assured – it may not be the largest firm, which is the traditional assumption. Second, following from this, the leader may differ over time or products – if for example loyalties shift, or multiproduct firms have strengths that vary across the product range. However, changes in the price leader's identity require some changes over time, or alternatively mixing over timing of moves. Third, leadership need not have collusion as its driving force. Nevertheless, it can result in higher prices than simultaneous pricing (Deneckere and Kovenock). Of the papers discussed above, only Rotemberg and Saloner focus on collusion as the driver. We are unable to test this prediction directly, but [Chevalier et al. \(2003\)](#) find little support for it.

The models covered so far focus attention on endogenous price leadership. A second strand of literature, relating to so-called Edgeworth cycles, has prices rising due to leadership, then falling by smaller amounts as firms in turn undercut rivals in order to dominate the market, before reaching a low point from which they are again raised. The basic theoretical framework is set out in [Maskin and Tirole \(1988\)](#) and the model has been extended by [Eckert \(2003\)](#) and by [Noel \(2008\)](#). Maskin and Tirole's model permits two possible equilibria. Under a non-trivial and possibly broad range of circumstances, firms engage in pricing behaviour of a "saw-tooth" style in one of their Markov-perfect equilibria, with substantial leader-driven price rises. Eckert shows that price cycle equilibria are more likely when relative firm sizes differ. One clear prediction: the smaller firm is the one more likely to undercut. For reasonable parameters, Noel shows using computational techniques that the saw-tooth pattern is robust to fluctuating marginal costs, mild product differentiation and asymmetry between firms. Price rises may be initiated due to cost hikes.

This Edgeworth cycle pattern has been observed in many gasoline retailing markets in the US, Canada, several European countries and Australia ([Wang, 2009](#)). Yet by no means all such markets exhibit these patterns (see e.g. [Lewis, 2011](#); [Noel, 2007, 2009](#); [Lewis and Noel, 2011](#); [Zimmerman et al., 2011](#)). Indeed, the market where the saw-tooth Edgeworth cycle pattern has been studied has almost always been gasoline retailing.

In our context, there are clearly many potential differences between gasoline markets and supermarkets/grocery markets. Most

obviously, the two companies whose prices we examine in detail are multiproduct in an extreme form. In gasoline markets, the product set examined essentially boils down to one. Additionally, it is common to investigate behaviour of a single market price, essentially excluding the possibility of longer-lived differences between the supplying firms' prices. Also, the periodicity is much shorter in gasoline than in grocery, given the visibility of prices. Finally, in gasoline a major empirical advantage is the easy availability of wholesale prices, whereas in grocery markets the wholesale contracts are complex, privately negotiated and commonly non-linear. In consequence, it is unclear whether the equilibria including the Edgeworth cycle mechanisms set out by Maskin and Tirole will be maintained in industries like groceries that are much further from the theoretical framework than is retail gasoline. Nevertheless we look for evidence of the phenomenon.

In sum, we draw predictions both from the endogenous price leadership models and from the Edgeworth cycle literature when we examine leadership in our data.

Edgeworth cycle behaviour should be distinguished from a related phenomenon whereby price rises more quickly when costs rise, than price falls when costs fall by an equivalent amount – asymmetric pricing behaviour. Peltzman (2000) finds this to be a widespread phenomenon in markets he studies (although not, incidentally, in his supermarket sample). This is distinct because (a) it does not necessarily involve a leader, but (b) it does require a cost change, which the Maskin–Tirole framework does not (Lewis and Noel, 2011).

3. The British supermarket industry

Grocery retailing is the largest retail sector in the UK and an important market. Verdict Research (2008), a market research organization, estimates that in 2007, food and grocery retailing accounted for around 42%, and rising, of total UK retail spending. The sector is dominated by four players. Tesco is by far the biggest of these, with Kantar putting its share at around 30% in 2011. Therefore, Tesco alone accounts for over 1/8 of British retail consumer spending, on these figures. In recent years Tesco, and to a lesser extent Asda, now the second largest firm, have grown significantly. In fact, Kantar figures suggest that until 1995, Sainsbury's (generally perceived as somewhat higher quality and less price competitive) was the largest firm, but first Tesco then, during 2003, Asda overtook it and Asda has maintained second position.² Both these firms operate large stores extensively; according to CC (2008), substantially fewer than ten of Asda's stores are less than 1400 m² in size.³ Tesco operates more of a variety of store sizes. Its nearly 1,400 stores in 2008 comprised four main groups, the two largest accounting for 564 stores (and undoubtedly a major share of their sales). Tesco and Asda together account for well over 40% of grocery sales.⁴

A key industry feature (CC, 2003) is that these firms practise national pricing. In other words, whether shopping in Cornwall or the Scottish Highlands, consumers face the same prices in their larger stores. Asda operates a uniform national pricing policy (with very minor differences) across all its British stores. Throughout our sample period, Tesco operates a uniform national pricing policy across its large stores, and many of their (smaller) Metro stores also. These uniform prices hold nationally – there are none of the intricate variations in prices that characterise US grocery retailing. Thus national TV advertising, for example, will include (selective) price information. This feature of the market is in itself curious,⁵ since costs such

as wages and rents, incomes and competition will differ from location to location. However, for present purposes, we take it as a given.

Both Tesco and Asda are part of major international retailing groups, in Tesco's case UK based. Tesco is one of the world's top four retailers; Asda is the British subsidiary of Walmart. Hence their pricing strategies are backed by powerful groups. They are the obvious candidates for price leadership in the market, given their size and growth. Tesco is a natural candidate since it is the dominant player in terms of market share and it enjoys a cost advantage (CC, 2008). Asda has been chosen for study because it has a reputation both as a keen pricer in relation to Tesco and an aggressive player – it is the chain most driven by price. More generally, there is close price rivalry between Asda and Tesco, as seen below. Sainsbury's, now the number three firm, has been notably less aggressive and more idiosyncratic in its pricing practices, and has preferred a quality image. Morrisons is very much the fourth player, absorbed with consolidating a difficult merger with Safeway in late 2003 and lacking an internet arm. Various reports including official investigations (e.g. CC, 2000, 2008) have described Tesco and Asda as leading market trends. Given their pricing practices, we examine their interrelationship using these national prices as our key statistics.

4. The data sample

We have available, week-by-week, the chain prices for 370 precisely defined products over seven years from late 2003 to late 2010 for both key players in the British supermarket industry. Our sample starts when Tesco started its "Tesco Price Check" website. This was an independently collected large scale weekly comparison of precisely defined products across Tesco, Asda, Sainsbury's and Safeway/Morrisons. We supplement this with data, from early 2008 onwards, downloaded from a website called mysupermarket.co.uk (who collected across Tesco, Asda and Sainsbury's) to create the seven year sample; the two samples overlap for much of 2008. Thus we have consistent data for Tesco, Asda (and Sainsbury's) over seven years. We use the Tesco and Asda data in this analysis.

Our 370 products are those where we are able to form a good quality price series over the full period.⁶ Some are branded products (e.g., Nescafe Gold Blend Coffee 200 g), others are essentially identical chain brand products (e.g. Own label fresh single cream, 568 ml). Of the 370 products, 331 were priced identically by Tesco and Asda, either at the start or soon thereafter. These 331 products, as from the 7th week, constitute the sample in our analysis below.^{7,8} Of these, 202 or almost 2/3 of the products, were priced identically within the final month of the sample. Of course, the prices were not identical at beginning and end, in fact mean item price at the start was a little over £1.50, but by the end was £1.85 and had been up to £1.90.

What we do not have are unit cost data on the products. We investigate prices in the absence of costs. However, we contend: (a) that price leadership is not necessarily directly or exclusively related to moves following cost changes, and (b) that given the nature of the industry and its bargaining and billing practices, unit cost data could be extremely misleading as to the true value of the transaction passing between supplier and supermarket. These issues with unit costs may be a problem beyond the British supermarket industry.

On point (a), this would exclude Edgeworth cycle type behaviour from our analysis. Such cycles involve cost-driven significant price rises followed by more numerous but smaller largely non-cost related moves down. On point (b), it is clear from the CC Groceries report

⁶ The sample is clearly not random. However, appropriately weighted, it tracks the official CPI well (see Chakraborty et al., 2011). The correlation between baskets constructed from our supermarket prices to mimic the CPI index and the index itself is uniformly very high, in excess of 0.93.

⁷ Here, including Sainsbury's would have required a change in methodology, given its different pricing levels.

⁸ See Section 6 for a fuller justification of the omission of earlier weeks.

² Both our sources agree on the latter point.

³ Very recently, Asda has purchased a smaller operator, Netto, which will have increased its store numbers in the smaller category.

⁴ TNS (2009) puts it at almost 50%.

⁵ This is studied in Dobson and Waterson (2008).

(2008) that payments for goods from suppliers involve substantially nonlinear pricing: lump sum payments and promotional allowances are common (see CC, 2008, Appendix 9.8). Many of these practices are well known in the grocery industry and slotting allowances, for example, have received significant study (e.g. Marx and Shaffer, 2010); some such practices have featured in the supermarket sector for some time (Chintagunta, 2002) and render the concept of a wholesale price somewhat problematic (Srinivasan et al., 2004, note that the widely-used Dominick's data suffers similar problems in later years).

In addition and less widely reported, British supermarket payments to suppliers are substantially affected by retrospective partial withholding of the agreed payment for a shipment, without a rational basis. To quote from CC (2008) "For example, a requirement for a price adjustment after goods have been ordered or after products have been delivered is a typical practice that is a source of unexpected costs to suppliers. Similarly, requirements for financing or promotions that were not agreed with the suppliers are also retrospective adjustments that are a source of uncertainty." (CC, 2008, para. 9.45); "For example, we saw that at least one grocery retailer imposes liability on some of its suppliers for losses suffered as a result of shrinkage (i.e. losses that arise where stock is recorded on a company's books but is not on hand, due to theft, the goods being lost or accounting error). In our view, the party best placed to control risks arising through shrinkage is the retailer" (CC, 2008, para. 9.48). So significant are these problems that a survey conducted by a firm of accountants reports (para. 9.61) "Only 50 per cent of suppliers felt highly confident, at the time of delivery, that the sale price would not be reduced by retrospective contributions sought." In these circumstances, an ex-ante unit cost figure is arguably extremely misleading.

5. Characterising pricing in the supermarket industry

Before moving to examining leadership specifically, we discuss pricing behaviour in the industry beyond the feature of uniform national pricing, to explain further why it is a good case study for examining price leadership and why we consider cost changes as a potentially relatively unimportant driver of price changes.⁹

First, prices in the industry are very flexible, even when short term offers are removed from the data; much more flexible than could possibly be explainable through changes in costs. Fig. 1 shows median duration of price moves to a new level across our products and time period. As can be seen, for most products at either of our two chains, the median duration is only a little over a month. The second point to emphasise is the variety of experience across products in terms of pricing behaviour, implicit in Fig. 1. Whilst in both chains milk (products) change prices infrequently, perhaps as little as once per year, other products change price frequently; amongst these alcoholic drinks are a category that stands out.

One common feature of supermarket pricing is the temporary offer price, where price is reduced for a short period, later returning to the same level. We have constructed separate series of temporary offers and of regular prices for later analysis. To get a clean split, we divide price movements into those that are "V shaped" Temporary Price Reductions (TPRs) which lead to a return to the same price, and all other price movements. The appropriate vehicle for doing this is Nakamura and Steinsson's (2008) Regular price under the "B" version of their algorithm, described in Nakamura and Steinsson (2010), yielding, for shorthand, NSB Regular prices. We adopt the exact definition Nakamura (2008) uses for weekly data (but examine it for robustness). This requires a TPR reversion to the exact same price as before the fall within the next six weeks. In constructing

⁹ Much more detail on general pricing behaviour in the industry is provided in Chakraborty et al. (2011).

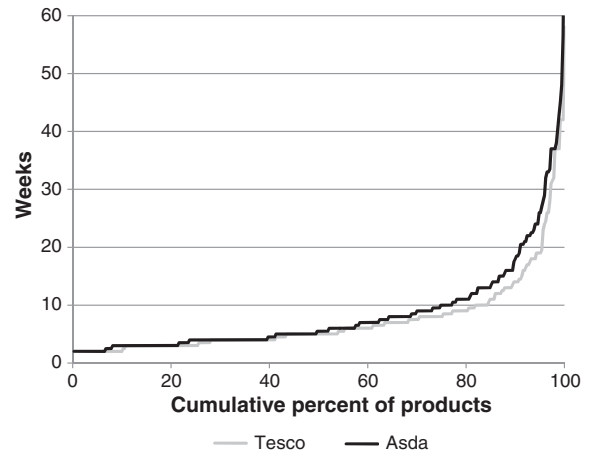


Fig. 1. Median duration of regular prices across our sample of 331 products.

Fig. 1, we removed these temporary price offers from more permanent moves, so the frequencies represent price changes to a new level.

We should also note an element of nonlinear pricing in temporary offers made by these and other chains (three for the price of two offers, etc.); we do not observe these. However it is clear that when we examine regular prices we look only at single item prices, not package deals.¹⁰ Thus investigating leadership in NSB regular prices involves a clear approach focussing on single unit purchases, whereas perhaps in looking at leadership in temporary prices there may also be leadership in special offers (e.g. matching of three-for-the-price-of-two) that is unobserved.

An associated feature of pricing in the industry, itself the subject of study in Chakraborty et al. (2011), is that at various times, markedly so in 2008, there is a welter of price cuts of very small monetary value even abstracting from TPRs. Indeed, penny price cuts, even on products costing several pounds, are very common. This pattern is unlikely to be related to changes in costs. In fact, our observations are consistent with the type of publicity these firms have engaged in at various stages, where prices of particular items relative to other chains, or a count of numbers of price falls, are highlighted.¹¹

Finally, in Fig. 2 below we show weighted basket prices calculated from our data sample of 370 products, using weights equivalent to those used in the CPI. This illustrates that Sainsbury's takes a somewhat different path from Asda or Tesco, with somewhat higher pricing.

6. Particularising the definition of price leadership to the British supermarket case

To examine leadership behaviour in the British supermarket industry, we must make certain specific choices. The first is the definition of price. As set out in Section 5 above, substantial temporary price reductions are a common marketing tool in supermarket retailing. Scanner based studies find significant purchases are made at times when especially low prices are set (Chevalier et al., 2003; Griffith et al., 2009). However we are concerned here more with price leadership than consumer purchases. For these purposes, we analysed price leadership separately in respect of TPRs and all other price movements. It transpires that those TPRs which are led form a relatively small proportion of all temporary price falls, so we devote

¹⁰ This aligns with the Macroeconomic literature on micro pricing behaviour (e.g. Kehoe and Midrigan, 2010; Nakamura and Steinsson, 2008, 2010).

¹¹ Recall that national pricing implies comparisons can be, and are, publicised on national television. Perhaps the most successful such campaign, according to industry insiders, is the Asda "arrows" advertisement series shown in 2008, which cheekily made use of the "Dad's Army" comedy show theme tune in comparing itself with Tesco.

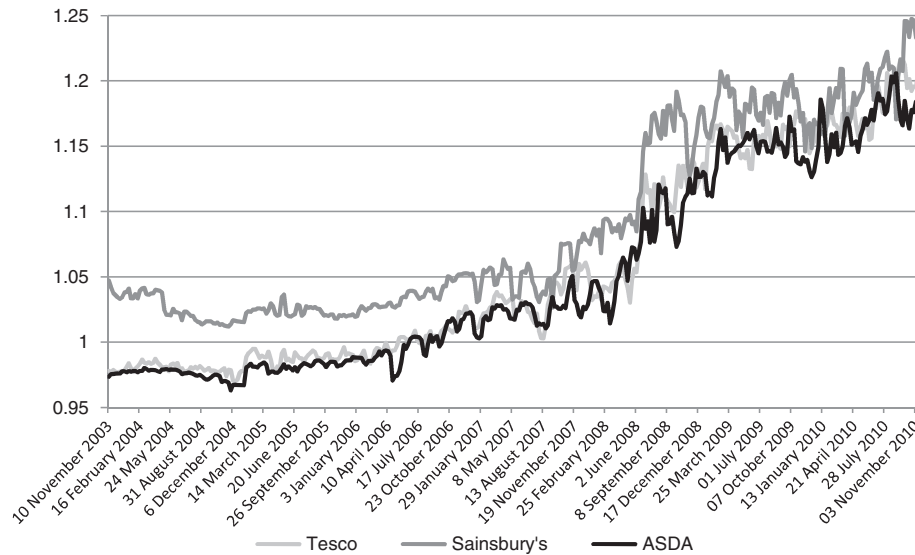


Fig. 2. Price indices calculated using CPI product weights from our data sample.

much more time subsequently to analysing the remaining price movements.

The second choice is the predetermined short period within which the follower responds. Most grocery shopping in large British supermarkets is done weekly or fortnightly (CC, 2008). Perusing the data, prices do sometimes vary as often as weekly. Therefore we adopt “within the next two weeks” as defining the predetermined short period. Nevertheless, since this is potentially controversial, we engage in sensitivity testing in the Appendix and report on it briefly in Section 7.

What do we mean by “the same product”? For a branded product, we mean the exact same product, or UPC, i.e. same brand, same description and packaging, same size. An example would be “Heinz baked beans and pork sausages 8’s 420 g”. But British supermarkets also sell very extensive ranges of own brand products, which we do not want to exclude, particularly since consumers commonly perceive them as very close substitutes in the lower quality ranges. An example would be “Own label budget chopped tomatoes 400 g”.¹² In Section 8 we compare leadership in branded and own label products.

Fourth is how to determine whether leadership takes place “significantly more often than would be expected by chance”. Here we must allow for the multiproduct nature of supermarket sales. There is some meaning to the statement that “Chain X is the leader in own label budget chopped tomatoes, 400 g” over a particular period. But there is significantly more meaning to the summative statement “Chain X is the leader in (NSB Regular) price rises in 2008”. Given our tight definition of what potentially qualifies as leadership we can say that on average, if price movements are random, we would observe just as many cases where chain X changes price by a particular amount, to be followed up to two weeks later by chain Y, as the reverse case, or cases where the two chains change prices simultaneously.¹³ Hence we can test overall price leadership, and specific product cases, by standard statistical methods, approximating the Binomial distribution (assuming numbers are sufficiently large).

The fifth choice is an appropriate starting point for analysing leadership behaviour. Widespread comparative price data became easily available to both players only with the innovation of the Tesco “Price Check” website. Within the first few weeks, a homogenisation of prices across the chains took place. For the first time, consumers

could easily make comparisons. We decide to start our investigation from a point six weeks after the start of the website, and to select those 331 products (the vast majority of our sample) initially priced identically in Tesco and Asda. The particular timing, six weeks after, is not critical, because in the early period there is relatively little price movement, as we shall see.

Finally, price leadership may be either upward or downward, as well as being driven by either player. To summarise then, we investigate leadership in TPRs by each player, plus upward and downward leadership in NSB Regular prices by each player, both summatively and to a lesser extent, in specific subsets of the data. Our investigation is positive, not normative, in spirit.

7. Leadership incidence, significance and impact at the aggregate level

We now turn to an empirical examination of leadership as between Tesco and Asda, using the definition we proposed in the Introduction. Following the separation discussed in Sections 5 and 6 above, we first briefly examine temporary price reductions and leadership. Because this turns out to be a relatively limited phenomenon, we spend significantly more time in examining leadership in NSB regular prices, as defined earlier.

7.1. Temporary price reductions and leadership

In examining *leadership* of temporary price reductions (TPRs), we ask whether a TPR by one of the players is followed, one or two weeks later, by a move to the same extent by the other player; for example if one firm reduces product X by y pence, for a temporary period, does the other reduce the same product to the same extent (*not necessarily for the same length of time*)? Of course, at the time the reduction is made, it is often but not always obvious that this is temporary.

Unsurprisingly, TPRs where the price is reduced for up to six weeks, later to return to the previous level, are a common feature in our data. Both firms employ them, although Tesco does to a greater extent than Asda. Overall incidence across the years is given in the upper panel of Table 1. Their use peaks in 2008, and they are relatively uncommon in the early years of our sample. A comparison between TPR events and TPR weeks (not listed in the table) shows that the average length of a TPR is in the 3–4 week range in the early years, shortening to 2–3 weeks on average in 2008 and after. There is no real difference between the firms on this.

¹² The supermarkets sell up to three quality levels. The word “budget” in this description means the lowest level. Own label plum peeled tomatoes, 400 g, being a higher quality product, command a premium. We always match like-with-like.

¹³ See Section 7 for fuller explanation of this argument.

Table 1
The incidence of temporary price reductions (TPRs), and TPR leadership cases by year.

	2004	2005	2006	2007	2008	2009	2010	Sum
Total TPR events	87	157	310	555	883	694	593	3279
Asda TPR	10	39	99	138	302	280	194	1062
Tesco TPR	77	118	211	417	581	414	399	2217
Total TPR leads	0	2	9	14	35	37	11	108
Asda TPR leads	0	2	7	11	29	33	8	90
Tesco TPR leads	0	0	2	3	6	4	3	18
Simult. TPR	0	0	3	3	4	10	0	20

Note: Based on 331 products.

The lower part of Table 1 examines TPR leadership. A rather small proportion of TPRs fit our definition of leadership. In fact on average only 3.3% of the TPRs observed can be described as leadership TPRs. Such cases are more commonly initiated by Asda and peak at 33 instances in 2009, but at peak this is less than 12% of its TPRs. One point of comparison is the number of simultaneous TPRs, appended at the foot of the table.

If TPRs were truly random, then on average a TPR led within the next two weeks by one of the firms would be equally as likely to occur as a simultaneous TPR.¹⁴ Because numbers of simultaneous moves, and of Tesco leads, are very small, testing the null of equal likelihood against the alternative is difficult. However, a chi-squared test of simultaneous TPR being equally likely as Asda TPR leadership over the period 2007 to 2009 clearly rejects the null, whereas by inspection Tesco clearly leads no more often than would be seen by chance. The implication is that Asda does on occasion lead TPRs, but Tesco does not.

This work is based on a temporary reduction of up to six weeks, which has the benefit of an academic pedigree (Nakamura and Steinsson, 2008) and has the merit of inclusiveness. However, there remains the possibility that the period is too long. Therefore, we also examined results using an alternative definition of four weeks TPR. This has the merit that it fits in with the mirror definition of pricing comparisons with previous prices in BIS (2010). The results (in the online appendix) are very similar, except that the proportion of TPRs which qualify as leadership TPRs is smaller than for the six week sample.

In conclusion under either definition, the number of leadership events within TPRs in total is small; leadership of TPRs exists only to a very limited extent. In consequence, we do not analyse TPRs further. Instead we turn to leadership instances that move the price to a new level, whether up or down.

7.2. Regular price leadership, aggregate influence and significance

We now investigate leadership in NSB regular prices as between Tesco and Asda. We identify two broad types. One is upward price leadership – a regular price movement upwards by one player associated with an increase of exactly the same amount one or two weeks later by the other player. Downward price leadership is defined completely analogously. Logically, there are four forms of price leadership here – it could come from Tesco or Asda, and it could be upward or downward. Within the sample, there are many examples of each over the period, as Table 2 shows.

Table 2 summarises our broad findings. Even given our tight definition, we see several hundred episodes that qualify as price leadership (subject to significance) over our large and quite lengthy sample. Thus price leadership appears extremely common; it resides

¹⁴ A TPR can be led by either firm with 50% probability, if random. But it can be either in the subsequent week or two weeks' time. Hence the probability that a random event is a lead within the next two weeks by (say) Asda equals the probability of observing a simultaneous TPR. This methodology is spelt out at greater length in the next subsection.

Table 2
Summary of findings regarding regular price leadership.

Occasions on which firm led	Tesco	Asda
<i>On price rise</i>	347	256
Average rise	15.2p	14.2p
Products illustrating leadership	58%	53%
Maximum leads/week	12	7
<i>On price fall</i>	562	1328
Average fall	5.3p	3.5p
Products illustrating leadership	62%	87%
Maximum leads/week	21	39

Note: These results represent findings over 331 products for 369 weeks using “NSB regular” prices.

in both players and covers a majority of the goods at some stage or another over our seven year period. In this sense, neither player is “the” price leader. Yet, it is difficult to think how the definition of leadership could be made narrower than the one we have employed, to reduce the incidence of leadership episodes. Our findings here are strongly confirmatory of the recent literature's broad emphasis that leadership is endogenous, not residing in one player, nor necessarily associated with the largest player.

Tesco is more often the price leader over price rises. In an echo of Walmart's “rollback” programmes, Asda dominates leadership in price falls, although these are on average smaller than the rises. In fact, one of the most substantial findings is that leadership over price falls greatly dominates leadership over price rises. Clearly, it is not necessarily the case that price leadership is creating higher prices than otherwise would be observed. This finding relates to the literature in the following sense. Although the traditional literature emphasised implicit collusion as a motive for leadership, the dominance of downward price movements in leadership episodes strongly argues against this conclusion. In that sense, our evidence is more in line with the less obviously motive-driven analyses of Deneckere and others (Amir and Stepanova, 2006; Deneckere and Kovenock, 1992; Deneckere et al, 1992), rather than the Rotemberg and Saloner (1990) collusion story. The finding that Asda dominates in leadership on price falls is consistent with predictions from Eckert's (2003) modelling of Edgeworth cycles where the smaller firm initiates.

The overall picture conceals some important temporal variation, which is illustrated in the upper panel of Table 3. Price leadership appears to become more significant over the seven year period, measured either in absolute terms or relative to the total number of price changes. It peaks in extent in 2009, with nearly a quarter of all the regular price changes made within the year being leadership moves (thereby covering almost 50% of regular price movements). Moreover, over our time period, Asda comes to dominate leadership on our definition, not only on price falls but also price rises, although it remains the smaller firm. This outcome is consistent with the models (e.g. Deneckere and Kovenock, 1992) where leadership is endogenous rather than residing in the largest firm, as is the finding that occasional changes to the leader occur. There is scant evidence (regarding Rotemberg and Saloner, 1990) of stable prices following an upward price lead.

Having painted the broad picture in Table 2 and the upper panel of Table 3, we investigate the important question of whether what we have styled leadership is different in a temporal, directional or fascia sense from random behaviour. We first examine this formally using a set of chi-squared tests, shown in the lower panel of Table 3, with the null hypotheses (i) that behaviour is random across years in terms of upwards versus downwards movements, (ii) that upwards and downwards movements are a random proportion of total price changes, (iii) that the share of upwards (downwards) movements by Tesco versus Asda is randomly distributed across the years. In each case, the calculated chi-squared value is substantially in excess

Table 3
Leadership in regular prices by year, firm and direction compared with total price changes.

		Movements by year							
		2004	2005	2006	2007	2008	2009	2010 (part)	Total
Up	Tesco	35	60	84	75	50	13	28	345
	Asda	4	15	19	10	99	69	40	256
Down	Tesco	7	13	42	47	138	259	54	560
	Asda	47	61	32	43	329	649	162	1323
	Sum	93	149	177	175	616	990	284	2484
	Total price changes	826	1142	1240	1776	4220	3994	2412	15,610
Proportion		0.113	0.130	0.143	0.099	0.146	0.248	0.118	0.159
Chi-sq tests									
Chi sq (6, 0.01) = 16.8									
H0: Random frequency of observations being rises rather than falls across the years, rejected, calculated chi-sq = 376.4									
H0: Random frequency of total rises are due to leadership, rejected, calculated chi-sq = 54.9									
H0: Random frequency of total falls are due to leadership, rejected, calculated chi-sq = 320.8									
H0: Frequency of leadership rises random across Tesco and Asda, rejected, calculated chi-sq = 189.8.									
H0: Frequency of leadership falls random across Tesco and Asda, rejected, calculated chi-sq = 63.1									

Note: Excludes the closing weeks of 2003. 2010 ends in November. Based on 331 products.

of the chi-squared value for six degrees of freedom at the 0.01 level, meaning we firmly reject each of these hypotheses. In all these senses, what we have identified as price leadership behaviour is not random.

We now turn to more formal tests of regular price leadership, focusing first on overall leadership across our sample of products. Does leadership occur more often than may be expected by chance? The underlying methodology we adopt is as follows. In any week, many prices do not change. Let us restrict attention to those that do change, and in particular, in examining leadership, to those that change by the same amount, Δp , given our definition. There are six relevant events in the space. Denote by $Y(t)$ a change in a price of Δp by chain Y (i.e. Asda, A or Tesco, T) in week t , starting observation at week 0. The relevant events are: $\{A(0), T(0)\}$, $\{A(0), T(1)\}$, $\{A(0), T(2)\}$, $\{T(0), A(0)\}$, $\{T(0), A(1)\}$, $\{T(0), A(2)\}$. Of these, the first and fourth events are simultaneous movements (by Δp), the second and third are leadership events by Asda and the fifth and sixth, leadership events by Tesco – notice that with independent moves, the first and fourth events are two events with the same outcome and outcomes are what we observe.

So suppose the events we have suggested are leadership actions that in fact take place by chance. By assumption there is an equal chance that Asda will change its price by Δp and that Tesco will change its price by Δp (this need not mean an equal chance of changing the price by a different amount), also price changes are distributed randomly across the year (which they are; Seaton and Waterson, 2012). Then if the events are truly random, the probability that the

outcome looks like Asda leadership is equal to the probability that the outcome looks like Tesco leadership and equal to the probability that the outcome looks like a simultaneous move by Δp .

This framework forms the theoretical basis for our test. Under these assumptions, we examine whether the proportion of outcomes of Asda (alternatively, Tesco) leadership compared with simultaneous moves is significantly greater than the null of 0.5. Given reasonably large numbers of observations, this proportion is distributed according to the Binomial under the null hypothesis, and we test using the Normal approximation to the Binomial.

Table 4 sets out our results, aggregated at the level of the whole sample, all Δp , and by year. Each segment gives the numbers of leadership outcomes, the number of simultaneous outcomes, the observed proportion and the calculated z-statistic based on that proportion. These give very clear results regarding upward price movements. Tesco is the overall leader in upwards price movements in years 2004 to 2007 inclusive. Then Asda takes over and is the leader upwards in 2008 to 2010. This significant result confirms our earlier more casual findings, and suggests that the leadership change may be linked to a change in proportions of loyal consumers (Deneckere et al., 1992) engendered by Asda's successful advertising campaign in 2008.

With downward price movements, the picture is a little more complex. Asda clearly leads in downward movements across the whole sample. However, Tesco also leads downwards in 2009 and 2010, and a little less certainly, 2008.

We next explore this and other results at various lower levels of product aggregation, in order to refine the findings. But first we

Table 4
Significance tests of leadership versus simultaneous chance moves, aggregate level.

	2004	2005	2006	2007	2008	2009	2010
Asda leads up	7	18	22	9	130	84	46
Simultaneous up	17	32	34	48	62	10	16
Observed proportion	0.292	0.360	0.393	0.158	0.677	0.894	0.742
z statistic		−1.980	−1.604	−5.166	4.907	7.633	3.810
Tesco leads up	33	58	86	85	52	17	28
Simultaneous up	17	32	34	48	62	10	16
Observed proportion	0.660	0.644	0.717	0.639	0.456	0.630	0.636
z statistic	2.263	2.741	4.747	3.208	−0.937	1.347	1.809
Asda leads down	49	62	35	61	718	1055	239
Simult down	5	26	11	37	344	125	14
Observed proportion	0.907	0.705	0.761	0.622	0.676	0.894	0.945
z statistic	5.988	3.838	3.539	2.424	11.476	27.073	14.146
Tesco leads down	7	31	50	55	368	412	83
Simult down	5	26	11	37	344	125	14
Observed proportion	0.583	0.544	0.820	0.598	0.517	0.767	0.856
z statistic		0.662	4.993	1.877	0.899	12.385	7.006

Note: Statistically significant results of the expected sign at 5% level are highlighted in bold.

Table 5
Leadership in branded products across year, firm and direction.

		Year						
		2004	2005	2006	2007	2008	2009	2010
<i>Branded products only</i>								
Up	Asda leads up	7	12	16	7	85	58	33
	Simultaneous move	15	14	18	23	35	6	14
	Proportion	0.318	0.462	0.471	0.233	0.708	0.906	0.702
	z statistic	−1.71	−0.39	−0.34	−2.92	4.564	6.500	2.771
Tesco leads up	Asda leads up	17	45	48	58	35	14	17
	Simultaneous move	15	14	18	23	35	6	14
	Proportion	0.531	0.763	0.727	0.716	0.500	0.700	0.548
	z statistic	0.354	4.036	3.693	3.889	0.000	1.789	0.539
<i>Branded products only</i>								
Down	Asda leads down	28	41	26	43	699	1012	217
	Simultaneous move	3	22	4	25	329	122	13
	Proportion	0.903	0.651	0.867	0.632	0.680	0.892	0.943
	z statistic	4.490	2.394	4.017	2.183	11.540	26.429	13.451
Tesco leads down	Asda leads down	5	27	41	34	355	406	83
	Simultaneous move	3	22	4	25	329	122	13
	Proportion	0.625	0.551	0.911	0.576	0.519	0.769	0.865
	z statistic	0.707	0.714	5.516	1.172	0.994	12.360	7.144
<i>Branded products only</i>								
Penny drops	Asda leads down	9	12	18	10	329	592	104
	Simultaneous move	0	8	2	8	108	92	6
	Proportion					0.753	0.865	0.945
	z statistic					10.572	19.118	9.344
Tesco leads down	Asda leads down	2	14	28	9	197	327	58
	Simultaneous move	0	8	2	8	108	92	6
	Proportion					0.646	0.780	0.906
	z statistic					5.096	11.481	6.500

Note: Statistically significant results of expected sign highlighted in bold.

report on sensitivity to the assumption that leadership is where the price change is followed within the next two weeks. Supermarkets change their prices weekly on occasion and so may be able to respond within a week. On the other hand, the full effects may take longer to be revealed. If we define leadership more narrowly as occurring only if the price change is followed next week, or more broadly as the price change following within the next three weeks, are the conclusions of Table 4 modified? The answer is they are not; both key aggregate findings – that Tesco leads upward movements to start with but then Asda takes over, and that Asda always leads downwards movements – are robust to these small definitional changes.¹⁵

8. Disaggregate tests of leadership in regular prices

8.1. Branded versus own-label goods

One obvious comparison is between leadership in branded and own label goods. Within our sample 96 products are own label and 235 branded. Comparing upwards leadership across these two categories of goods, we see that both are led up roughly equi-proportionally by both Asda and Tesco. A more significant comparison is between upward led moves on branded products by the two firms and simultaneous upward moves, as set out in the upper panel of Table 5.¹⁶ It is apparent from this that Asda takes over from Tesco in 2008 in leading branded good prices upwards.

¹⁵ Obviously, the probabilities of a random outcome change from those described above because the event space changes, so the tests are slightly modified. Also, in two additional years, when looking at next week moves, there are small sample problems with the test. Results are available in the online appendix.

¹⁶ Own Label may be obtained by subtracting Branded (Table 5) from Aggregate (Table 4).

What is much more common is downward leadership of branded goods. This completely dominates over downward movements of own label goods. The middle panel of Table 5 covers these tests. Asda clearly leads branded goods down much more than expected by chance in every year of the sample. With Tesco, the picture is rather more mixed and sporadic. Only in 2006, 2009 and 2010 can we say Tesco leads branded goods down more often than would be expected by chance.

Very many of these downward movements are drops of a penny, covered in the bottom panel of Table 5. Again, neither firm leads on penny drops amongst own label products. Because simultaneous penny drops (and in fact, penny drops more generally) are rare before 2008, we focus attention on the last three years. Both Asda and Tesco lead branded good prices downward by a single penny very significantly more often than would be expected by reference to simultaneous penny drops (numerous though these are in the latter three years of our sample). Clearly, this became a major marketing tool, very possibly driven by the direct price comparisons the two companies engaged in, with well-known brands an obvious point of focus.

By the same token, whilst it remains clear that Asda leads price drops larger than a penny on branded goods far more commonly than would be expected by chance (wherever the numbers allow us to test this), only in 2009 does Tesco lead such larger price falls down more often than by chance.

These results nuance our broader findings slightly. Most significantly, price leadership appears far more prevalent on branded items than unbranded. Such leadership in upward price moves remains with Tesco in the earlier years but switches to Asda in 2008. Asda remains the clear leader in downward price movements on branded products. Very many of these are price leads down by a single penny in the years 2008 to 2010.

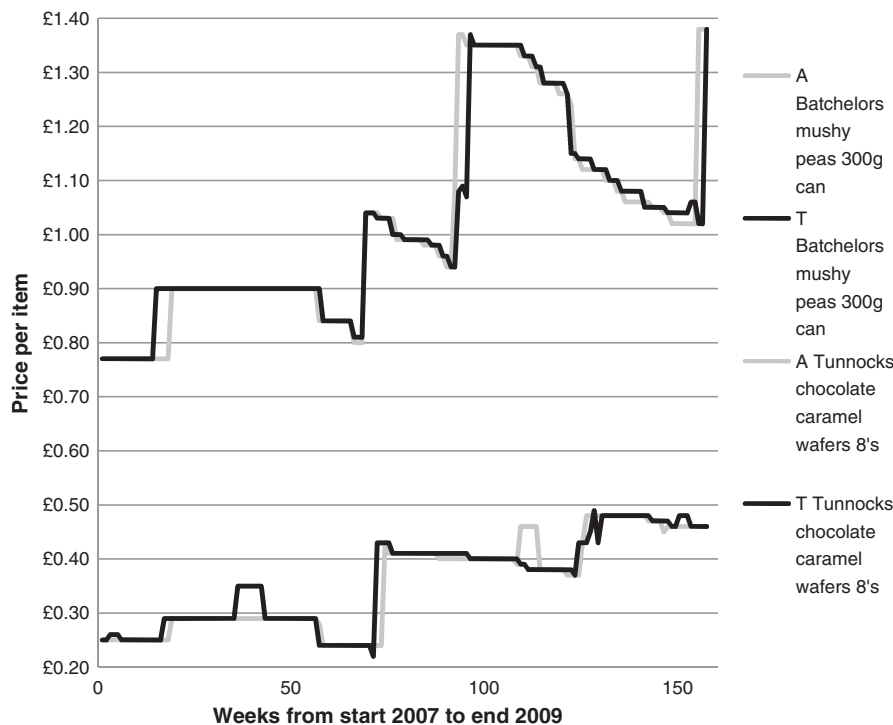


Fig. 3. Two examples of price paths for products where price has risen significantly over the period 2007 to 2009.

8.2. Comparisons across product types

Another interesting question is whether specific types of products (e.g. detergents, bread) are subject to price leadership. Plausibly, consumers notice and respond to the prices of some goods far more than others, implying we may see patterns across broad product types in leadership. Here of course we are constrained by product numbers in particular categories, as defined by COICOP (see Appendix Table A1). We have four categories with good numbers of products (Bread and Cereals; Milk cheese and eggs; sugar, jam, chocolate and confectionery; specified other food products) and two with reasonable numbers (processed vegetables; non-durable household items). Leadership activity certainly varies amongst them. Again, we use simultaneous price movements as a point of comparison. The table detailing the results, which is fairly lengthy, is relegated to the online appendix.

The most numerous category, Bread and Cereals, is also one of the most active. Both companies lead price movements on products. Tesco leads prices both up and down across all years and Asda leads prices down and, in later years, up. This provides a considerable contrast with the Milk, Cheese and Eggs category, in which there is no evidence of upward price leadership and little evidence of downward leadership within our sample. The Sugar, Jam, Confectionery category is one of the few where Tesco is more active in leading prices down than is Asda, which is rather more likely to lead them upwards. There is a lot of downwards leadership in Processed Vegetables, but only relatively little upward leadership from Tesco early on. Asda is more active in leading both up and down in the Detergents etc. category. In sum, there is quite a variety of experience looking across product types, rather than homogeneity of behaviour.¹⁷

In a little more depth, there are a few striking things emerging from examining behaviour across product type in relationship to

upwards price leadership.¹⁸ First, we observe only Tesco leading upward in the areas of tea and coffee products and spirits, whilst we observe only Asda leading up on beers. In the soaps and detergents category, we do not see any product example in which *both* firms lead up at one time or another, although there are particular items for which one firm or another leads. But the overall impression is of relatively limited patterns of specialisation amongst the wide range of product prices being led.

8.3. Impact of price leadership

Examining upward price leadership, a legitimate question given our narrow definition is whether those products exhibiting most upward price leadership episodes also increase most in price; there being several other means whereby prices can rise (e.g., simultaneous price rises). We examined the percentage price changes over time across all 331 products we use for this exercise and correlated these with the number of upward leadership episodes by each player. Tesco leadership episodes appear moderately important in explaining price rises, consistent with Deneckere and Kovenock's (1992) model with a simple correlation of 0.307 (significant at conventional levels), although this does not of course demonstrate causation. But for Asda, the correlation is insignificant at 0.076.

Also, within the most numerous sub-categories of goods in our sample,¹⁹ those that experience more Tesco price leadership episodes also exhibit greater overall price increases. Within Bread and Cereals, the mean price increase across the seven products with five or six instances of such leadership was 68.6%, whereas for those 16 with zero instances it was 34.4%, a figure which is significantly lower, based on

¹⁸ The comparisons in this and the following paragraph relate to raw numbers, not significance compared with simultaneous moves.

¹⁹ We look at sub-categories since within these products are likely to experience similar cost pressures. For example, if wheat rises in price, this will affect all bread and cereal products similarly. Less populated sub-categories exhibit too few degrees of freedom to examine this question with any degree of confidence.

¹⁷ This diversity of experience across product types does not appear to be determined primarily by the proportion of branded products within subgroups. Own label products are proportionately most common in the three subcategories Bread and Cereals, Milk Cheese and Eggs, and Sugar, Confectionery, Jam, which show a variety of experience.

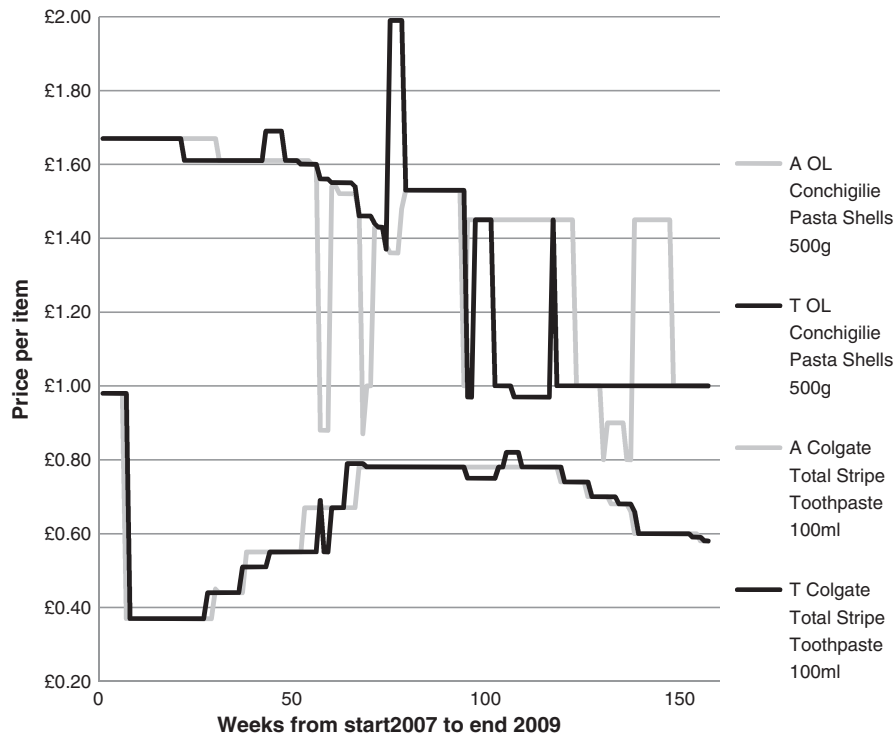


Fig. 4. Two examples of price paths for products where price has decreased significantly over the period 2007 to 2009.

a t-test for mean differences. Hence there is tentative evidence that upward price leadership is instrumental in raising prices.

8.4. Four case studies

To provide a more detailed flavour of our data, the following four case studies illustrate the nature, complexity and possibly limited nature of leadership. As we have seen, leadership is both upward and downward and engaged in by both parties, but is not the only means by which prices change. We have chosen to illustrate the patterns over the key period of 2007 to 2009 where upward leadership overall switched significantly from Tesco to Asda and where, even confining analysis to regular price changes, downward leadership increased to staggeringly high levels. Across the four cases, there are two examples of products where the NSB regular price increased markedly over the period and two where it decreased markedly. They illustrate (but are not necessarily representative of) both branded and own label products and we have also made choices based on ease of representation within a single graph at reasonable scale.

Looking first at Fig. 3, illustrating products where price rises significantly, the Tunnocks' chocolate wafers case (the upper two curves) looks like a classic Edgeworth cycle, a saw-tooth pattern of significant upward moves followed by downward smaller movements, albeit played out over a year. Almost all leads in this case are followed. The first key upward move is clearly initiated by Tesco, whereas the second in week 69 is simultaneous (although not from exactly the same level) and the final two upward moves start with Asda. Between the second and third upward moves, there is a downwards path with leadership alternating, whereas between third and fourth, Asda dominates the downward moves. In the case of Batchelors' mushy peas (the lower two curves of Fig. 3), not all moves are followed, with both firms attempting an upward move at one point that is not reciprocated, and no obvious saw-tooth pattern. Nevertheless, there is a key upward move led by Tesco in week 72 to 43p following which it declines slightly to 41p, followed by a long slight decline, then a

second upward move in week 122 started by Tesco but pushed higher by Asda to 48p, settling at 46p.

Fig. 4 shows two cases where prices end up a good deal lower than they began. Colgate toothpaste (upper pair of curves) exhibits some very noisy pricing behaviour, with a large number of unreciprocated moves in both directions. However there is one main large move downwards by Asda in week 94, followed by Tesco, preceding a series of apparent recantations to higher values but settling at around £1 to finish much lower than at the start. The lower pair of curves show a staggering early fall in the price of own brand pasta shells led by Asda but adopted by both players. There is then a gradual rise over a long period from around week 28, with the players taking turns to raise price first, settling for a while at 55p, but then rising to 78p, with some variance. In 2009 there is a slow decline in price led by Asda to around 60p.

All four cases, incidentally, illustrate that pricing to end in 9 is not a particularly common feature in our data. Price endings seem to range widely across the products and time. These cases also illustrate the closeness in these companies' prices on many occasions.

9. Conclusion

We have proposed a very tight, falsifiable, definition of price leadership then developed it, applied it to a particularly significant market and tested for significance. Although the definition is tight, we observe leadership to be a very common phenomenon, across the firms, products and time; it cannot be explained away as randomness in the data. It also appears that leadership, as narrowly defined, has become more important in recent years as a phenomenon in the British supermarket industry. But we cannot identify either firm as the consistent food market leader.

Leadership differs over products as well as time, particularly regarding upward price leadership, where it clearly switches from Tesco to Asda in the latter years of our sample. This is consistent with the more recent theoretical literature's emphasis on endogenous upward leadership and occasional changes in leadership engendered

by shifts in loyalty, rather than leadership by a single dominant firm, or the largest firm. There is no evidence that it is related to collusion, although there is limited evidence of it influencing pricing levels. The extensive downward price leadership is, in some instances, consistent with cycles of the Edgeworth kind. Of course, the theory does not predict that Edgeworth cycles are the only outcome, merely a distinctive one. Also, consistent with Eckert's (2003) theoretical predictions, Asda, the smaller firm, dominates overall in downward price moves. We are necessarily agnostic on whether the price moves relate closely to underlying changes in costs.

Overall however, what we observe, including the relative focus on branded goods, is also consistent with a casual theory in which supermarkets are very concerned about their position on price comparisons

for particular products. Thus we see substantial volumes of downward price moves on branded products, not necessarily fitting closely to Edgeworth cycles, followed defensively by the other player, presumably in order that their supermarket is not judged by consumers as being relatively expensive.

Our aim has been to analyse leadership behaviour in the industry using a framework where we test for significance against random alternatives and linking it to established positive models of the phenomenon. Whilst we have limited evidence in one category of goods (Bread and Cereals) that products led upwards increase more in price than others not led, this is far from a conclusion that price leadership is a major driver of rapid price increases, particularly given the extent to which downward price leadership is observed.

Appendix A. Sensitivity to the two-week window for regular prices

We chose our time period, within which one of the players must follow the other in a move to a different price level to count as a leadership event, as two weeks. However, although informed to some extent by industry practice, this is necessarily a little arbitrary. Hence we explored the sensitivity to the period being alternatively one week or three weeks. The broad results are set out graphically below and more detailed results are available in the online appendix. Observe that in most cases there is only a marginal gain, in terms of numbers of cases where Asda or Tesco leadership is seen in the data in each year, from increasing the time to three weeks; there is also of course potentially more "noise" introduced given the longer period. In most cases significantly more events are captured using a two-week rather than a one-week window, indicating perhaps that one week would be too short to capture the effects. What is reassuring is that the basic pattern of leadership events is very similar in structure across the three potential time periods and this is confirmed in formal tests reported in Section 7 above. Therefore we retain the two week window for our analysis.

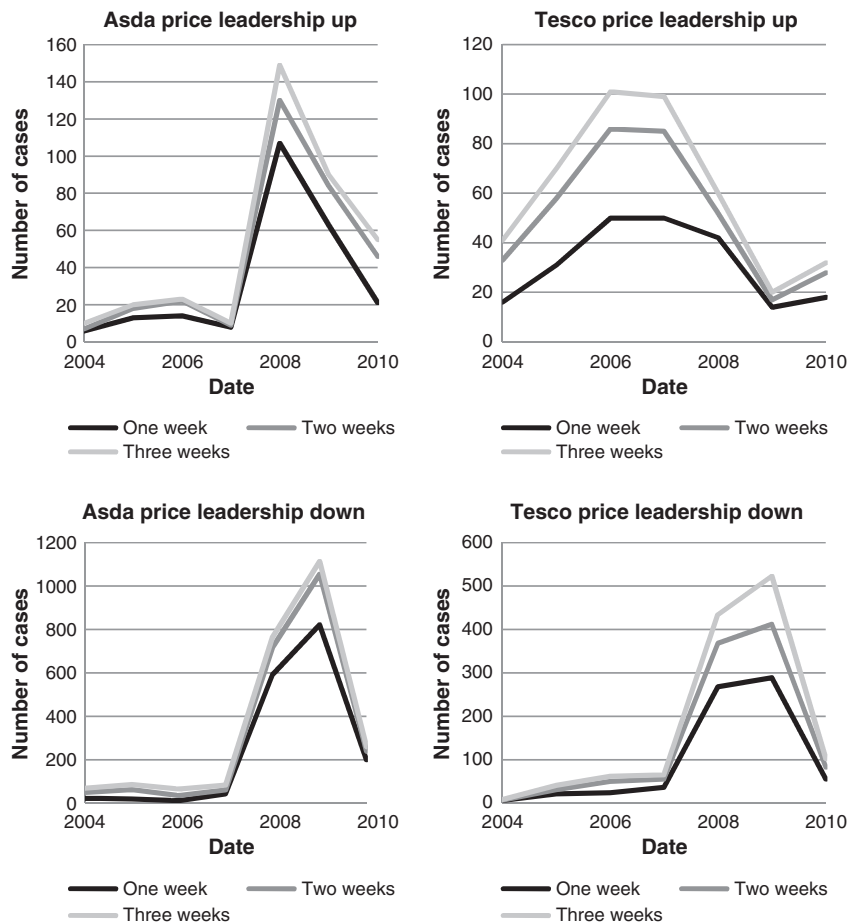


Fig. A1: Sensitivity tests on leadership patterns given different times to respond (Note, the vertical axis is not to the same scale across the four figures).

Table A1

Distribution of the sample of products across product categories.

COICOP classification	Products (additional description)	Product numbers
01.1.1	Bread and cereals (including breakfast cereals)	71
01.1.4	Milk, cheese and eggs (including simple manufactures e.g. cream)	40
01.1.5	Oils and fats (olive oil, margarine, butter etc.)	20
01.1.7	Vegetables (mainly canned goods such as beans)	24
01.1.8	Sugar, jam, chocolate, confectionery etc.	32
01.1.9	Food products n.e.c. (sauces, ready-prepared food, condiments)	58
01.2.1	Coffee, tea and cocoa	9
01.2.2	Mineral water, soft drinks, fruit and vegetable juices	2
02.1.1	Spirits (whisky, gin, etc.)	11
02.1.3	Beer (canned and bottled)	9
05.6.1	Non-durable household goods (detergents etc.)	25
09.3.4/5	Products for pets (pet food etc.)	16
12.1.2/3	Articles and products for personal care (e.g. tissues, toothpaste)	14
TOTAL		331

Note: These products are listed by COICOP category. This is Classification of individual consumption by purpose, developed by the United Nations Statistics Division to classify and analyse individual consumption spending.

Appendix B. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.ijindorg.2013.07.002>.

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