PRICES, PROFITS, AND PASS-THROUGH OF COSTS ALONG A SUPERMARKET SUPPLY CHAIN: BARGAINING AND COMPETITION[1]

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Abstract

In this paper we present an empirical study of a supermarket supply chain to understand the determinants of prices and profits enjoyed by farmers, processors and supermarkets. We study the liquid milk market which has seen much controversy about both the distribution of rents and the mechanisms firms have used to influence the distribution. We discuss insights from a series of interviews we conducted with executives and farmer representatives. Our interviews suggest a model in which the farmer's price is determined mainly by the sterling value of international commodity prices, the retail price is determined by marginal costs and the intensity of supermarket competition, and the wholesale price is determined in private bilateral negotiations between retailers and processors which are characterized by well-informed agents and a high level of efficiency. We present a simple theoretical model that captures these features and bring it to data on supply chain prices for the period 1994-2014. We find that over this period there has been great variation in the intensity of retail price competition and in the sterling value of international commodity markets, which together result in large changes both to the overall surplus in the supply chain and to its distribution between farmers and the other firms. After farmers have been paid the sterling value of international commodity prices, the profit that remains to be split between processors and retailers mostly goes to supermarkets, because of competition between processors.

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I. INTRODUCTION

There are many reasons to be interested in food supply chains. Their operation impacts the prices paid by consumers and the distribution of rents along the supply chain. One of the most commonplace concerns is the high level of concentration at supermarket level, and its implications for suppliers and consumers.[4]

The UK milk supply chain has been the focus of much controversy. The issues include the intensity of retail competition, the volatility of farmer welfare, and the distribution of supply chain profits between supermarkets, processors and farmers.[5] The controversy is not only about the distribution of rents between supermarkets and suppliers, it is also about the methods used to change the distribution: a recent attempt by retailers and suppliers to pass through costs to retail prices, and pay farmers a higher price, was condemned as unlawful by the Office of Fair Trading (OFT). Some of the supermarkets argued that they should not have been penalized for these methods, as that they had been designed to help farmers pass on their costs "at a time of considerable economic pressure and public debate about whether farmers were getting a fair price for their products."[6]

How much market power is exercised by supermarkets in fresh milk supply, and how is the profit distributed between supermarkets, processors, and farmers? What determines this distribution and why does it change over time? What is the nature of bargaining between processors and retailers? Why is farmer profitability so volatile?

To answer these questions we build an empirical model of the milk supply chain in the UK. We do this in three stages. First, we present insights from a series of interviews we conducted with executives at various stages in the chain, and draw some lessons from competition inquiries. Second, we use these insights to develop a simple theoretical model of prices and rent distribution in the supply chain. Third, we combine the model with data on prices to analyse profits along the milk supply chain between 1994 and 2014.

Our interviews, and the competition cases, find that retailers are individually very reluctant to differ from each other in terms of the retail price of milk, such that they are unwilling to make unilateral retail price changes that they think would lead to such a difference. This in turn means they must bear the full cost if they concede to a supplier a wholesale price increase that

[4] An investigation in the UK by the Competition Commission (CC) into the grocery market (see CC (2007)) led to the appointment of a Groceries Code Adjudicator in 2013, who now has the power to impose fines (up to 1% of turnover) on supermarkets that violate a code of good practice towards suppliers.
[5] See the discussion surrounding the variability of farmgate prices in House of Commons (2015).
[6] Justin King, Sainsbury CEO, quoted in the Guardian 7th December 2007.

is unrelated to an industry-wide cost and retail price increase. We find that the wholesale price is determined in private bilateral negotiations between retailers and processors, and that these negotiations are characterized by a high level of certainty on each side about costs and volumes. The negotiations appear to be consistent with a model of efficient bargaining. Suppliers claim that supermarkets have many tactics for extracting surplus. Our interviews also indicate that farmers are largely price takers and have little ability to raise prices on their own, but if they are unhappy with the prices they get from domestic supply they have the alternative option of supplying milk to commodity markets, as their output is readily tradable.

In our empirical evidence we find that there is great variation in the overall level of profit to be distributed between the firms and farmers. This is a consequence of changes to the intensity of retail price competition. The proportion of this overall surplus that is secured by farmers is changes from year to year, depending on international commodity prices, which determine the domestic price that farmers can secure. The profit that remains, after farmers have been paid, is split between processors and retailers, and most goes to supermarkets, because of competition between processors.

The paper is of relevance to food supply chains in economies other than the UK and to products other than milk. In many other countries milk prices and the distribution of profits are matters of intense policy discussion and many of the issues that we discuss for UK milk have been debated and discussed elsewhere, e.g. see Cotterill et al (2003) and Coterill (2006) for a discussion of the US liquid milk market.

The model discussed here is likely to be applicable to other food products with a similar vertical structure, involving three levels namely farmers, processors/packagers, retailers, in which the tradability of the farmers produce affects the prices they can obtain. A large number of food products, in many countries, share these features, and have a similar level of market concentration at each level of the supply chain (cheese, bread, eggs, fruit, and meat, are just a few of many possible examples).[7] Moreover, the insights, from our interviews, on the bargaining process between supermarkets and manufacturers, are likely to apply to many products sold in supermarkets: the practices discussed in these interviews have been mentioned in the context of a wide range of other products.[8]

One of the issues discussed in the paper is the dissatisfaction among farmer groups of the extent of pass through of upstream costs to wholesale and retail prices. The extent and rate of pass

[7] See Clarke at al (2002) for a discussion of the market structure of food supply chains in the EU.
[8] See for example Chapter 9 of Competition Commission (2007).

through has been studied for a number of other food markets. Namura and Zerom (2010) study cost pass through in the coffee market using data on retail and wholesale prices in the US, and find a role for menu costs. Misra et al (2010) study the US liquid milk market and find cost pass through in the milk category is asymmetric (when comparing cost rises and cost falls). Loy et al (2014) consider pass-through in the German milk market. The paper is also related to the literature on the effect of international trade on supply chain margins (for example Hellerstein (2008) for the case of beer).

Finally the paper is related to the theoretical literature that seeks to understand relations between firms in supply chains (see for example Katz (1989), Inderst and Wey (2003)). There has been relatively little empirical work that brings theoretical models to data on food supply chains, as this paper does.[9]

The rest of the paper is organised as follows. In Section II we describe the structure of the milk supply chain. In Section III we discuss the market for raw milk. In section IV we present insights from a series of interviews we conducted with executives, and draw conclusions on the nature of bargaining between suppliers and retailers. In section V we discuss what we can learn about retail pricing from recent competition cases. In Section VI we set out a simple model of vertical relations that predicts the prices of retail, processed, and raw milk. In Section VII we take the model to the data to analyse changes to prices and profits in the supply chain. Section VIII concludes.

II. THE MILK SUPPLY CHAIN

The supply chain for fresh liquid milk has three levels: farmers, manufacturers, and retailers. There are three corresponding products: raw milk, processed milk, and retail milk. Figure 1 shows how they are related. Farmers produce raw milk and either sell directly to processors or to cooperative groups who sell to processors. A farmer that sells to cooperatives receives a standard farmgate price (f). This is the price the farmer gets for milk to be picked up at the farm. If the farmer supplies directly to a processor then she may get a higher price, to compensate for the extra requirements of direct supply. [10] Farmers have two corresponding types of contract: a standard contract between a farmer and a cooperative, for onward sale to processors, and a direct contract, directly between a farmer and a processor.

[9] See Villas Boas (2007) for a study of the yoghurt market. See also Chipty and Snyder (1999) and Grennan (2013) for examples of empirical bargaining models for supply chains outside the food market.
[10] These costs are mostly (i) the cost of guaranteeing the steady annual supply required for retail milk and (ii) the risk associated with the relative insecurity of such contracts.

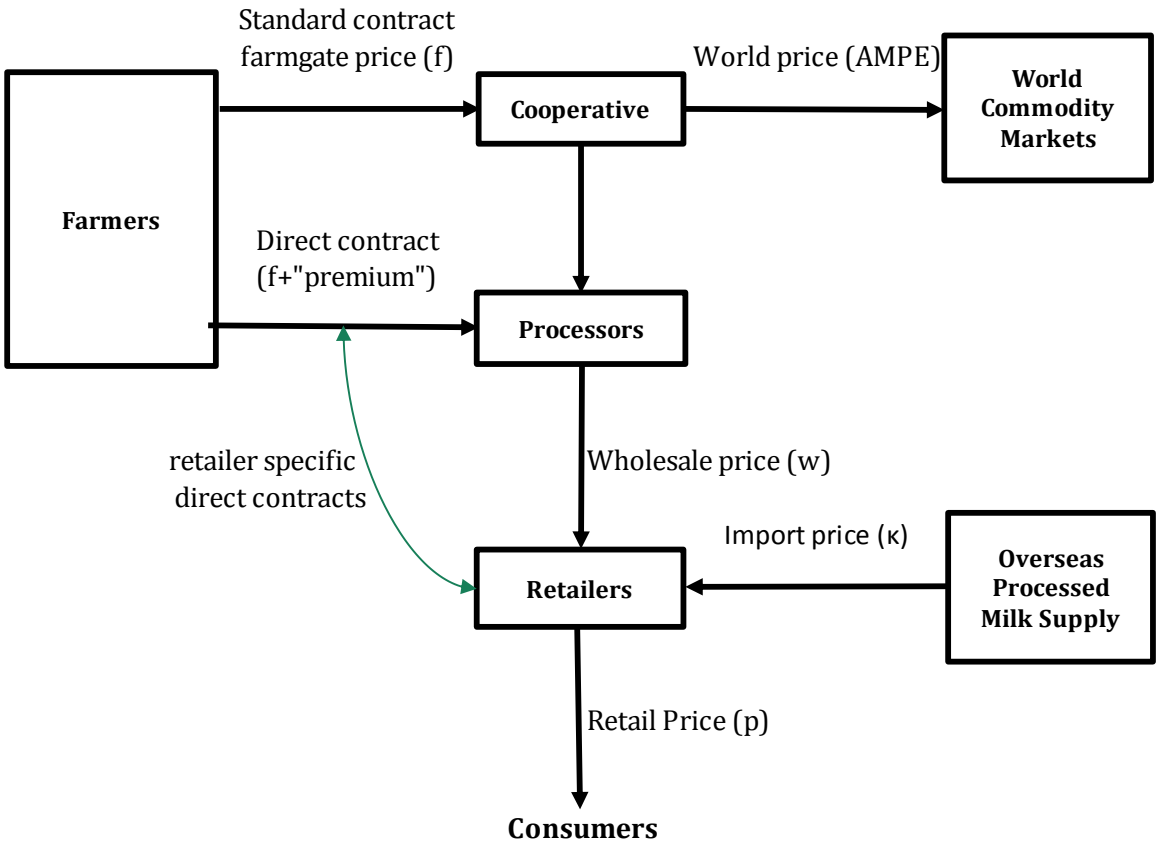


Figure 1: Organization of the Milk Supply Chain

A recent development is that consumers are increasingly interested in the provenance of food products. Retailers have responded by asking processors to ensure their milk can be traced back to an exclusive group of farmers, who are on retailer-specific contracts. The milk must not mix with milk from other farmers. These contracts require higher standards of agricultural practice in return for higher farmgate prices. Though the farmer is paid by the processor, the retailer agrees with the processor the price its farmers are paid, and these prices are public. In our interviews with executives (discussed in section IV), one supermarket emphasised the animal husbandry conditions that came as part of the contract, such as a ban on exporting live calves. This supermarket said that retailer-specific farmer contracts were a response to research which had shown consumers were concerned about how supermarkets treat farmers. A further advantage is that by vetting the farmers the supermarket can avoid the least efficient farmers.[11]

[11] As noted in Coleman and Harvey (2004), farmer productivity is very heterogeneous, and related to scale of production.

About half of raw milk is made into fresh liquid milk for the retail market. The other half is processed (often by the cooperative) into alternative products, some of which, such as skimmed milk powder, commodity cheese and butter, are traded on world markets. A measure of the farmgate value of milk sold to commodity markets, known as AMPE (Actual Milk Price Equivalent), is calculated by DairyCo; we use this measure later in the paper.[12]

The processors pick up the raw milk from farmers, or the coop, and pasteurize, bottle, and deliver it to supermarkets for a wholesale price w. The wholesale price is determined in bilateral negotiations. If these negotiations break down a retailer told us that retailers could, as a last resort, import fresh milk from overseas, at an effective price denoted κ, including shipping costs, but this is generally inefficient and nearly all fresh milk is sourced domestically.[13] Finally, retailers sell milk to consumers at price p_r.

Farmers are numerous, and are price takers. In contrast there are only a few cooperatives, processors, and supermarkets. The competition authorities have intervened to split up the cooperatives to ensure the market for raw milk is competitive. At the same time they have allowed a concentrated market structure to emerge at processor stage: since 1994 the number of processors capable of supplying supermarkets has fallen from six to three. [14] Supermarket supply is also very concentrated: the largest four supermarkets supply around 65-70% of the retail milk market. They now face little competition from the processors' doorstep delivery business, which has declined rapidly since 1994.

III. THE MARKET FOR RAW MILK

From the 1930s to 1994, milk farmers in Great Britain were required by law to sell to the local milk cooperative. The largest was the Milk Marketing Board (MMB) of England and Wales, with over 80% of GB raw milk, implying a legally-protected monopoly position when selling raw milk to processors. After deregulation in 1994 it became legally possible for farmers to have direct supply contracts with milk processors. By 1998 the MMB (now known as Milk Marque) had lost about a third of its farmers and its market share had fallen to about 50% of GB raw milk.

This large market share led to the market being referred to the Monopolies and Mergers Commission (MMC (1999)). They noted that the cooperative, Milk Marque, had a *buyer of last resort* role: a farmer failing to secure a direct contract with a processor was guaranteed one by

[12] DairyCo, formerly known as the Milk Development Council, is an officially instituted levy-funded not-for-profit dairy farming organisation that provides information and advice to farmers and other industry participants, and promotes research into the milk supply chain.
[13] See DEFRA (2007) for a discussion of this possibility.
[14] See CC (2003) for a detailed discussion of the liquid milk supply chain.

Milk Marque. The MMC noted that, in consequence, all direct buyers set prices to farmers *with reference to* Milk Marque's prices (in some cases explicitly so), and concluded that Milk Marque could thus effectively set the price of raw milk. Milk Marque was broken into three regional cooperatives, with the aim of a more competitive raw milk market.

Table 1 shows that the price premium between direct and cooperative contracts still applies in 2014. The cooperative contract pays the lowest price 30.29 pence per litre (ppl), and farmers are rewarded by about 1ppl if they opt for direct contracts with processors. Farmers can supply as much as they want at the negotiated prices for the contract they are on. Typically they have a 1-year notice period if they wish to change to a different contract. The Table also shows examples of retailer-specific direct contracts, for which there is a further price advantage.

Table 1: Selected Contracts between Farmers and Raw Milk Buyers

Contract	Type of Contract	Annual price July 2014 (ppl)
Dairy Crest M&S	Retailer Specific Direct	34.41
Arla Tesco	Retailer Specific Direct	33.82
Dairy Crest Sainsbury	Retailer Specific Direct	32.92
Dairy Crest Liquid	Direct	31.14
First Milk Liquid	Coop Contract	30.29
Average Farm gate Price	-	31.79

Source: DairyCo.

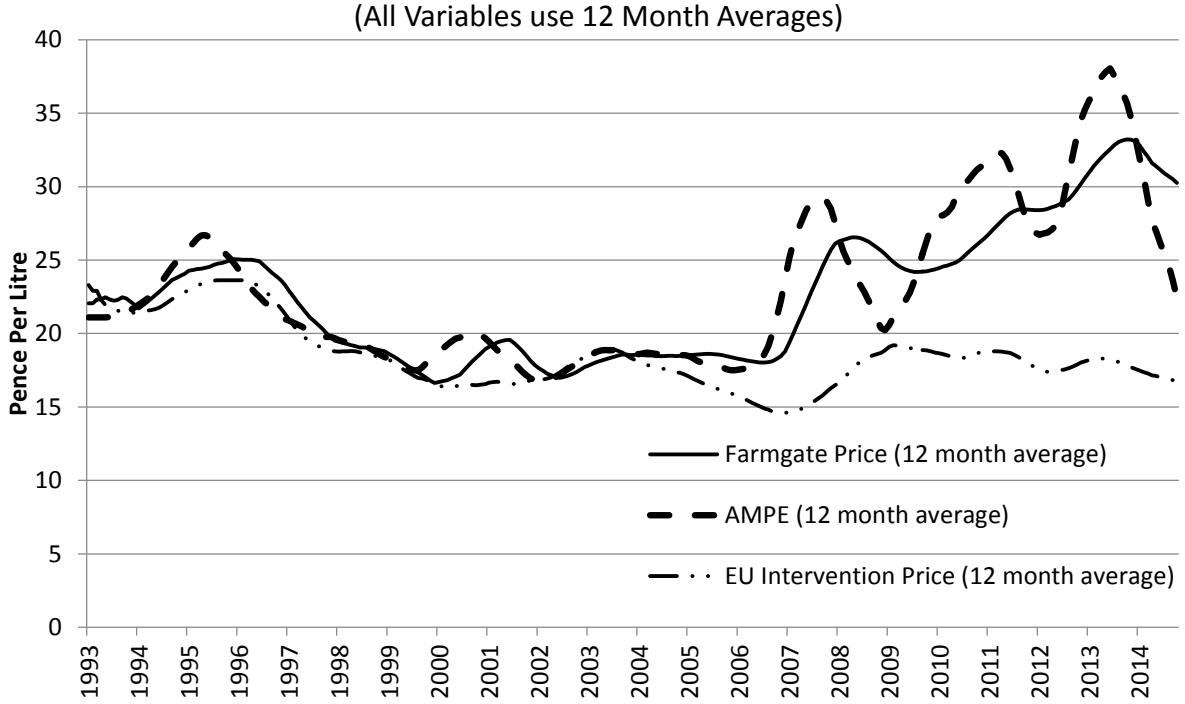
Farm gate prices for milk, regardless of type of contract, are strongly related to international milk commodity markets. The per-unit opportunity cost to the cooperative of supplying raw milk to a processor is the price forgone from its use in commodity markets. When the world price of commodity milk products is high, the alternative to supplying the processor is attractive, so the cooperative must be offered a correspondingly high price by the processor, which is returned to farmers.

The farm gate price can also be affected by the EU's Common Agriculture Policy under which intervention purchases of butter and skimmed milk powder are made when prices fall below pre-determined floor levels. The intervention stocks can be released onto markets when prices rise. These intervention prices are set in euros, which means that if sterling strengthens the sterling value of the intervention support price will fall.

Figure 2 plots three data series to show these determinants of farmgate prices. All series are 12-month averages, which allows us to smooth out seasonal variation. The series *Farmgate Price* is the average price (in pence per litre) paid to milk farmers for raw milk. *AMPE* is a measure of the farmgate price implied by international commodity markets. Also on the chart is

the EU Intervention Price, converted to Sterling, measured using DairyCo's variable *IMPE*. As Figure 2 shows, there is a close relationship between IMPE and the farmgate price between 1995 and the end of 2003, but not thereafter. The farmgate price tracks AMPE closely, though recently AMPE has been the more volatile of the two.

Figure 2: Farmgate Price and Commodity Prices
(All Variables use 12 Month Averages)



What accounts for the variability in world commodity prices in Figure 2? The fall between 1995 and 2000, the source of much financial pressure on farmers, was in large part a consequence of the appreciation of sterling against other currencies, resulting in a reduction in both the value of selling to world commodity milk markets and the EU intervention price. The increase from 2007 is commonly linked to a drought in Australia and increasing demand in China. More recently a Russian ban on EU milk imports in 2014 has depressed prices. An implication is that farmer fortunes are volatile. The actual on-farm costs of producing raw milk depend on the costs of inputs such as agricultural feed, fertilizer, and fuel. These can themselves be volatile and have little relationship to world commodity prices of milk. Coleman and Harvey (2004) estimated that in 2003 about 60% of dairy farms and 40% of milk by volume in England and Wales made a loss relative to marginal on-farm production costs. Bell et al (2008), in a study for the Scottish government, noted that the commodity price rises of 2007 outstripped the rise in feed, fertilizer and fuel prices, resulting in an increase to farm profits.

IV. NEGOTIATIONS BETWEEN PROCESSORS AND SUPERMARKETS: INTERVIEW EVIDENCE

A major challenge in the study of retailer-supplier relations, in general, is that negotiations are private. To build a picture of how the supply chain for liquid milk should be modelled we conducted interviews with senior executives in the dairy supply chain in the period 2006-7. We interviewed two executives from the biggest four supermarkets, one executive from a milk processor, and two farmer representatives: one from a cooperative, and one from the National Farmers Union. We also interviewed a manufacturer of a branded good that uses skimmed milk powder as an input, and which is sold to supermarkets. There was high level of consistency across the interviews.

THE PROCUREMENT PROCESS

There are two levels in the procurement process: tendering, when the supermarket approaches a number of suppliers to make bids, and ongoing renegotiation over prices with a continuing supplier when costs need to be passed through. KPMG (2003) describes the tendering process between supermarkets and milk processors as follows:

> "Negotiations...seem to follow guidelines which are relatively common across most supermarket/supplier relationships. The trigger is usually an invitation to tender by the supermarket or a periodic supplier review programme similar to the Sainsbury initiative in early 2002. The invitation to tender usually contains a demand profile using assumed quantities and container sizes. Bids are made on a per-gallon basis, regardless of actual product size, and a supplier is selected." (Para. 178-179)

Our interviews confirm this description: tendering is initiated regularly by the supermarkets, an assumed volume is specified, and prices are on a per-unit basis. The supermarket typically contacts all major processors. When established contracts are broken off it is usually a consequence of supermarket retendering. Contracts can be cancelled with three months' notice. A supplier indicated that a supermarket might invite them to tender as follows:

> "...the chips are all up in the air, tell us how you would like them to come down."

The supermarkets can easily switch large volumes from one supplier to another, resulting in great output volatility on the part of processors, as noted in the following paragraph from Competition Commission (2002):

> "It is now the case that a high proportion of the sales of each processor to national multiples is concentrated in only three or four customers, such that the loss of any one

of these is likely to have a serious consequence for the processor. The merger parties told us that the national multiples were fully aware of this fact and play off the major processors against each other. [The national multiples] have the ability to switch volumes easily between suppliers [...]. In contrast a processor cannot readily find another avenue to market if it loses sales to a national multiple." CC (2003, Para. 5.97)

The motive for tendering varies. One motive is the supermarket being unhappy with existing prices. Retendering has been triggered when a processor, unsuccessful in a recent retender, approached a new supermarket offering to supply on better terms. Alternatively, tendering happens for non-price reasons, such as a new approach to milk supply, such as the retailer-specific direct farmer contracts we mentioned in the previous section. In general, logistics are complicated enough that detailed bilateral discussions are always required, which may explain why negotiations are preferred to auctions.

Supermarkets differ in the number of processors they use. One of the supermarkets bought from two processors, supplying distinct sets of stores. The number of stores supplied by each processor could be flexed as a bargaining tool. This supermarket was seen by other executives as being keen to play processors off against each other. The other (similarly sized) supermarket obtained all its milk from a single supplier.

Table 2: Volumes Sold to Largest 4 Supermarkets by Main UK Milk Processors

Date	Processor 1	Processor 2	Processor 3	Total
10/2003	585	690	870	2145
11/2004	575	555	1020	2150
1/2005	350	835	940	2125
10/2005	430	760	920	2110

Data from industry sources. Units are millions of litres per annum

There is considerable output uncertainty for processors, a consequence of the small number of supermarkets, and their ready willingness to switch. A processor can suddenly be faced with a retendering process and lose a large share of their output. Consider the volumes sold to the largest four supermarkets by the main competing milk processors shown in Table 2. In the two months between November 2004 and January 2005 the three largest supermarkets (accounting for around half of all UK grocery sales) all changed their suppliers almost simultaneously. The aggregate volume produced does not change much, reflecting the stable consumer demand for milk, but the volumes in each bilateral retailer-processor relationship changed greatly.

KNOWLEDGE OF COST AND QUANTITY

Retailers and processors both appear to have a very good level of information in the negotiations over wholesale prices. For suppliers, the expected volumes required from a deal

are predictable to a high level of precision. The contract would be for the entire consumer demand for milk at a supermarket, or some identified set of stores. The processor said the supermarket tells them "we expect to sell X units volume of stock keeping unit Y from distribution centre Z" for a number of Ys and Zs. One of the retailers pointed out that suppliers have good information as a result of being offered historic data on daily volumes by store for many years. Milk demand is not subject to large unpredictable shocks.

Actual realised volumes depend, of course, on the retail price. However this does not generate much uncertainty in the negotiations. This is a consequence of a policy on the part of the major retailers always to set a common retail price for milk. The supermarkets told us they had a strong aversion to differing on price and retailers are very reluctant to change their price individually. Though the retailers (jointly) change retail prices from time to time, this does not add much volume uncertainty as the aggregate elasticity of milk with respect to price is low. (An elasticity of -0.4 has been estimated in Lechene (2001)). Thus volumes are, more or less, known at the time of the contract.

One of the supermarkets said they considered themselves to be very well informed about the costs of the processors, in large part because they have information on logistics, production, energy, raw material prices etc., from a host of different suppliers as a result of their large product range, so they stand fully informed as to acceptable supplier cost changes for an efficient producer.

Relationship Between Retail Price and Wholesale Price

If a wholesaler could persuade a supermarket unilaterally to agree a higher wholesale price, our interviews suggest that there would be no knock-on effects for the retail price of the supermarket. This is because of the supermarkets' strong aversion to deviating from each other in terms of retail price. One of the processors told us that changes to retail prices are not directly related to wholesale price, though it was likely that wholesale and retail prices could both be correlated with underlying industry-wide costs. We took this to suggest that negotiated changes to an intermediate price did not have direct price or volume consequences, i.e. there was not likely to be double marginalization.

Terms of contract: linear v non-linear prices

We were interested in whether firms negotiate only over marginal price or also over fixed fees. The interviews were consistent: contracts are over marginal price and there are no fixed fees. CC (2003) noted that the negotiated wholesale price is national and does not vary over regions. Thus the contracts are very simple.

Why are the contracts so simple? In economic theory, fixed fees are often suggested as a means to achieve a surplus redistribution between retailers and suppliers. Here, however, it may be that the wholesale price can be used for this purpose without retail price implications, following our discussion above. Moreover, as we report later in this section, the suppliers believe supermarkets have many other means to redistribute surplus, such as to demand an increase to the frequency of distribution. Our interviews indicated that volume discounts could happen if exceptional volumes were required; for one of the supermarkets there was a discount if volume exceeded some threshold level, above the normally anticipated levels. One of the supermarkets said that contracts with suppliers had to be simple for practical reasons: they had just 40 people managing a buying budget of £4.5bn per year and it was not practical to devise complicated tariffs.

The processor gave a clear picture of the negotiation process over the wholesale price. The price is fixed for about a year. There is an iterative procedure in which the processor first suggests a price, and then the supermarket responds:

> "We [the supplier] suggest a pence per litre price X. They [the supermarket] respond by saying "that is much too high, we could go to your rivals and get Y". And so it goes on."

The processor said that they did not know the prices their competitor firms were offering, and there is a question of whether the supermarket is bluffing when they say "we could go to your rivals and get Y" as in the quote above; alternatively it could indicate that the processor's own costs have strayed from best-practice. The supermarket does sometimes change supplier and, the processor argued, this could be partly so as to keep threats of moving believable.

Bargaining Practices of Supermarkets and Processors

CC (2003) found that national multiples are able to exercise a significant degree of bargaining power in respect of purchases of liquid milk. The interviews shine some light on why this might be the case.

One retailer said that they could ultimately resort to importing fresh milk from outside Great Britain, e.g. Ireland, if they were unable to agree a deal with suppliers. On the other side the supplier said that the loss of a contract meant a corresponding loss of volume through their milk plants. These appeared to us to be their ultimate disagreement points in the negotiation.

One of the processors said that, in deciding what to bid in a re-tendering process, it considers the capacity situation of the other processors. For a large retail order, the winning rival might

be capacity constrained and then have to withdraw from other contracts. This puts limits on how aggressively the processor should bid.[15]

The only way a supplier could persuade a retailer to concede an increase to the wholesale price would be to make a justification based on costs. Even then both suppliers that we interviewed -- the liquid milk processor and the branded good manufacturer -- expressed dissatisfaction on the issue of passing through cost increases to the wholesale price. The milk processor said that if they wanted a higher price from a supermarket then they would make representations to the supermarket only if they were sure that other suppliers would be suffering similarly. This firm argued that the supermarkets were reluctant to concede a wholesale price increase on the grounds that unilateral retail price increases are impossible, so the wholesale price increase would be incurred fully by the retailer.

Both the suppliers that we interviewed said that the supermarket had many ways of extracting surplus. What the supermarket gave to the supplier by way of an increased wholesale price could be taken away by other means. The processor said the supermarket might condition the wholesale price increase on new terms on delivery, such as improvements to the frequency of distribution, which transfers surplus from the supplier to the retailer. The branded good manufacturer said that a wholesale price rise could be tied to a product innovation such as a new flavour. Sometimes the supermarkets would make unexpected demands for contributions to promotional campaigns. One supermarket had approached the branded goods manufacturer demanding £2m to cover such costs, or else they would remove the product from their shelves. The manufacturer refused to pay and the retailer carried out the threat.

Both suppliers said that, in negotiations over the wholesale price of any given product, there were threats on sales of other products: e.g. when negotiating the wholesale price of liquid milk the retailer might say "watch your next cheese contract". A supermarket might threaten to delist some products or package sizes, or reposition the product in shelf location. One of the supermarkets accepted that this was indeed a standard practice. The supermarket said that, as it buys many products, it is aware of cost changes that apply to products with common inputs (e.g. the costs of producing cooked meats and sausages) so price negotiations of products can be linked for this reason. But the retailer said that links can also be to encourage desired behaviour. The example was given of a manufacturer of cooked meals (spaghetti bolognaise)

[15] It seems plausible that a successful rival could sometimes find themselves constrained on winning a large order from a supermarket. The CC(2003) computed that following the merger of Arla and Express there would be excess capacity of 29% in the industry.

who was not innovating satisfactorily; this manufacturer was not allowed to supply any further products until investment on the spaghetti meal offering materialised. [16]

There was agreement that large retailers could, on average, secure lower prices than small fringe retailers, i.e. that large retailers had buyer power. But this was not always the case: small supermarkets might sometimes buy at a low price because suppliers could sell to them using unfilled gaps in capacity. Indeed, there was often more competition for these small supermarkets, as they could also be supplied by a fringe of smaller processors.

V. FARMER DIRECT ACTION AND RETAIL PRICE INITIATIVES 2000-2005

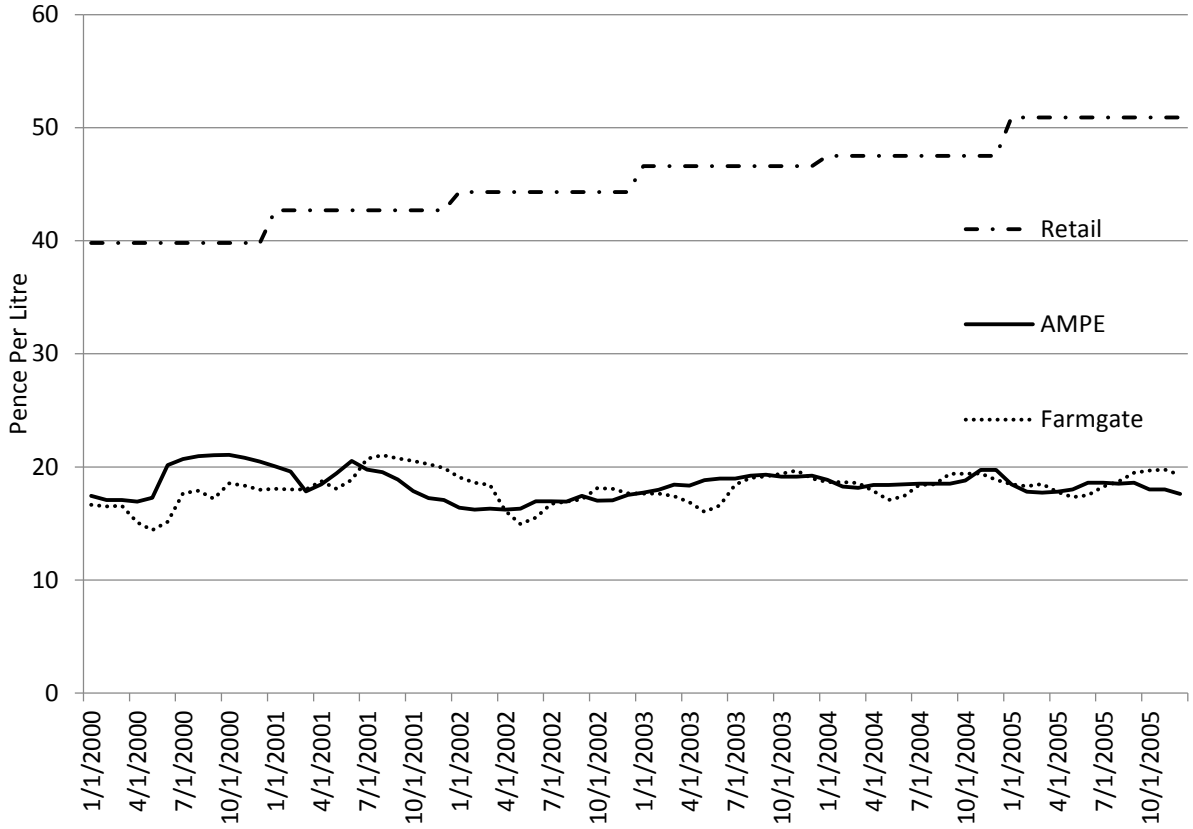
In the period 2000-2005 there was pressure from farmers for an increase in milk prices at all levels. The episode illustrates a feature of retail competition that plays a key role in motivating our theoretical model: that individual supermarkets are very keen to avoid differences from their competitors in the retail price for milk.

Figure 3 shows that over this period the retail price of milk increased from about 40ppl to over 50ppl. This would be expected to greatly increase revenue, assuming that the elasticity of demand for milk is about -0.4%, as estimated in Lechene (2001). The price rise was brought about in five steps, associated with farmer direct action events, and subsequent joint retailer-supplier led price increases, known as Retail Price Initiatives, listed in Table 3.

The background for these events was the fall in the farmgate price up to 2000, from about 25ppl to about 17ppl, which we saw in Figure 2. A direct action campaign group, known as Farmers for Action (FFA), led the call for higher farmgate prices, which, they argued, had fallen below on-farm costs of production. Farmers for Action used direct action: large agricultural vehicles blocking exit and entry to milk processing plants. These episodes were initially used against processors (and not against retailers), in 2000 and 2001, and were followed by an increase to farmgate and retail price changes.

[16] Some of the comments by suppliers, regarding supermarket negotiation practice, are similar to those by a much broader group of supermarket suppliers in Competition Commission inquiries (see CC (2007)).

Figure 3: Farmer Direct Action and Retail Price Initiatives



Farmers complained that the resulting increases in farmgate prices were transitory, while increases to the retail price were not. In 2002, following a slump in farmgate prices, farmers extended their direct action blockades to supermarket depots, with a view to influencing retailers. A senior manager of a milk processor said this move had a very strong impact because it affected all retail products, not just milk:

> They [FFA] had picketed us…at several of our sites. But when they turned up at the supermarket sites and they shut down a regional distribution centre, I think they were much more sensitive to being closed down than we were, because it encompassed all their business and certain stores could be extremely vulnerable to being out of goods. (OFT (2011)).

FFA pressed for joint price increases all along the supply chain, known as Retail Pricing Initiatives. These had the aim of getting supermarkets to increase their retail prices, on the understanding the price increase would be fully passed through to farmers, i.e. for each 1ppl increase at retail level there would be a corresponding 1ppl increase for milk farmers. Retail

prices increased under these initiatives in 2002, 2003, and 2005, with some dispute as to whether gains were fully passed through to farmers.[17]

Table 3: Direct Action and Retail Price Initiatives 2000-2005

Date	Principal Actors	Direct Action	Remarks
September 2000	Farmers and Processors	YES	Objective was to increase farmgate price to match recent commodity price rises. Largely successful. Retail price increase followed.
April 2001	Farmers and Processors	YES	Initially successful but did not last as farmgate prices followed commodity prices downwards in 2002. Retail prices did not fall.
September 2002	Processors and Retailers	YES	Now retailers are targeted in direct action. Retail price increases partly passed back to farmers. OFT investigated but did not charge.
July 2003	Processors and Retailers	NO	No direct action used from now on. OFT Investigated and charged some processors and retailers.
March 2005	Processors and retailers	NO	No investigation. Justified on the basis of rising processing and farmer costs. Farmgate price increases not maintained long.

Source DairyCo/MDC (2006).

In our interviews we asked executives why farmer action seemed to work in raising retail prices. Some executives emphasised the publicity cost. One mentioned a negative feeling amongst customers as to how dairy farmers were being treated. Another emphasised that there were severe financial costs from the interruption of deliveries. A letter from Safeway, to Farmers For Action, suggests supermarkets were sympathetic to the retail price increase, if the gains were passed to farmers, but were very reluctant to raise prices unilaterally:

> We would support a significant increase in the retail price of milk provided that the dairy farmers were the sole beneficiaries and that we did not thereby disadvantage

[17] It can be difficult to compute whether the price increases were fully passed on. One complication is that not all raw milk goes to liquid milk. One executive told us that some of the cooperatives passed on the benefits to all their dairy farmers, including those that produced cheese, which diluted the price increase.

> ourselves in what is a very price sensitive product market. Unilateral action by any major retailer to increase prices would be of no use to anyone. (OFT (2011)).

The Retail Pricing Initiatives were designed to allow multilateral price increases and hence avoided the main concern of the supermarkets: retail price differences with rivals. The Price Initiatives were even given support of the most public kind in a report by a House of Commons Committee of MPs, which stated: "We welcome the decisions of the supermarkets to increase the retail prices of liquid milk and cheese last year [2003] while specifying that the price increases must be passed along to farmers."

The OFT took a different view, however. It did not dispute the motive of the parties involved, namely the intention of passing the proceeds of increased retail and wholesale prices to UK dairy farmers to help them to cover on-farm costs. However, as the OFT pointed out, motives are not relevant to the legal question. OFT (2011) looked at documentary evidence, including emails between executives, and concluded that the 2003 initiative was unlawful under the 1998 Competition Act, because it involved the indirect exchange of retail pricing intentions between retailers via dairy processors, with a purpose to coordinate increases in the retail price of milk.[18]

VI. A Model of Prices and Margins Along the Supply Chain

To help analyse the data on retail prices we now develop a model of pricing in the supply chain, which is motivated by the interview evidence and the evidence from the OFT's investigation into the Retail Pricing Initiatives.

The model is as follows, beginning with farmers. The farmgate price f is the price the farmer receives at the farm from liquid milk buyers. We assume farmers have an alternative of selling to the commodity milk market at an exogenous effective price $a = p_c - \gamma$ where p_c is the world price of commodity milk and γ is the marginal cost of converting farmgate milk to commodity milk. Thus a is the opportunity cost at the farmgate of supplying liquid milk. We assume farmers are price takers so that the farmgate price f they get for liquid milk matches their marginal (opportunity) cost:

$$f = a.$$

[18] The OFT also looked at Cheese Retail Price Initiatives and found some firms had violated competition law. One of the retailers appealed the OFT's decision regarding the Cheese Retail Price Initiatives to the Competition Appeals Tribunal, which in 2013 upheld some but not all of the OFT's decisions.

In this analysis we do not therefore assign any bargaining power to the cooperatives on behalf of the farmers they represent. We will see that this does not appear to be a strong assumption as our modelling framework can closely explain the supply chain prices.[19] Some farmers are on direct contracts and receive slightly more, say $a + \varepsilon$ where ε is an additional premium to compensate for the extra costs of direct supply. We assume that the direct farmers are infra-marginal: they supply the base load and therefore are irrelevant to the cost of milk at the margin for any retailer or processor.

We assume the cost of converting a unit of raw milk at the farm to a unit of retail milk at the store is a constant, denoted m. The overall marginal cost c of retail milk is thus the farmers opportunity cost of supply at the farmgate added to the cost of converting farmgate milk to retail milk:

$$c = m + a$$

We saw in our discussion of the Retail Price Initiatives, and the interviews, in the previous sections, that retailers do not tolerate price differences with rival retailers for liquid milk, and that retail price changes happen from time to time depending on two factors: changes to the marginal cost of milk (mostly driven by the available price on commodity markets, a) and changes to the intensity of price competition (either because of a Retail Price Initiative or some other change such as the loss of competition from doorstep milk). We capture the intensity of retail price competition using the parameter θ. We allow this to change over time. We assume that the equilibrium price at any time is a function of these variables, given by the following reduced form pricing equation:

$$p = p(c, \theta). \qquad (1)$$

Notice that wholesale prices do not appear in this expression: there is no double marginalization. An individual retailer that concedes a change to their own wholesale price does not expect retail prices to increase unless it is associated with a change in industry-wide marginal cost c; this is consistent with our interview evidence.

The wholesale price w is determined by processors and retailers in bilateral negotiations, treating expected retail prices as given. Our interviews suggest that the parties have a high level of information about volumes and costs and the negotiations are over prices per unit. Since retailers are unwilling to pass changes in their individual wholesale price to retail price, it

[19] In unreported work we have extended the analysis to model the bargaining power of the cooperatives. This adds complication for only a modest increase in explanatory power.

follows that the parties have in mind an expected retail price p from equation (1) and hence an expected volume, given by demand function $q(p)$.

If the firms agree a wholesale price w then the retailer's payoff is $(p - w)q(p)$ and the processor's payoff is $(w - c)q(p)$. To complete the model of bargaining we specify a disagreement point: the payoff each party obtains if they fail to agree. For the retailer, suppose it is possible, as a last resort, to import fresh milk from abroad at an effective marginal price κ. For the processor we assume the disagreement payoff is zero, as it loses the milk contract altogether. This yields the following disagreement payoffs: $(p - \kappa)q(p)$ to the retailer and zero to the processor.

Let $w(N)$ denote the equilibrium wholesale price when there are N processors. Suppose, initially, there is only one processor. The price $w(1)$ that solves the Nash Bargaining Solution to this problem is given by

$$w(1) = c + (1 - \lambda)(\kappa - c) \tag{2}$$

where λ is the bargaining skill of the supermarket. This is intuitive: when $\lambda = 1$ the supermarket has all the bargaining skill and can to obtain a wholesale price equal to marginal cost. At the other extreme, $\lambda = 0$, the manufacturer can push the price up to the price of the imports κ, which is the supermarket's disagreement point. We describe $(\kappa - c)$ as the bargained-over margin.

Now suppose there are two processors and supermarkets have no preferences over them: the supermarket picks one and negotiates. If there is a disagreement with the chosen processor the retailer will go off and bargain with the other processor. If he does end up in negotiation with the second processor we assume he cannot return to the first, so the bargaining game is therefore, at this stage, identical to the position when there is only one processor. Thus the retailer's negotiated wholesale price with the second processor would be $w(1)$, as given in equation (2). By a backward induction argument, the negotiation with the first processor will now have as its disagreement point $w(1)$ instead of κ. So we simply replace κ in equation (2) with $w(1)$ to get the negotiated wholesale price when there are two processors, i.e.:

$$w(2) = c + (1 - \lambda)(w(1) - c) = c + (1 - \lambda)(1 - \lambda)(\kappa - c)$$

Using the same logic the equilibrium wholesale price with N firms is

$$w(N) = c + (1 - \lambda)^N(\kappa - c). \tag{3}$$

Given that $(1-\lambda) \leq 1$ an increase in the number of processors N generally reduces the wholesale price. This is because the supermarket's disagreement point (and hence bargaining position) is improved the more alternative processors there are to turn to before it must import the milk. An assumption made in this model is that the retailer is not able to return to the first processor if negotiations break down with a later processor. If it could, then we would have Bertrand competition between suppliers, which yields marginal cost pricing. (Our model nests this case, as there is marginal cost pricing when $\lambda = 1$).[20]

Which exogenous variables determine prices along the supply chain? There are five key parameters. The intensity of retail price competition θ impacts retail prices, for any given marginal cost c, and hence the overall surplus to be shared. The international price for commodity milk, a, shifts all three prices: farmgate, wholesale, and retail. The margin that goes to wholesalers is determined by the number of processors N, the cost of importing fresh milk from abroad κ, and the bargaining power of the supermarkets λ; these three parameters redistribute surplus between processors and retailers and do not influence farmers or consumers.

VII. Milk Supply Chain Prices and Margins 1994-2014

The total price-cost margin in the supply chain, and the share of this margin that is taken by farmers, suppliers and retailers, has changed dramatically over time, from deregulation of the market for raw milk in 1994 to the present day. We now bring the model that we developed in the previous section, to the data on supply chain prices, in order to understand these changes.

The milk supply chain is relatively transparent compared to other supermarket supply chains, which allows us to use empirical variables that match the theoretical model very closely at all three levels of production in the chain. The farmgate price f is measured using an average figure for the raw milk price, computed by the UK government department responsible for agriculture (DEFRA). The wholesale price of milk w is calculated by DairyCo using information (only available up to 2011) from processor annual reports. The retail price p is measured using a price index for a litre of milk sold through retail outlets, supplied by DairyCo.

The opportunity cost to the farmer of supplying liquid milk to supermarkets, denoted a in the model, is given by AMPE, a variable constructed by DairyCo using actual commodity prices and exchange rates, to yield an estimate of the Sterling value, at the farmgate, of supplying to

[20] This bargaining model is a variant of the model of competition in Smith and Thanassoulis (2012), and, more generally, related to the bargaining models in Horn and Wolinsky (1988) and Stole and Zwiebel (2006)

international commodity markets. We lag this variable by one year, to allow for a delay in the transmission process between the commodity price change and the farmgate price.[21]

We calculate the marginal cost, m, of converting raw farmgate milk into processed retail milk using an approach, described in detail in the Appendix, in which we identify all the steps required to take milk from the farmer to the retailer, and allocate an assumed cost per litre for each step, using data from authoritative industry sources. Added together, we obtain the marginal cost of retail fresh milk: $c = m + a$.

Note that this measure of marginal cost uses the opportunity cost to the farmers of supplying retailers, measured as the foregone international commodity price, rather than the on-farm costs such as labour and fertlizer. This is for two reasons: (i) this appears to be the relevant economic marginal cost of domestic liquid milk and (ii) it is much more easily measured than on-farm costs which are very heterogeneous across farmers.

Finally, the marginal cost to the retailer of importing fresh milk, κ, is constructed using a similar method, using shipping costs and the price of farmgate milk in nearby EU countries, as described in the Appendix.

Table 4 presents statistics from these data series. In the first two columns and first five rows we report the mean and standard deviation for these variables, using annual averages for the full period of the data 1994-2014, from deregulation of raw milk supply to the present day. The following rows of the table shows price cost margins for the three types of firms: retailers, processors, and farmers. We compute margins using some alternative measures of costs: AMPE a, marginal cost c, wholesale prices, w, and farmgate prices f.

We can see from the table that the farmers' margins with respect to their outside option, AMPE, are negligible, on average, consistent with our modelling assumption that farmers are price takers. The table shows that farmgate prices f are quite volatile, and this can result in periods of negative margins, relative to the farmer's on-farm costs of production.

As a check on the realism of the cost assumptions that we used in the Appendix, we note that the average margin of the processor over marginal cost, denoted $w - c$, is on average 1.8ppl, which is close to the figure of 1.5ppl that is reported in KPMG (2003)[22]. This suggests that our marginal cost assumptions, detailed in the Appendix, are reasonable.

[21] Figure 2, and our interviews, indicate that such a delay is appropriate; farmer contracts are fixed for a short period and cannot respond immediately to commodity prices.
[22] Paragraph 110, page 40.

We now discuss retail margins over marginal cost, i.e. $p - c$. In our model of retail pricing, in equation (1), this margin is informative about the intensity of price competition, which we summarize using the symbol θ. Table 4 shows that the retail margin over marginal cost changes quite widely over time: it has a mean of 10ppl and a standard deviation of 7.2ppl.

Table 4: Supply Chain Prices and Margins in Pence Per Litre (ppl)

		1994-2014		Means for Selected Years				
		Mean	StDev	1995	2001	2006	2009	2014
Retail Price	p	49.2	7.8	42.1	42.7	51.6	67.0	51.8
Wholesale Price	w	38.3	4.1	42.1	35.2	37.1	45.0	
Marginal Cost	c	39.2	6.7	36.9	34.6	34.8	42.4	56.2
Farmgate Price	f	22.6	4.7	24.4	19.4	18.2	24.7	32.0
AMPE	a	23.1	5.5	26.5	18.9	17.7	21.6	29.1
Supermarket Margin over:								
Wholesale price	p-w	10.0	6.6	0.0	7.5	14.5	22.0	
Marginal cost	p-c	10.0	7.2	5.2	8.1	16.8	24.5	-4.4
Farmgate price	p-f	26.6	6.9	17.7	23.3	33.4	42.3	19.8
AMPE	p-a	26.1	7.3	15.6	23.8	33.9	45.4	22.7
Manufacturer Margin over:								
Cost	w-c	1.8	2.0	5.2	0.6	2.3	2.5	
Farmgate Price	w-f	17.5	1.5	17.7	15.8	18.9	20.3	
AMPE	w-a	17.2	2.8	15.6	16.4	19.4	23.4	
Farmer margin over:								
AMPE	f-AMPE	-0.5	2.6	-2.1	0.6	0.5	3.1	2.9
Lerner Index	(p-c)/p	0.20	0.1	0.12	0.19	0.33	0.37	-0.08
Conduct Parameter	e*(p-c)/p	0.08	0.0	0.05	0.08	0.13	0.15	-0.03

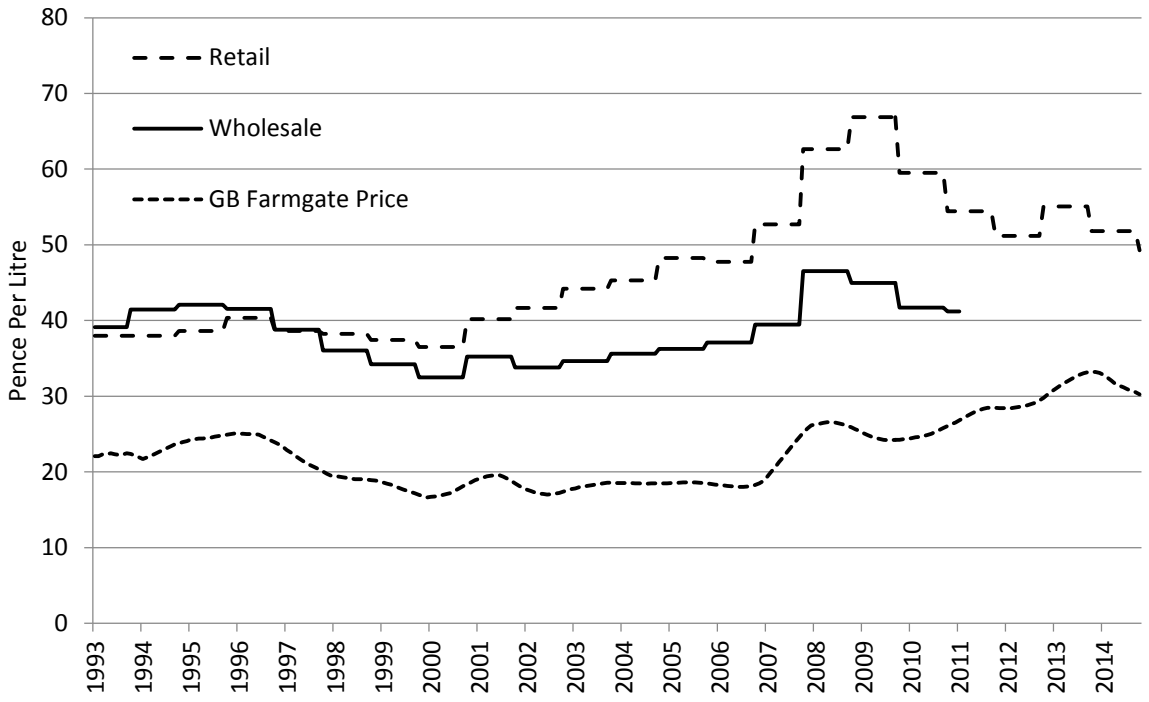
Note that wholesale prices not available from 2011 onwards. Variable e stands for elasticity of demand.

The bottom two rows of Table 4 give some useful further measures of the level of retail market power. The Lerner Index is the percentage retail margin and is a standard measure of market power. It has an average value of 0.20 in the period 1993-2015. To help us judge what this means for the intensity of price competition, in terms of familiar textbook models, we also calculate a retail-price Conduct Parameter, also known as the elasticity-adjusted Lerner Index.[23] The Conduct Parameter is an intuitive measure of the intensity of retail price competition, given by the product of the Lerner Index and aggregate demand elasticity. We have assumed demand

[23] See Genesove and Mullin (1998) for a discussion of the Conduct Parameter and its interpretation. As we have direct estimates of marginal cost, our analysis is not subject to the Cort's critique, mentioned by these authors.

elasticity is -0.4, as estimated in Lechene (2001). The Conduct Parameter can take any value between 0 and 1. It takes the value 0 when retailers are maximally competitive and have no market power. It takes the value 1 when firms are maximally collusive, setting joint monopoly prices (by the inverse elasticity pricing rule). Values of the Conduct Parameter that fall between 0 and 1 can be interpreted as follows: the level of competition is "as if" the prices had been generated by a $(1/\theta)$-firm Cournot oligopoly. (For example a value of $\theta = 0.33$ would indicate competition equal to that of a 3-firm Cournot oligopoly).

Figure 4: Farmgate, Wholesale, and Retail Prices 1994-2015



We find that the Conduct Parameter has an average of 0.08 which is much closer to the maximally competitive than the maximally collusive level, and implies the same markups as a Cournot oligopoly with about 12 firms.

We now use the model to explain why farmgate, wholesale, and retail prices have changed over the period 194-2014, using the individual year columns in Table 4 and the plots in Figure 4.

Let us start in the years from deregulation in 1994 to 2001. Figure 4 shows the decline in the farmgate price in the period from 1994 to 2000. This decline resulted in a decline in farmer fortunes and was the impetus to farmer direct action and the Retail Price Initiatives (as discussed in Section V). In contrast the position of the retailers seems to have improved in this period. In 1995, retailers had strikingly low margins compared to later periods: a Conduct Parameter of 0.05 suggest that the retailers were exercising market power similar to that of a

20-firm Cournot oligopoly. A plausible reason for this intense level of competition is that retailers were competing with doorstep deliveries at this time. Table 4 shows that by 2001 retail price competition softened. Over this time doorstep deliveries declined to become a much less important part of the market, and it seems likely that retail competition became less intense as a consequence.[24]

We now turn to the period 2000-2006, associated with farmer direct action and the Retail Price Initiatives. Figure 4 shows a dramatic increase in retail prices. By 2006, retail margins (whether calculated over marginal costs, wholesale prices, or farmgate prices) appear to have increased greatly. The retailer's margin over marginal cost, for example, increases from 8.1ppl in 2001 to a high of 16.8ppl in 2006. This results in a Lerner Index that increases from 0.19 to 0.33, and an increase in the Conduct Parameter from 0.08 to 0.13, a substantial softening in the intensity of retail price competition. Thus the intensity of retail price competition was at its lowest in the period after the Retail Price Initiatives, when retailers and processors worked together to effect multilateral retail price hikes.

The supply chain entered a new phase in 2007 when it was hit by a sudden increase in world prices for commodity milk (seen previously in Figure 2), caused in part by an Australian drought. Under our model this should impact all prices, farmgate, wholesale and retail, and Figure 4 shows that this is indeed the case.

Between 2009 and 2014 retail margins have fallen again, implying a more competitive phase in retailing pricing. A possible explanation for this is that household disposable incomes fell in the recession and discount retailers such as Lidl and Aldi began to threaten the large retailers. At the same time commodity prices have been extremely volatile, sometimes pushing the marginal cost to levels that exceed the retail price, as seen in Figure 5 for the year 2014.

We now present a simple empirical analysis of the bargaining model between processors and supermarkets and the determinants of the wholesale price. Figure 5 focuses on variables relevant to the bargaining model. Our theoretical model suggests bargaining can lead to any wholesale price in the range between marginal cost c and the cost of importing fresh (given by kappa, κ), depending on the bargaining power λ of the retailer. Figure 5 shows that the wholesale price generally lies in this range, consistent with our model; it is closer to marginal cost c than to κ, indicating a limited ability of processors to increase the wholesale price.

[24] See Competition Commission (2003) for a discussion of the decline of doorstep milk deliveries.

Figure 5: Wholesale Price and the Bargained-Over Surplus

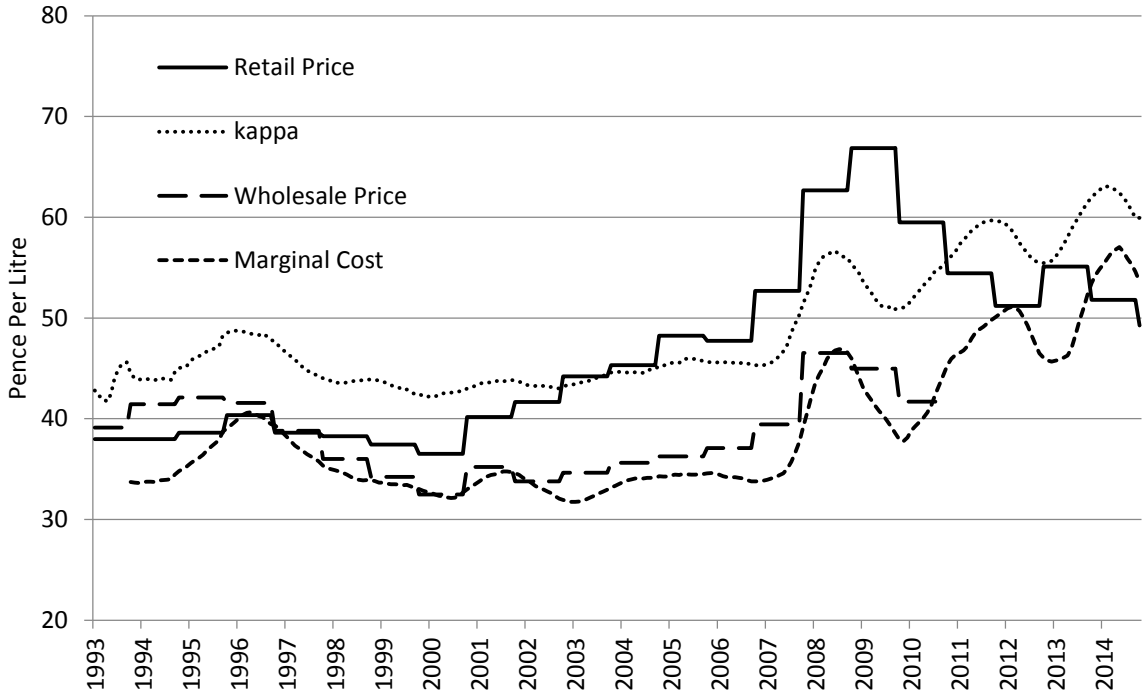


Table 5 presents the empirical variables for the bargaining model including the bargaining parameter λ. We have presented the figures for each year in the period 1004-2014 and then the averages for three periods: 1994-1999, 2000-2005, and 2006-2010. The wholesale price is not available after this period. The third column gives the retailer's share of the gross margin $p - c$. This is about 55% in the 1990s but in subsequent years has risen to over 80%. This varies over time from a low of zero in 1995, when retailers had low margins, to above 80% through the 2000s.

In the fourth and fifth columns we present the processors' share of the bargained-over margin. In the baseline case we use $\kappa - c$ as the bargained-over margin. We also report an alternative case (the "no imports case"), where the bargained over margin is $p - c$, i.e. where the retailer does not have the option of using imports from overseas and has a maximum willingness to pay given by the retail price p. (For this case, in the theoretical model, κ is replaced with p). Whichever case is used, the processor on average gets a low share of the bargained-over margin, typically 20% or less in recent years.

Table 5: Bargaining Between Processors and Supermarkets

Year	#Processors	Cost of Processed Imports	Retailer Share Gross Margin	Processor % bargained-over surplus		Supermarket Bargaining power	
				Baseline case	No imports case	Baseline case	No imports case
	N	κ	(p-w)/(p-c)	(w-c)/(κ-c)	(w-c)/(p-c)	λ	λ
1994	5	44.54	0.00	0.70	1.00	0.07	0.00
1995	5	46.79	0.00	0.53	1.00	0.12	0.00
1996	5	48.94	0.69	0.13	0.31	0.34	0.21
1997	5	46.23	0.78	0.11	0.22	0.36	0.26
1998	5	44.23	0.85	0.11	0.15	0.36	0.31
1999	5	43.76	0.97	0.02	0.03	0.53	0.50
2000	4	44.03	1.08	-0.05	-0.08	1.00	1.00
2001	4	44.03	0.93	0.06	0.07	0.50	0.48
2002	4	43.81	1.00	0.00	0.00	1.00	1.00
2003	4	44.24	0.86	0.17	0.14	0.36	0.38
2004	3	45.18	0.90	0.12	0.10	0.51	0.54
2005	3	46.09	0.92	0.12	0.08	0.51	0.56
2006	3	46.09	0.86	0.20	0.14	0.41	0.48
2007	3	47.31	0.80	0.34	0.20	0.30	0.41
2008	3	55.71	0.92	0.13	0.08	0.49	0.57
2009	3	53.16	0.90	0.24	0.10	0.38	0.53
2010	3	53.58	0.96	0.06	0.04	0.60	0.65
1994-1999	5	45.75	0.55	0.27	0.45	0.30	0.21
2000-2005	4	44.56	0.95	0.07	0.05	0.65	0.66
2006-2010	3	51.17	0.89	0.20	0.11	0.44	0.53

The supermarket bargaining power parameter, λ, is obtained using the data and the theoretical expression for wholesale prices in equation (3).[25] We compute a separate value for each year. The parameter varies somewhat over time: 0.30 in 1994-1999, 0.65 in 2000-2005, and 0.44 in 2006-2010. These vary around the standard value used in the Nash Bargaining Model, i.e. 0.5. This suggests that the individual processors are, on average, at least as able negotiators as the supermarkets. The model suggests that the processor gets a low share of bargained-over margin not because it is a poor negotiator in any bilateral situation but because the retailer can approach a number of other processors if there is disagreement, whereas processors find it hard to identify new rival outlets for milk. To illustrate this effect note that a bargaining power

[25] λ in any year is given by rearranging equation (3) to give $\lambda = 1 - \sqrt[N]{(w-c)/(\kappa-c)}$.

parameter of 0.44 would imply that, if there was one processor, the wholesale price would be set so that the gap between the marginal cost and import price would be bargained 56:44 in favour of the processor (equation (2)). However with three processors our model predicts that the gap between the marginal cost and import price would be bargained 82:18 in favour of the supermarket. With five processors the wholesale price would be set 95:5 in favour of the supermarket. (This conclusion is robust to the alternative of the no-imports case).

We can now use the model to provide some counterfactual analysis. First we consider how much our model suggests that a counterfactual fall (or rise) in farmers' costs would be passed through to wholesale and retail prices. This is interesting because a common complaint is that retail or wholesale prices fail to adjust fully when there is a cost change to farmers; those who issue this complaint presume that a 1-for-1 pass through is natural.

Suppose, then, that world commodity prices fall by 1ppl. This leads to a fall of 1 in both farmgate prices f and in marginal costs c. To work out the fall in wholesale prices we turn to equation (3), using the mean parameter values from Table 5. Assuming that κ, the cost to the retailer of importing from abroad, does not change then 0.82ppl of the reduction should be passed through to the wholesaler.[26]

The amount of cost reduction pass-through to the retail price depends on the model of retail level competition. Generally speaking, the closer the retail market is to being competitive, then the closer the pass-through rate should be to unity. Suppose that the retailers behave "as if" they were Cournot firms with n=12 firms, which, as we noted above, is the implication of our average Conduct Parameter estimate of 0.08 in Table 4. Suppose also that the demand curve is linear. Then the cost reduction would pass through at the rate 12/(12+1)=0.92.[27] Thus we do not expect to see the full 1-for-1 pass through of costs to either wholesale or prices.

Finally let us consider the effect of a merger of processors from three to two firms. Then from equation (3) the wholesale price would go up by about 1.58ppl.[28] This is a substantial percentage increase in processor margins (which are only 1.8ppl on average, as noted above). The merger however has no adverse effect on retail or farmer prices, it merely redistributes

[26] Assume the mean values of variables from Table 5 for the period 2006-2010: κ=51.2, N=3, λ=0.44. The mean value for the marginal cost for this period is 39.7 (this not reported directly in the Tables). Equation (3) implies that with these parameters wholesale price changes from 41.73 to 40.90 when c drops to 38.7, a change of 0.82ppl.

[27] For a Cournot oligopoly with linear demands and constant linear marginal cost the formula for the proportion of a unit marginal cost increase that is passed through to retail prices is N/(N+1). See Weyl and Fabinger (2013) for a discussion of cost pass through.

[28] Assume the mean values of the relevant variables are as used in Footnote 23 for the period 2006-2010, i.e. κ=51.2, N=3, λ=0.44 and c= 39.7. These parameters imply a wholesale price increase from 41.73 to 43.32 using equation 3 and imposing a reduction in N from 3 to 2. This is an increase of 1.58ppl.

surplus from retailers to processors, a consequence of our assumption of efficient bargaining, as informed by our interviews. This argument can be used to defend the Competition Commission's decision in 2003 (see CC (2003)) which reduced the number of processors N from four to three.

VIII. CONCLUSIONS

This paper has investigated prices and profits along the milk supply chain using interviews and milk price data observed at three levels in the market: raw, wholesale, and retail.

Our interviews with executives, and analysis of evidence in the competition cases, lead us to find that bargaining between retailers and suppliers is characterized by a high level of certainty about costs and volumes. We find that retailers are reluctant to differ from each other in the retail price of milk, and this has the consequence that any wholesale price increase that retailers concede in negotiations with processors is unlikely to have a direct effect on retail prices. We argue that bargaining is thus likely to be efficient, with the wholesale price redistributing surplus between suppliers and retailers but not affecting total volumes. Suppliers claim supermarkets have many other tactics for extracting surplus, in addition to the wholesale price.

Farmers are largely price takers and have little ability to raise prices on their own. They do however have the alternative option of supplying milk to commodity markets, which results in farm prices being highly volatile.

In our empirical evidence we find that the intensity of retail price competition varies widely, and it was at its lowest in the period after retailers and processors worked together to effect multilateral retail price hikes, known as Retail Price Initiatives, with the aim of helping farmers, a practice that violated competition law, even with unselfish motives on the part of retailers and suppliers.

In negotiations between supermarkets and processors, our empirical results show that most of the profit accrues to the supermarkets, and our model suggests that this is because competition between processors reduces their bargaining position.

Overall the picture in the period between deregulation in 1994 and the present day is one of a volatile distribution of rent, driven by changes in the price of commodity markets, on the one hand, and by changes in the intensity of retail price competition, on the other. The farmers and the retailers have the most variable fortunes, and the retailers enjoy the highest average margin.

The paper focuses on the supply chain for liquid milk in the UK. However the framework that we develop here is likely to be applicable to other food supply chains, both in other countries and other products. Many of the issues that we discussed for the British milk chain have been debated and discussed in milk supply chains elsewhere (see Cotterill (2006)). Many food products, both in the UK and elsewhere, have a very similar vertical structure to milk, involving three levels (namely, farmers, processors/packagers, and retailers), and have a similar level of market concentration at each level. It is a feature of many food markets, not just milk, that farmer produce can be traded on international markets, affecting the prices farmers can obtain from domestic buyers. Finally, the insights from our interviews, on the bargaining process between supermarkets and manufacturers, are likely to apply to other products than milk: many of the practices we discussed in these interviews have been reported for other food supply chains.

APPENDIX: ASSUMPTIONS IN THE CALCULATION OF MARGINAL COSTS

In this Appendix we describe how we compute marginal costs c and the costs to the retailer of sourcing fresh milk abroad κ. We begin with c. This is the overall marginal cost of supply to a supermarket right up to the cost of delivery to the store. We take an "engineering approach" and add together two main identifiable additive components of the cost:

1. The opportunity cost to the farmer of supplying raw milk compared to the alternative of supplying to the Coop for onward sale to commodity markets. This is denoted a in the model and is given by the data series AMPE (which we have discussed in section VII), which is computed by DairyCo using commodity milk prices (including cheese, skimmed milk powder, and butter) and data on transport costs to the cooperative.
2. The costs from farmgate to retailer, denoted m in the theory model. This cost is computed as follows.
    a. The transport cost from farmer to coop and from coop to processor. DairyCo estimated these to be 1.5ppl in 2007 for transport to Coop and we assume the same cost for transportation from the coop to the processor.
    b. The cost of processing the milk (including pasteurization). We assume this is 3.5ppl, reported in West LB Panmure (2000) as corresponding to the midpoint of the range 3-4ppl that they report as the standard cost in the industry in 2000.
    c. The cost of bottling and distribution to supermarkets. West LB Panmure (2000) reports each of these costs to be 4.5ppl in 2000.

We had these costs checked by an independent industry expert recommended by DairyCo. He confirmed they were reasonable assumptions. As some the costs under items 2a-2c were reported for one year only we inflated these using the most closely related price index available from official Producer Price Index statistics. The details of these inflation indices and a summary of the components of marginal costs are given in Table 6.

The variable κ is the cost of sourcing milk from abroad in the hypothetical off-equilibrium event of a disagreement in the negotiations with a domestic processor. We calculate this cost by adding together the following components.

1. The raw milk cost, computed by taking the average EU farmgate price for Ireland, France, Belgium and the Netherlands; this is the most variable component and we have a full data for each year between 1993 and 2015.
2. The farmgate to retailer cost, which we assume to be the same as items 2a-2c above, as calculated for GB earlier in this Appendix, plus the cost of shipping the milk across the sea. For this we use figures from DEFRA (2007 Table 4.3) for the costs of trucking raw milk over the sea and returning empty. These costs are given as Belgium 5.9ppl, Netherlands 6.0ppl, Ireland 5.2ppl, Northern Ireland 5.7ppl, and France 3.0ppl. We take the mean of these shipping costs, giving 5.2 ppl.

As the shipping costs are reported for one year only (2007) we inflated this using the Services Producer Price Index for Sea & Costal Water Freight Transportation Services. The assumptions are summarized in Table 6.

Table 6: Assumptions used in Marginal Cost Calculations

Item	Marginal Cost (ppl year 2000)	Source	Inflation Index
Domestic Production (m)			
Processing	3.5	West LB Panmure	PPI Manufactured Products Output Prices
Bottling	4.5	West LB Panmure	PPI Plastics and Rubber Index
Distribution from Processor To Store	4.5	West LB Panmure	Services Producer Price Index SPPI Freight Transport by Road
Distribution from Coop to Processor	1.27	DairyCo (1.5ppl in 2007)	SPPI Freight Transport by Road.
Total	13.77		
Sourcing From Abroad (κ)			
Raw Milk in France, Belgium, Netherlands, Ireland	Farmgate Prices	EC DG Agriculture	Data Series available for all years
Transport Across Sea	5.2	DEFRA (2007)	SPPI Sea & Costal Water Freight Transportation Services
Production Costs	13.77	As Above	
Total	18.97		

Notes: PPI is Producer Price Index, SPPI is Service Producer Price Index, UK Office of National Statistics

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