The Milk Supply Chain Project

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The authors would like to thank the Milk Development Council (MDC) and DEFRA for financial support. In addition we are grateful to all the industry executives who kindly made themselves available for us to interview. The views in this report our solely ours and cannot be attributed to the MDC, Oxford University, DEFRA or any other industry participant.
Executive Summary

This report presents the results of an Oxford University research project into the UK liquid milk supply chain. Financial sponsorship was kindly provided by the Milk Development Council (MDC) and by DEFRA. The research reported here is independent academic research which is not designed to further any group’s particular agenda. We have striven to be as objective as possible.

The project’s aim is to investigate the competitive forces which influence the buyer-seller relationships between supermarkets, processors and farmers; to measure and understand the level of market power that exists at each stage in the supply chain; and to understand the effects of this market power on the main players in the supply chain.

In conducting the research we have interviewed industry executives at all stages in the supply chain for liquid milk: from the supermarket right up the supply chain to farmers’ representatives. We have constructed a theoretical model of the bargaining and price setting which occurs at all levels in the industry. Finally we have conducted an empirical estimation of the model using publicly available financial data and further data provided by the Milk Development Council.

This report is split into four sections:

0. Initially we offer a Layman’s Introduction to all the research undertaken and the findings generated.

1. Chapter 1 presents “Estimating Bargaining Power In The Supply Chain”. The theoretical model of the bargaining in the supply chain above the supermarket is developed and then estimated empirically. The chapter offers a quantitative analysis of where bargaining power lies. The chapter allows counterfactual industry scenarios to be modelled.

2. Chapter 2 presents “Milk Prices in Retail Competition”. A theoretical model of consumers’ dual choice of first supermarket, then volume of milk to buy, is offered. The model is estimated providing demand elasticities for milk and non-milk. Hence mark-ups compatible with non-collusive price competition between supermarkets are generated.

3. Chapter 3 presents “Upstream Competition and Downstream Buyer Power”. The bargaining relationship between supermarkets and their suppliers of own-label products (such as milk) is analysed further. The implications of the bargaining form on the creation of buyer power are discussed. Further the chapter explores how waterbed effects are propagated (the creation of a large buyer alters supply terms for other buyers). Finally the investment incentives of upstream firms in the context of large buyers are studied.

The keynote results of our study are as follows:

- Suppliers negotiate with supermarkets over only a subset of the profits of the supply chain. The highest price suppliers can secure is constrained by the buyers’ ability to source from the next closest market. In the case of milk this would mean sourcing abroad. This limits the supply chain to bargaining over quite a small ‘pie’. For example, in the case of milk, bargaining is over only about 5ppl of surplus. Only a fraction of this is secured by the supply chain.
Much of the supermarkets’ retail margins are therefore out of reach to the suppliers. (Supermarket margins for milk are estimated by the MDC as over 15 ppl.)

- Supermarket bargaining strength comes from the competition between suppliers, not any innate better quality of bargaining. In one to one negotiations over milk we estimate that processors have greater bargaining power than supermarkets. However the competition between processors yields the greater share of gains to the supermarket.

- The data we analyse provides a consistent estimate of the bargaining power of the processors versus the supermarkets as our theoretical model predicts. However the estimate exhibits a blip in 2002, shrinking in 2003, when processors appeared to enjoy a surge in their bargaining power. This is very compatible with the current OFT allegations, which have been accepted by most of the parties, of collusion in the milk industry during these years.

- In the bargaining between milk processors and cooperatives, the processors hold the stronger bargaining position. Our estimates suggest that the processor secures over two thirds of the margin per litre supplied, for every third secured by farmers. This estimate bares the standard caveat that longer data series would allow refinement of the estimate.

- At the retail end of the supply chain, our model of consumer demand quantifies how inelastic the demand for milk is. The product elasticities estimated imply that mark-ups of around a third remain compatible with standard price competition. Such large mark-ups are similar in scale to those actually levied in UK supermarkets for milk.

- Analysis of the model we have developed of the bargaining between supermarkets and their suppliers of own label products illustrates buyer power effects. If the upstream technology is characterised by economies of scale then the largest buyers will be able to secure better input prices than smaller buyers. This is because large buyers are key in ensuring that the benefits of the economies of scale are realised.

- Under standard supplier cost shape assumptions, waterbed effects will exist between supermarkets and their suppliers. That is downstream acquisitions which make some downstream buyers more asymmetric will worsen the terms of trade for other downstream buyers.

- The presence of large buyers will create an incentive for suppliers to develop technologies yielding greater economies of scale. Such technologies further improve input prices for the largest buyers and damage them for the smallest buyers.

We are grateful to all those executives who spared their time to discuss with us our modelling assumptions. We are also grateful to the MDC and DEFRA for their support. Chapters 1 through 3 of this report present independent academic work. These pieces of
work are objective and represent research output for us. They are being presented in academic venues and will be submitted to academic journals for publication.
Layman's Version

Howard Smith and John Thanassoulis
Layman's Introduction

Overview

This introduction gives a layman's overview of the findings of the three research papers which were developed in the Dairy Supply Chain research project, undertaken at Oxford University with financial assistance from the Milk Development Council. The papers themselves follow in Chapters 1-3 respectively.

The project's aim is to investigate the competitive forces which influence the buyer-seller relationships between supermarkets, processors and farmers; to measure and understand the level of market power that exists at each stage in the supply chain; and to understand the effects of this market power on the main players in the supply chain. The research methods include (i) interviews with industry executives at all stages in the supply chain; (ii) the theoretical modelling of price setting at all levels in the industry and (iii) the empirical estimation of the model using data provided by the Milk Development Council.

Chapter 1 Estimating Bargaining Power In The Supply Chain explores the relationship between supermarkets, processors, and suppliers. A theoretical model is presented, based on assumptions that come from the interviews undertaken in the project.

In the model of processor-supermarket bargaining the processors are in competition to supply milk to supermarkets who are themselves in competition. The competition between processors creates uncertainty for any individual processor as to its final output. The negotiated price lies naturally between an upper and a lower bound. The upper bound is the price that the supermarket could obtain by going abroad for its milk; the lower bound is the marginal production cost of the milk.

The exact point between these bounds that the two sides will negotiate depends on the number of processors and the bargaining power of the supermarkets. The more processors there are the more options the supermarkets have and lower the price the processors negotiate. We fit this model of bargaining to data on prices and costs from the milk industry.

A model of negotiation between farmer cooperatives and processors is also developed. Following discussions with the industry we consider this best modelled using a bilateral monopoly in which cooperatives and processors split the gains from trade according to their bargaining power. The farmers are assumed to have an inside option given by the commodity market prices that are available. (This captures the cost and opportunity cost to the farmers of supplying milk for drinking). We use price data to estimate the bargaining power of the processors in the processor-cooperative negotiations. The prices obtained by direct farmers are determined as a mark-up to the prices obtained by the farmer cooperatives.

Overall the model explains: (i) the prices negotiated between processors and supermarkets; and (ii) the prices obtained by coops and direct farmers. The model
provides a method for calculating how profit splits would alter if parties were to merge or if costs were to change. We explore some of these counterfactuals.

Chapter 2 Milk Prices in Retail Competition explores retail pricing behaviour by supermarkets. Unlike previous studies of milk demand we are able to estimate elasticities of demand for milk at the level of the retailer rather than at the level of the product. This allows us to analyze the pricing incentives of supermarkets. We develop a model of consumer choice in which consumers choose their supermarket based on the retail prices of a basket of products. Milk is an important component of most shoppers' baskets. Supermarkets are assumed to set their retail prices to maximize profits over marginal costs. Alternative models of supermarket pricing include cooperative and non-cooperative pricing. The retail mark-up that is obtained depends on (i) the price sensitivity of consumers and (ii) whether or not supermarkets cooperate with each other in their setting of milk prices. To estimate the model we use consumer data from the TNS survey as provided by the MDC. We find that the estimated price elasticities of consumers imply non-cooperative mark-ups that are close to the actual mark-ups. Thus, the model suggests that the market power enjoyed by supermarkets (i.e. their ability to increase prices above marginal cost) derives from the price sensitivity of consumers rather than from any attempt by supermarkets to coordinate prices.

Chapter 3 Upstream Competition and Downstream Buyer Power This paper extends the theory model in Chapter 3 to explore the circumstances in which (i) a large supermarket buyer has more buyer power than small supermarkets (ii) the presence of a large buyer causes prices negotiated by small buyers to increase (a phenomenon known as a waterbed effect). As in Chapter 1 competition between processors creates uncertainty for any individual processor as to its final output; i.e. the model incorporates the uncertainty experienced by a supplier at the point of negotiation with any given buyer over how successful the supplier it will be with the other buyers. In this setting we find a new source of buyer power when supplier cost functions are nonlinear: the event of negotiation with a large buyer increases the seller’s expected output, which changes the expected average costs of supplying the buyer. This increases the power of a large buyer when the seller’s cost function has increasing returns to scale. We use this framework to analyze the pricing and welfare consequences of changes to market structure upstream and downstream. We also analyze investment consequences of buyer power. We show that upstream suppliers respond to buyer power by selecting technologies with increasing returns to scale, which disadvantage smaller buyers and benefit larger buyers.
Chapter 1  *Estimating Bargaining Power In The Supply Chain*

**Introduction**

In this chapter we aim to explain why profits accrue where they do in the milk supply chain. A schematic depiction of the supply chain is presented above in Figure 1. The analysis is both theoretical and econometric.

In the theoretical part of the paper we present a theory model of bargaining between competing suppliers and downstream retailers to capture Stage A. This is followed by a theoretical model for stage B which captures the relationship between farmers and processors. This analysis incorporates both coop and direct formers.

In the empirical part of the paper we introduce the data and estimate the bargaining power at each stage of the supply chain.

Finally, we perform some policy counterfactuals and draw conclusions.

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A model of bargaining between competing suppliers and downstream retailers

This model captures the bargaining in part A of the chain.

Evidence Gathering: Executive interviews

Interviews were conducted at all stages of the supply chain. This included supermarkets, processors, co-operatives, farmers via the National Farmer's Union (NFU), and the Milk Development Council (MDC). The aim of the interviews was to identify key aspects of the bargaining processes at all stages in the chain. In the course of these interviews the following insights emerged regarding the supplier-retailer interface, i.e. stage A in the diagram above.

1. Supermarkets unilaterally start new procurement rounds at unpredictable points in time.
2. Suppliers face uncertainty regarding successful tenders. When bidding for new contracts, suppliers think strategically about likely tender successes with other retailers and quote prices that are competitive and expected to cover overall costs.
3. Supermarkets receive a per unit transfer price.
4. The suppliers’ costs are well known to the supermarkets through their contact across many different input suppliers.
5. The volumes of product demanded are highly predictable.

Model Key Features

We assume there are U upstream suppliers in competition to supply D downstream buyers – who themselves compete. The U suppliers have access to the same technology; variable cost per unit of $c$.

We first determine natural lower and upper bounds to the negotiated price.

We assume that the lower bound to any agreed price is determined as follows:

The U suppliers will never agree to an overall price per unit of less than marginal cost $c$ as this would be loss making. Thus marginal cost $c$ acts as the lower bound for any bargaining agreement.

We assume the upper bound is determined by the supermarkets' ultimate outside option. If a supermarket argues with all U suppliers then (we assume) she can source the milk from abroad. Thus the retailer will not have to go without product. But sourcing from abroad is expensive: a cost of $\kappa$ per unit. Thus we have an upper bound to the agreed price is as follows:
A buyer will never agree to an overall price per unit of more than $\kappa$ as sourcing abroad would then be preferable. $\kappa$ acts as an upper bound for any bargaining agreement.

We make a number of further assumptions that fit the setting of liquid milk.

First, we assume that there is one winner per contract: each of the D buyers desires one input supplier on any contract. This may be because of the costs of contracting for example. Thus there will be losing suppliers for any given contract. In the liquid milk market some supermarkets have more than one supplier but our assumption is justified by the observation that these supermarkets subdivide milk contracts geographically, e.g. a southern England & Wales contract and a Scotland & N. England contract, but for each of these subdivided contracts one supplier is sought and contracted with.

Second, we assume that on the contract that is up for tender the buyer proceeds as follows. The buyer initially selects a first supplier to bargain with from the U suppliers that exist in the market. If negotiations with this supplier should break down then the buyer can approach the next supplier on her list. However, as there are now fewer competing suppliers the buyer is a little disadvantaged at this point. This bargaining form thus captures the following implicit buyer threat:

“You are only one of U suppliers. If we fail to strike a deal then I will still have U-1 suppliers I can source product from. Thus to get the business you must make it worth my while.”

The buyer must therefore be able to get at least the profit she secures if only U-1 suppliers are left. But note that if there are only U-1 suppliers left the retailer's threat is weakened, because there are now even fewer suppliers left to threaten to move to. This means that there is an advantage (to both the $U^{th}$ supplier and the retailer) of striking a deal (rather than moving to the next supplier). The monetary size of this advantage is the incremental pie. Thus the bargaining problem between $U^{th}$ supplier and retailer is how to split the incremental pie. The exact way this is split is determined by the bargaining power of the processor. We use the parameter $\lambda$ to refer to the processor's bargaining power; this is defined such that the incremental pie is split $\lambda$ parts to the retailer and 1- $\lambda$ parts to the supplier. $\lambda$ is a bargaining power parameter between 0 and 1. A value of $\lambda$ below $1/2$ means that suppliers can more than hold their own in bilateral discussions.

The extent to which the supermarkets can negotiate price down towards the lower bound--the processors' marginal cost $c$--is determined by two factors:

(i) The number of processors $U$: the more processors there are the more options the supermarket has to turn to before the ultimate outside option of sourcing abroad.

(ii) The supermarket bargaining power parameter $\lambda$: the greater the bargaining power of supermarkets the greater their ability to bargain in any one-to-one negotiation with an individual processor.

Capturing Supplier Uncertainty As To Contracts Won

Our interviews indicated that retailers can and do switch milk supplier at relatively short notice. This is possible as the contracts typical in this industry are usually rolling with

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notice periods of only three months. Thus at any point supermarkets may be about to open up negotiations with suppliers as to the price for input going forward. To capture this aspect of the market we assume that all buyers go to the suppliers simultaneously, and a supplier in any given negotiation does not know how she will she will do in negotiations with other potential retailers. This is a way of capturing the uncertainty the supplier faces regarding how many contracts she will win (a feature of the market that came through in our interviews with executives).

**Bargaining Over A Two-Part Tariff**
The model assumes that the parties bargain over a two part tariff: a fixed fee and a per unit price. In interviews the parties reported that negotiations were actually over *prices per unit* but this is easily reconciled with our two-part tariff assumption because volumes are highly predictable so that a per unit price translates into a very predictable total payment from a two-part tariff. (The parties also in practice agree volume discounts and spot prices if unusual volumes were subsequently required so a retailer forced to respond to a significant unexpected demand change optimises over an input price per unit that is not the same as the agreed per unit price.)

**Efficient Bargaining Result**
With the two part tariff assumption we have the following result: parties agree to a two part tariff in which the marginal price in the event of unexpected demand realizations is at a marginal cost of $c$. This is efficient because it means that the price setter (the retailer) faces the correct incentives (marginal cost, $c$) from the whole chain's point of view.

**An Intuition for Efficient Bargaining Result**
One aspect of the supplier’s and retailer’s interests are aligned: to grow the incremental pie as much as possible. The two part tariff allows this by letting the retailer optimise against marginal costs when setting retail prices (and hence volumes). The profits made are then maximized and can be divided between the supplier and retailer using the fixed fee. The implication that final retail price is then optimized against the actual variable costs of production is true no matter how many suppliers compete upstream so that upstream mergers would not alter the downstream retail prices in this model.

Efficient bargaining appears to be a plausible feature of the model. In negotiations parties profess to be keen to avoid losses that occur if volumes differ from the efficient level given marginal cost (i.e. they are keen to avoid double marginalization losses).

**Deducing The Total Retailer Payment**
The total payment per unit by the retailer will depend on four industry parameters: $\kappa$ (cost of sourcing abroad), $c$ (variable cost of domestic production), $\lambda$ (supermarket bargaining power) and $U$ (number of upstream competitors). This is depicted in Figure 2. $\kappa$ and $c$ give the upper and lower bound to the agreed per unit payment. The position of the agreed price between these limits is determined by the supermarkets’ bargaining power $\lambda$ and the number of competing processors $U$. An increase in either $\lambda$ or $U$ has a downward effect on the price negotiated with the processor. All of these parameters are observable with the exception of $\lambda$ (which we will estimate).
Figure 2: The Four Parameters Determining the Supermarket-Processor Split

\( \kappa \) and \( c \) give the upper and lower bound to the agreed per unit payment. The position between these limits is determined by the supermarkets bargaining power \( \lambda \) and the number of competing processors. An increase in either \( \lambda \) or \( U \) has a downward effect on the price negotiated with the processor.
The Bargained Split

We derive an expression for the actual per unit price paid by the supermarkets to the processors. This is done by working backwards through the U potential suppliers, i.e. we first compute the price that would be agreed with the last remaining supplier using $\kappa$ as the outside option, this price then is in turn the outside option used when negotiating with the U-1'th supplier, and so on. As shown formally in the paper the agreed per unit price which results is given as follows:

$$\text{Overall per unit payment by retailers} = c + (1 - \lambda)^U(\kappa - c)$$

This equation gives the price (i.e. payment per unit) paid by supermarkets to suppliers. This price is decreasing in both $\lambda$ and $U$--i.e. decreasing in the number of processors and (for any given number of processors $U$) decreasing in supermarkets bargaining power, $\lambda$.

The term $(1 - \lambda)^U$ is of key importance. It may take values in the range zero to one. It represents the bargaining position of the processor. Thus the price paid by the retailer to the processor is pushed to its lower bound $c$ as $(1 - \lambda)^U$ goes to zero and is pushed in the other direction to its upper bound $\kappa$ as $(1 - \lambda)^U$ increases to one.

$(1 - \lambda)^U$ is the share of the available surplus $(\kappa - c)$ that the processor captures in the negotiations.

The effect of a merger of processors can be computed by reducing $U$ by one integer, e.g. from 4 to 3. We will discuss some counterfactuals of this type later in the chapter.

Profits remaining to be split between processors and farmers

The value of the profit accruing to the parts of the supply chain upwards from the retailer (i.e. to be split between processors and farmers) is thus given by the following:

$$\text{Profit to be split between processors and farmers per unit supplied} = (1 - \lambda)^U(\kappa - c)$$

The irrelevance of retailers' margins above $\kappa$.

Our model highlights the important insight that there is an upper bound on the price the milk supply chain (i.e. the farmers and processors) can extract in negotiations with supermarkets. This upper bound is determined by the cost $\kappa$ to the supermarkets of going to the next closest market to secure the desired input. As depicted in Figure 3, the bargained over surplus per litre is therefore just $(\kappa - c)$. It is of this that we have calculated processors are in a position to receive a share of $(1 - \lambda)^U$. Even though the supermarkets may be able to raise retail prices above $\kappa$ and enjoy some additional surplus (depending on competitive retail market conditions) this additional surplus is beyond the reach of the farmers and processors via negotiations, as it is still available to the retailers if they dropped local farmers and sourced from abroad.
Figure 3: What the Processors Can and Can't Bargain Over
Bargaining Between Processors, Cooperatives and Farmers

Figure 4: Relationships Between Processors, Cooperatives and Farmers

Figure 4 sets out the key relationships in the model of bargaining between processors, cooperatives (coops) and farmers. We begin with a discussion of the processor-direct farmer contracts.

**Processor to Direct Farmer Contract**

Suppose that a processor has agreed to buy q litres from its cooperative at a price of \( P + \) (farmer marginal costs). In other words suppose the price that the coop obtains in pence per litre is given by \( P/q + \) farmer marginal cost.

We assume that the negotiations between processors and direct farmers take as a reference point this price agreed between coops and processors, with a risk premium as follows:

\[
\text{Direct Farmer ppl payments} = \text{[costs]} + \frac{P}{q} + \left[ \frac{\text{risk}}{\text{premium}} \right]
\]

In the interviews we were told that the risk premium is for a range of factors including: (i) the processor’s sales are more volatile than coop’s; (ii) the coop can make it
unattractive for a farmer to return; and (iii) coops serve farmers while processors serve shareholders.

**Cooperative To Processor Bargaining**

We model this as a standard bilateral bargaining situation. The reason for this is that the relationships between coops and processors are more stable through time than those between processors and supermarkets, perhaps due to geographic proximity between coop and processor facilities. Currently First Milk is the only cooperative providing substantial milk volumes to the main processors (Wiseman and Dairy Crest in this case). Arla, the other leading UK processor of milk, is almost all direct farmer supplied, but does a little load balancing with Milk Link.

The processor and cooperative bargain over the payment $P$ *above costs* for $q$ litres supplied. The deal is therefore worth $P$ to coop. But because $P/q$ is used as a benchmark for the payments to direct farmers, to the processor the deal is worth:

\[
\text{Profit to be split between processors and farmers} - P \frac{P}{q} \times \text{Volume direct farmers supply}
\]

That is we are assuming that the coop accepts that the payment $P$ provides a reference point for direct farmers. The risk premium payable to direct farmers is not however part of the bargaining between cooperative and processor. The risk premium is therefore a cost the processor voluntarily elects to bear in return for having direct farmers whose milk supply is 100% secured.

Note that the coop farmers ultimately get less than $P/q$ for milk. This is because the cooperative also sells to commodity markets, and profits on these markets are lower than profits on liquid milk. This reduces the average profit to coop farmers from a unit of milk.

The final split between processors and the coop is determined by the processor’s bargaining power in this bilateral relationship. We denote this $\alpha$. This parameter lies between 0 (coop gets all the rents) and 1 (processor gets all the rents). The actual payment is found using the Nash Bargaining Solution which is a standard approach.

The payment to direct farmers follows:

\[
\left[ \text{Total ppl payment to direct farmers} \right] = \left[ \text{Production costs} \right] + (1 - \alpha) \cdot \left[ \text{Processor plus cooperative profit per litre supplied} \right] + \left[ \text{risk premium} \right]
\]

As the equation shows, as the bargaining power of the processors decreases towards 0 so the payments to direct farmers increases to capture all of the surplus from the supply chain captured by processors in their negotiations with supermarkets.
Data on Costs and Payments in UK Liquid Milk

We now take the model we have developed to the data to estimate bargaining power in the supply chain. This allows us to understand and explain where profits accrue as well as to perform counterfactual analysis. To do this we need to construct estimates of the variable cost of GB milk production (the variable $c$); the minimum cost to supermarkets of sourcing milk abroad (variable $\kappa$); and the risk premium paid to direct farmers.

Before constructing these estimates we detail five data series that are available and used in our analysis.

Five Data Series

1. Commodity Price of Milk: reasons to choose MCVE

Milk commodity markets are primarily those for cheese, butter, or Skimmed Milk Powder (SMP). The monthly margin available from these uses at the coop gate is calculated by the MDC. DEFRA notes that in 2005/6, 49% of milk made in Great Britain is used for things other than liquid milk. Of this 28% (the majority) went to cheese, 2% for butter, and 12% for powders and condensed milk. We conclude that the cheese margin will be the best measure of milk’s opportunity cost. This conclusion is supported by the observation that in recent years the wholesale price of milk (as paid by the supermarkets) tracks MCVE better than any other measure, as shown in Figure 5.

![Figure 5: MCVE tracks the wholesale price of milk better than other measures](image)
2. Supermarket Payments for Milk

Annual financial accounts include volume data and can be used to obtain a figure for the price per litre paid by supermarkets for milk. The MDC have computed this. Details of the computations are given in the full paper.

3. Farmgate Price For Milk outside GB

Should a retailer fail to source milk in GB it can in principle go outside GB. The nearest neighbour markets are Ireland, Northern Ireland, France, Belgium, and the Netherlands. The European Union's DG Agri provide farmgate milk prices in Euros per 100kgs for the four Eurozone countries, while the Department of Agriculture and Rural Development (DARD) produces figures for Northern Ireland. The MDC has supplied exchange rate figures which we use to convert to sterling. To compute a single figure for the farmgate price of milk outside GB we take an average monthly figure. Summary statistics for this are given in Table 1

<table>
<thead>
<tr>
<th>Observations</th>
<th>Mean (ppl)</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>European farm gate average price (ppl)</td>
<td>96</td>
<td>18.35</td>
<td>1.59</td>
<td>15.53</td>
</tr>
</tbody>
</table>

Table 1: European Farmgate Average Price

4. Direct Farmer Payments

We obtain information on monthly direct payments to farmers using figures from mandatory filings with DEFRA. This data is made available monthly from April 2002 through to March 2005. We take a weighted average of payments to direct farmers by Wiseman, Arla, Dairy Crest (weights are by volumes).

<table>
<thead>
<tr>
<th>Observations</th>
<th>Mean (ppl)</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct farmer payments in Great Britain (ppl)</td>
<td>36</td>
<td>19.02</td>
<td>1.01</td>
<td>16.95</td>
</tr>
</tbody>
</table>

Table 2: Direct Farmer Payments in Great Britain
5. Inflation

Shortly we will establish base-year estimates for transport, processing, and bottling costs. To allow for the effects of inflation on these costs over time we use the Office of National Statistics inflation index for plastics and rubber. This is the most appropriate index given the importance of plastic and oil in the bottling and distribution process. This index is shown in Figure 6.

Construction of Key Variables

Using the data series presented above the papers details how one can construct estimates of the three main variables required. These were the variable cost of GB milk production (the variable c); the minimum cost to supermarkets of sourcing milk abroad (variable κ); and the risk premium paid to direct farmers.

Complete Variable Costs of Production, c

To supply into the liquid milk supply chain, a farmer must give incur the costs of production and forgo the opportunity to supply the commodity markets. We estimate this opportunity cost (which includes the cost of production) as MCVE. To obtain the complete variable cost of production to the supermarket gate we add MCVE to the costs of production from farmgate to supermarket. We obtained costs of production from farmgate to supermarket using estimates from published sources. This includes costs of processing, bottling and distribution.

These cost estimates are detailed in Table 3 along with the published source for the estimate. Nothing in our empirical work replies upon the breakdown of the overall
figure into individual components. The only figure that is of relevance is the overall figure. We presented the figures to experts on the milk processing industry. They told us that the overall figure of 16.7 ppl at 2007 prices was a reasonable estimate.

<table>
<thead>
<tr>
<th>Item</th>
<th>Variable Cost</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottling</td>
<td>4.5ppl</td>
<td>West LB Panmure</td>
</tr>
<tr>
<td>Distribution from processor to supermarkets</td>
<td>4.5ppl</td>
<td>West LB give average of 4.5 ppl for industry: much higher for smaller stores but focus here on supermarkets.</td>
</tr>
<tr>
<td>Distribution from farm to cooperative</td>
<td>1.35ppl</td>
<td>MDC use 1.5ppl for average cost from farm to cooperative in 2007. Deflate to a 2000 figure</td>
</tr>
<tr>
<td>Distribution from cooperative to processor</td>
<td>1.35ppl</td>
<td>As same volume of milk must be sent on by cooperative as is received we have assumed the same cost as above</td>
</tr>
<tr>
<td>Wastage/Inefficiency</td>
<td>2.5% loss assumed</td>
<td>Guesstimate.</td>
</tr>
</tbody>
</table>

**Total production cost in 2000 prices**

<p>| | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td><strong>15.1 ppl</strong></td>
<td><strong>1.025 * (3+4.5 + 4.5 + 1.35 + 1.35)</strong></td>
</tr>
<tr>
<td>Inflated to 2007</td>
<td>10.6% price rise</td>
<td>Plastics and rubber index (correlated with fuel and bottling costs)</td>
</tr>
<tr>
<td><strong>Total Production Costs:</strong></td>
<td><strong>16.7 ppl</strong> (2007 prices)</td>
<td><strong>1.106 * 15.1</strong></td>
</tr>
</tbody>
</table>

**Table 3: Complete Variable Costs of Production**

The overall variable costs of liquid milk production are therefore given by the equation below. They equate to the sum of the production cost from farmgate to supermarket and the farmers’ opportunity cost of supplying milk. We compute this figure for each month in the period of the study (using inflation figures to compute the production costs).

\[
\text{Marginal cost of liquid milk production} = \left[\text{production cost from farmgate}\right] + \left[\text{farmer's cost including opportunity cost}\right] \\
\text{MCVE} + 13.7 \text{ ppl in 2000}
\]

\[
\text{Total Production Costs:} \text{ farmgate to supermarket} = 16.7 \text{ ppl (2007 prices)} \times 1.106 \times 15.1
\]

It is perhaps worthy of note that the costs of the farmers are taken into account by this procedure: they are subsumed into MCVE. In other words we have identified MCVE as
an estimate for the combined sum of the famers’ unavoidable costs of production and their opportunity cost of selling milk into other uses.

Minimum cost to supermarket of sourcing milk abroad $\kappa$

The minimum cost to the supermarket of sourcing milk abroad, $\kappa$, is computed as follows. We assume that production costs are as computed above in Table 3. To these we add the EU farmgate price for milk and the estimates of the transportation costs as given in DEFRA’s document *The Potential for GB-European Trade in Liquid Milk* (September 2007). The details of this calculation are shown in Table 4.

<table>
<thead>
<tr>
<th>Item</th>
<th>Variable Cost</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw milk costs</td>
<td>EU farm gate price</td>
<td>Average of Ireland, Northern Ireland, France, Belgium, Netherlands as nearest countries and so cheapest sources of imported milk.</td>
</tr>
<tr>
<td>Production Costs</td>
<td>16.7ppl</td>
<td>Assumed same technology as in GB (2007 prices).</td>
</tr>
<tr>
<td>Transportation Across Sea</td>
<td>5.2ppl</td>
<td>DEFRA$^1$ give transport costs if trucks bring raw milk over the sea and return empty. These costs are Belgium at 5.9ppl, Netherlands 6.0ppl, Ireland at 5.2ppl, Northern Ireland 5.7ppl and France 3.0ppl. The mean of these prices is 5.2ppl.</td>
</tr>
<tr>
<td>Minimum cost to supermarket of importing Milk from outside GB</td>
<td>EU farm gate price + 21.9 ppl</td>
<td>EU farmgate + 16.7 + 5.2 ppl 2007 prices</td>
</tr>
</tbody>
</table>

Table 4: Cost to Supermarket of Sourcing Milk Overseas

Direct Farmer Risk Premium

The figure used for the direct farmer risk premium is derived as follows. During executive interviews we were given the following figures for the risk premium: Dairy Crest pays 1ppl more than First Milk, Arla pays 0.3ppl more than DC, and Wiseman pays 0.2ppl more than Arla. Thus we assume the average risk premium is 1.3 ppl and constant over time.

Number of Processors

The number of processors $U$ is assumed to be 3 from 2004/5 onwards and 4 before this. The change is due to the merger of Arla with Express.

---

$^1$ DEFRA (September 2007) *The Potential for GB-European Trade in Liquid Milk*, Table 4.3
Explaining The Profit Split Between Supermarkets and the rest of the Supply Chain

We do not seek to impose any seasonality and so take the ppl price paid to the processors over the year as the appropriate one in each month. We can therefore calculate a value for the supermarkets’ bilateral bargaining power (λ) every month from April 1999. We plot these values in Figure 7. Over any year these λ estimates will show some seasonality inherited from MCVE and these are shown in the plots. Therefore to average these out we also present in the figure the annualized λs, i.e. the average value of λ for each calendar year in the data. Outside of 2002 and 2003 the bargaining power of the supermarkets λ is consistently estimated at between 0.3 and 0.4.

Note that λ is lower in 2002 and 2003. The processors appear to become stronger bargainers in 2002 and (to a lesser extent) 2003. Collusive actions which acted to increase the money in the supply chain are one (but only one) explanation for such a result. Since the calculations were conducted, the UK Office of Fair Trading has issued an accusation of price collusion on liquid milk by supermarkets and processors for the years 2002 and 2003. The majority of the accused parties have in turn admitted to the alleged anticompetitive practices. The spike in processor bargaining power is very consistent with this development.

**Annual Estimation of Supermarket Bargaining Power**

![Figure 7: Plot of Monthly Lambda Parameters and Annualized Averages](image)

Descriptive statistics for λ over the 74 months in the entire period of the bargaining power data set are presented in Table 5. The mean value of λ over this period is 0.294:
### Table 5: Descriptive Statistics for the $\lambda$ parameter

<table>
<thead>
<tr>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>95% Conf Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$</td>
<td>74</td>
<td>0.294</td>
<td>0.015</td>
</tr>
</tbody>
</table>

#### Interpretation of the Supermarkets' Bargaining Power Parameter $\lambda$

We have determined a supermarket bargaining power parameter ($\lambda$) of 0.294. If the unusual years 2002/3 are omitted then $\lambda$ rises to take values in the range 0.3-0.4. How do we interpret this? A parameter of $\frac{1}{2}$ would represent equality of bargaining power in one-on-one negotiations between supermarkets and processors. The estimated parameter is slightly less than this which suggests that in one-on-one situations processors can more than hold their own against supermarkets.

Recall that $\lambda$ is only one of two factors determining how close negotiated prices are pushed to marginal cost $c$, the other factor being the number of processors $U$. The fact that $\lambda = 0.294$ suggests that the extent to which supermarkets can push prices down towards marginal costs comes from upstream competition ($U$) rather than superior bargaining power in one-to-one negotiations with processors. In layman's terms, the supermarket may be said to have advantageous outside options rather than inherently superior negotiating skills.

Recall that:

$$(1 - \lambda)^U$$ is the share of the surplus ($\kappa - c$) that the processor is able to capture in the negotiations.

**Interpretation:** As the number of processors $U=3$ and we have estimated that $\lambda=0.294$ the processor is able to capture a proportion $(1 - 0.294)^3 = 36\%$ of the surplus ($\kappa - c$) that is being bargained over.

**The irrelevance of retailers' margins above $\kappa$.** As we noted earlier there is an upper bound on the price the milk supply chain (i.e. the farmers and processors) can extract in negotiations with supermarkets, which is determined by the cost $\kappa$ to the supermarkets of going to the next closest market to secure the desired input. The bargained over surplus ($\kappa - c$) is approximately 5ppl; predominantly driven by the cost of transport of milk between Northern Europe and the UK. The above calculations show that the processors are in a position to receive 36% of this, with the remaining going to supermarkets. Thus although supermarkets do in practice raise retail prices above $\kappa$ and enjoy additional profit, this additional profit is not available to the farmers and processors through negotiations. This is because this additional profit is still available to the retailers if they dropped local farmers sourced from abroad.
We now use the estimate $\lambda = 0.29$ (which includes the contentious data for 2002 and 2003) to calculate the wholesale prices that the model predicts that supermarkets and processors negotiate. We plot the financial year means for these predictions in Figure 8. Also on the table we plot the actual price data as used to estimate the model. The figure is intended to give a visual representation of the fit of the model, i.e. a visual representation of how well the model predicts the wholesale price.

The model fits well in most financial years. There are two unusual years. In 2000/1 the actual wholesale price is significantly below the predicted value. In 2002/3 the actual wholesale price is significantly above the predicted value. One possible explanation for this is that during 2000 Wiseman were investigated by the Competition Commission in the UK for aggressive price reductions which were alleged predatory towards the expansion of a rival (Express) in the Scotland. The Commission did find Wiseman guilty, though with a split panel. Such a conclusion is compatible with Wiseman agreeing to supply at lower prices than their bargaining position would entail. The situation in 2002/3 has already been discussed.

Figure 8: Plots of Model-Predicted and Actual Price Paid by Supermarkets
Explaining The Profit Split Between Farmers and Processors

Turning to the split between farmers and processors we estimate the processors bargaining power $\alpha$ according to the following equation implied by our theoretical bargaining model:

\[
\frac{\text{Total PPL payment to direct farmers from DEFRA survey}}{= [MCVE] - [1.5ppl transport cost (in 2007)]} \\
+(1-\alpha)\left\{\frac{\text{ppl paid to processors}}{-[MCVE + 13.7ppl (in 2000)]}\right\} + [1.3ppl risk premium]
\]

The inflation series is used to inflate the costs appropriately. A value of 1 for the parameter $\alpha$ would indicate a maximal possible level of bargaining power for processors while a value of 0 would represent the minimal possible level of bargaining power.

**Model Predictions**

We run a regression model based exactly on the above theoretical model.

<table>
<thead>
<tr>
<th>Our data delivers:</th>
<th>$\alpha = 0.73$</th>
<th>95% conf interval $[0.57, 0.89]$</th>
</tr>
</thead>
</table>

Thus processors have upper hand against cooperatives

**Regression results for 1-$\alpha$**

The regression output is reported in the table below.

<table>
<thead>
<tr>
<th>Direct estimate</th>
<th>(1-$\alpha$) estimate</th>
<th>Std error</th>
<th>T</th>
<th>P</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.271</td>
<td>0.077</td>
<td>3.50</td>
<td>0.001</td>
<td>[0.114,0.428]</td>
<td></td>
</tr>
<tr>
<td>R²=0.259</td>
<td>Obs=36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The fit of the model is shown visually in Figure 9, where the model tracks the data well, with the exception of some seasonal variation which our model does not aim to track.
Interpretation of alpha

The cooperatives bargain on behalf of their farmers. The prices they secure from processors form the benchmark against which direct farmer contracts are set. Thus cooperatives represent all farmers either directly or by proxy. Thus in our calculation of the bargaining power of the processors versus the cooperatives, we have found that farmers in general are able to secure 27% of the total processor-cooperative surplus (in excess of costs). In other words 27% of the surplus secured by the chain from the supermarkets will flow to farmers, the remainder to the processor.

The interviews we conducted suggest that the processor bargaining strength derives in part from its ability to approach individual coop farmers. This (a) allows the processor to secure some supply in the event of impasse with the cooperative. (b) signing farmers to direct supply weakens the cooperative in further negotiations. As evidence that signing up large proportion of the required volume by direct supply is the outside option for processors, one might point to Arla which is currently almost 100% direct supply.
A Counterfactual Analysis

Our research into the bargaining power in the UK Milk Supply Chain allows us to explore a number of counterfactual analyses as to the implications of changes to costs and changes to market structure (e.g. via merger). Here we provide a summary of some potentially interesting counterfactuals and the movements of profits they imply.

As our research highlights, supermarkets and processors bargain over only a subset of the available profits: the upper bound on input prices is provided by the cost of sourcing abroad, while the lower bound is the variable cost of production c. As a benchmark figure this bargained-over surplus (\(\kappa - c\)) is approximately 5ppl which is predominantly driven by the cost of transport between Northern Europe and Great Britain.

In the structural model the supermarket payments per unit are given by the following relationship:

\[
\text{Overall payment by supermarkets per unit supplied} = c + (1 - \lambda)^U(\kappa - c)
\]

This gives a per unit profit obtained by processors as follows:

\[
\text{Profit to be split between processors and farmers per unit supplied} = (1 - \lambda)^U(\kappa - c)
\]

Our empirical research estimates \(\lambda = 0.29\). As the number of processors \(U\) is 3, this implies that the proportion of the bargained-over surplus extracted by processors in the negotiations is given by \((1 - \lambda)^3 = 0.36\).

This profit, obtained by processors, is split with the farmers. Our model of processor-cooperative bargaining suggests that the cooperatives' bargaining power is \(\alpha = 0.27\), i.e. that the per unit margin bargained by the processors is split 27% to the farmer (direct or coop) and 73% to the processor. So at current market structure farmers obtain 27% of 36% (=10%) of the bargained over surplus \((\kappa - c)\) per litre supplied. The direct farmers in addition receive the direct-farmer risk premium which comes from the processors’ share of the pie.

*Note on retail prices:* recall the efficient bargaining solution discussed earlier: supermarkets always set their prices in reference to the marginal cost \(c\) rather than the negotiated wholesale price. Therefore in the below counterfactuals retail prices only change if \(c\) changes.

Using the above equations and the estimated parameters we can analyze the effect of a number of interesting counterfactual scenarios on processors and farmers.

**Effect of Cost Changes on Negotiation between Processors and Supermarkets**

**Scenario 1** a 1ppl increase in marginal production costs \(c\) (of farmers or processors)
Implications: If the marginal production costs $c$ rose by 1ppl, e.g. because commodity prices rise, then this increases the lower bound $c$ to the negotiated price but shrinks the size of the surplus $(\kappa - c)$ to be bargained over. The overall effect on the negotiated price is positive. The above equation predicts that the price to suppliers would rise by $1 - (1 - \lambda)^3 = 1 - 0.36 = 0.64$ ppl. Thus there is support for the claim that cost increases can be passed through to supermarkets.

Note on retail prices: Given the efficient bargaining result retailers set prices with respect to actual marginal costs $c$. Thus we expect retail prices to increase in this scenario.

Scenario 2 a 1ppl increase in the cost $\kappa$ of sourcing milk abroad.

Implications: If the cost $\kappa$ of going abroad for milk rose by 1ppl then the bargained-over surplus $\kappa - c$ increases by 1ppl. The suppliers can capture a proportion $(1 - \lambda)^3$ of this extra surplus. Thus the price they receive increases by $(1 - \lambda)^3 = 0.36$ ppl. As the processors are bargaining over the benefit they offer to supermarkets above going abroad for milk. So the processors can extract more surplus if the cost of going abroad increases.

Note on retail prices: Given the efficient bargaining result retailers set prices with respect to actual marginal costs $c$. Thus we do not expect retail prices to increase in this scenario.

Effect of Changes to Market Structure on Prices and Profits

Scenario 3: A processor withdraws, or is acquired by the other two processors, so that we move from 3 to 2 competing processors, with no effect on marginal cost $c$.

Implications: Prior to any merger, with 3 competing processors we calculated that the supply chain was able to secure 36% of the bargained-over surplus $(\kappa - c)$; roughly 1.8ppl (=0.36x5ppl). The 36% figure is deduced by the equation

$$(1 - \lambda)^U = 0.36 \text{ when } \lambda = 0.29 \text{ and } U = 3$$

We have calculated the supermarket bargaining power parameter $\lambda$ at 0.29. The fact that this is less than $\frac{1}{2}$ implies that we have found that in one to one negotiations processors can more than hold their own against supermarkets. Supermarkets get the deal they do because of upstream competition between the U suppliers. After the postulated processor merger, the number of competing processors $U$ falls by 1. Now there is less competition between processors so they get a greater share of the bargained-over surplus $(\kappa - c)$. Our analysis would imply that the supply chain would then be able to secure 50% of the available surplus, as derived from the following equation:

$$(1 - \lambda)^U = 0.5 \text{ when } \lambda = 0.29 \text{ and } U = 2$$

Thus the processor can extract half the bargained over surplus, i.e. approximately 2.5 ppl. This is up from the 1.8ppl prior to the merger.
We have estimated that the cooperatives' bargaining power is $\alpha = 0.27$. Therefore our model predicts the enlarged surplus of $2.5 - 1.8 = 0.7$ ppl negotiated by the processors will be split 73% to the processor and 27% to the farmers (cooperative and direct). Thus processors would expect to see their margins rise by a further 0.5 ppl, while farmers would expect to see an extra 0.2 ppl. The farmers who work for a cooperative would of course see a smaller rise as a consequence of profits being shared with farmers whose milk is used for uses other than liquid milk.

**Note on retail prices:** In this scenario we assume the change in the number of processors does not impact on c. Therefore final retail prices are unchanged due to the efficient bargaining result (i.e. retailers set prices with respect to actual marginal costs c).

**Scenario 4:** A new processor enters, or an existing processor is split into two, changing the number of processors from 3 to 4 (e.g. undoing the Arla/Express merger), with no effect on marginal cost c.

**Implications:** This scenario involves the same calculations as in scenario 3 except that we now increase $U$ to 4 rather than reduce it to 2. Again, the processors are bargaining over the benefit $(\kappa - c)$ that they offer to supermarkets above going abroad for milk.

Our model implies the processors can secure $(1 - 0.29)^3 = 36\%$ of this surplus at the current market structure. Moving to a structure with four processors (e.g. undoing the Arla/Express merger) would decrease this to a figure of $(1 - 0.29)^4 = 25\%$.

Thus moving to four processors would have a significant negative effect on the surplus negotiated by processors. As 27% of this surplus is shared with farmers, farmers are negatively impacted too (because $\alpha = 0.27$).

**Note on retail prices:** As with the previous scenario we assume the change in the number of processors does not impact on c. Therefore final retail prices are unchanged due to the efficient bargaining result (i.e. the result that retailers set prices with respect to actual marginal costs c).

**Scenario 5:** Suppose retailers required processors, as a condition of business, to ensure farmers are rewarded on a cost-plus contract. So that all farmers must receive a certain margin for all of the units they supply.

**Implications:** Such contracts strengthen the hand of the farmers when negotiating with the processors they supply. They reduce the allowable set of agreements which can be struck in the farmers’ favour. If the margin guaranteed is below that which would be received anyway through bargaining then they would have no effect. However, suppose that the cost plus contracts were more generous. In this case the cooperative and farmers’ share secured from processors will grow to ensure that farmers get the margin specified. However the processor, when negotiating with the supermarket, now faces a larger per unit cost of supply mandated by the buying supermarket. Hence (a) the processor will secure higher prices as the increase in the variable costs of production are passed through the chain via efficient bargaining, and (b) retail prices will also rise as the supermarkets respond to the new higher production costs of every unit of milk.
**Scenario 6**  Suppose that direct farmer contracts became uncommon or are phased out. How would the processors’ bargaining power change?

**Implications:** The relationship between cooperatives and the processors they supply is relatively stable through time as compared to other levels of the supply chain. Nevertheless we calculate that processors have the upper hand in bargaining with cooperatives and are able to secure roughly 73% of supply chain profits as compared to farmers securing 27%. Industry interviews suggest to us that the reason for this econometric result lies in the fact that, in the event of disagreement between coop and processor, the processor can approach coop farmers directly and sign them up. This allows milk to be sourced regardless of the coop and, importantly, weakens the coop in further bargaining rounds. As evidence that this can and does happen one might point to Arla which has now become almost totally supplied by farmers with direct contracts. If such direct contracts were not possible then one would expect the bargaining power of cooperatives to grow versus the processors. Thus farmers would receive more of the supply chain profits. This would not be expected to feed into retail prices however. This is because the actual variable costs of production in the supply chain will not have been affected. Unlike scenario 5 there is no external restraint on the processor raising the per unit variable cost of milk production. Thus it is in no party’s interest to introduce double marginalization losses into the supply chain. All that has happened is that the balance of power in sharing the surplus between processor and cooperative has been altered. That is the total profit to the supply chain would not be altered, whereas the profit splits between farmers and processors would be, in favour of farmers.
Conclusions

This paper develops a model of bargaining in the supply chain when upstream suppliers compete. We apply this model to the UK milk industry using both publicly available data and further data provided by the MDC and DEFRA. Our main results are:

- Suppliers negotiate with supermarkets over only a subset of the profits of the supply chain. The highest price suppliers can secure is constrained by the buyers’ ability to source from the next closest market. In the case of milk this would mean sourcing abroad. This limits the supply chain to bargaining over quite a small ‘pie’. For example, in the case of milk, bargaining is over only about 5ppl of surplus. Only a fraction of this is secured by the supply chain. Much of the supermarkets’ retail margins are therefore out of reach to the suppliers. (Supermarket margins for milk are estimated by the MDC as over 15 ppl.)

- Supermarket bargaining strength comes from the competition between suppliers, not any innate better quality of bargaining. In one to one negotiations over milk we estimate that processors have greater bargaining power than supermarkets. However the competition between processors yields the greater share of gains to the supermarket.

- The data we analyse provides a consistent estimate of the bargaining power of the processors versus the suppliers as our theoretical model predicts. However the estimate exhibits a blip in 2002, shrinking in 2003, when processors appeared to enjoy a surge in their bargaining power. This is not incompatible with the current Office of Fair Trading allegations against the milk industry of collusion during these years. Other explanations are also possible.

- In the bargaining between milk processors and cooperatives, the processors hold the stronger bargaining position. Our estimates suggest that the processor secures over two thirds of the margin per litre supplied, for every third secured by farmers. This estimate bares the standard caveat that longer data series would allow refinement of the estimate.

Finally note that the bargaining splits we have calculated have included no analysis of the fixed costs of setting up plants and factories, nor of the accounting costs of depreciation against those assets. This is because in economic terms these costs are sunk. That is they have already been spent or committed to, and current price negotiations will not affect that. It is true that any business which cannot make back its cost of capital is liable to close. However, conditional on staying open, the accounting costs of depreciation are not economic variable costs of production and so do not form part of the profit maximisation calculations which the parties undertake in deciding what prices they can agree to.
Chapter 2 Milk Prices in Retail Competition

Overview

The aim of this paper is to understand retail milk pricing. Specifically we are interested in understanding what determines the size of the margins between retail prices set by supermarkets and the marginal cost of milk. This mark-up depends primarily on two factors: the sensitivity when making their supermarket choice of consumers to changes in milk prices and whether the retailers are cooperating when setting prices.

To investigate empirically the determinants of the observed margins we estimate a model of consumer demand using TNS data and use this to compute the elasticity of demand for a supermarket firm with respect to a change in the price it sets for milk. We use the estimated demand model to compute the milk margins that these demand elasticities imply in the absence of any agreement or coordination between supermarkets. We then compare these margins to those observed in the data. The model is estimated for the years (2002-2005).

We begin by presenting some facts about milk prices and milk shopping. We then present the model of consumer shopping and discuss the consumer data used to estimate the model. Finally we present the econometric results and derive the price elasticities and hence the implied non-cooperative milk profit margins. We compare these with the actual retail profit margins and conclude with a discussion of the results and some caveats.

Some Facts: Milk Prices and Milk Shopping

<table>
<thead>
<tr>
<th>Year</th>
<th>Farm to Retailer</th>
<th>MCVE</th>
<th>Total MC</th>
<th>Retail Price ppl</th>
<th>Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>13.7</td>
<td>21.81</td>
<td>35.6</td>
<td>42.7</td>
<td>17%</td>
</tr>
<tr>
<td>2002</td>
<td>13.8</td>
<td>16.81</td>
<td>30.6</td>
<td>44.3</td>
<td>31%</td>
</tr>
<tr>
<td>2003</td>
<td>13.8</td>
<td>18.74</td>
<td>32.5</td>
<td>46.6</td>
<td>30%</td>
</tr>
<tr>
<td>2004</td>
<td>13.9</td>
<td>20.15</td>
<td>35.0</td>
<td>47.5</td>
<td>28%</td>
</tr>
<tr>
<td>2005</td>
<td>14.6</td>
<td>20.42</td>
<td>35.0</td>
<td>50.9</td>
<td>31%</td>
</tr>
</tbody>
</table>

Table 1: Milk Margins (using Marginal Costs Derived in Paper 1)

Table 1 presents retail milk margins for the years 2001-2005. Note that the retail margins are based on industry marginal cost rather than the wholesale price. Our concept of industry marginal cost is built up using MCVE as the opportunity cost of the farmer in the same way as described in Chapter 1. Thus the total MC (marginal cost) figure in the table is the same as the c variable in Paper 1. We can see that the margins have risen over time from 2001 to a figure of 31% in 2005.

The next series of tables give a description of milk shopping:
Million Litres | %
---|---
Regular Milk | 2.93 | 90.7
Filtered Milk | 0.2 | 6.2
Organic Milk | 0.1 | 3.1

Table 2: Sales Volumes by Type of Milk 2005 [Source MDC]
Table 2 shows that regular milk (as opposed to filtered or organic milk) constitutes 90% of retail milk.

<table>
<thead>
<tr>
<th>Year</th>
<th>% Volume Retail</th>
<th>Doorstep Price</th>
<th>Retail Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>83.3%</td>
<td>75.5ppl</td>
<td>46.2ppl</td>
</tr>
<tr>
<td>2004</td>
<td>86.5%</td>
<td>77.5ppl</td>
<td>48.6ppl</td>
</tr>
<tr>
<td>2005</td>
<td>88.6%</td>
<td>79.6ppl</td>
<td>48.7ppl</td>
</tr>
<tr>
<td>2006</td>
<td>90.2%</td>
<td>82.2ppl</td>
<td>52.2ppl</td>
</tr>
</tbody>
</table>

Table 3: Comparison of Retail and Doorstep [Source MDC]
Table 3 shows that the retail market is 90% of liquid milk (i.e. that doorstep delivery is now a small part of the market).

<table>
<thead>
<tr>
<th>Firm</th>
<th>All Goods</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesco</td>
<td>0.27</td>
<td>0.25</td>
</tr>
<tr>
<td>ASDA</td>
<td>0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Sainsbury</td>
<td>0.16</td>
<td>0.12</td>
</tr>
<tr>
<td>Morrison</td>
<td>0.10</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>0.80</strong></td>
<td><strong>0.69</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Firm</th>
<th>All Goods</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coop</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>Somerfield</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Kwik-Save</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Waitrose</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>M&amp;S</strong></td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Iceland</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Lidl/Aldi/Netto</td>
<td>0.04</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 4: Market Shares of GB Supermarkets 2002-2005
Table 4 shows that the market is quite concentrated: the largest four supermarkets account for 70% of milk sales.

| Expenditure Shares |
|-------------------|----------------|
| Primary Shopping  | Secondary Shopping |
| 75%               | 25%              |

Table 5: Primary Shopping Dominates Source TNS
(Primary Shopping is expenditure in top store in shopping period)

| Median Household |
|------------------|------------------|
| Primary Shopping | Secondary Shopping |
| 87%              | 54%              |

Table 6: % of biweeks where household includes milk in basket Source TNS
Table 6 shows that milk is present in most shopping baskets. Primary shopping is the main shopping trip in any given two-week period.

| Mean Household |
|----------------|----------------|
| Primary Shopping | Secondary Shopping |
| 4.2%           | 4.3%           |

Table 7: Milk Share of Shopping Budget: Household Averages
Table 7 shows that milk only makes a relatively small share of the baskets
<table>
<thead>
<tr>
<th>Percentile</th>
<th>% periods visit &quot;top&quot; store</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>.25</td>
</tr>
<tr>
<td>20</td>
<td>.53</td>
</tr>
<tr>
<td>30</td>
<td>.70</td>
</tr>
<tr>
<td>40</td>
<td>.83</td>
</tr>
<tr>
<td>50[median]</td>
<td>.91</td>
</tr>
<tr>
<td>60</td>
<td>.96</td>
</tr>
<tr>
<td>70</td>
<td>.98</td>
</tr>
<tr>
<td>80</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 8: Proportion of biweek periods household visits its top store

Table 8 shows that people switch stores infrequently.

A Model of Retail Pricing

Retailers' Milk Pricing Incentives

We assume that consumers consider the price of a basket of groceries when deciding which store to shop at. Thus for any supermarket the basket price determines number of customers. For this reason the milk price affects demand not just for milk products but also for products other than milk.

Where firms sell a single product, theory tells us that non-cooperative margins depend inversely on the price elasticity of demand for the product offered by the firm. For multiproduct firms such as supermarkets the same principle applies although the price also depends on the cross-elasticities. In particular the equilibrium prices tend to be lower because of the complementarily of the products: when a supermarket cuts the price of milk it increases the number of people coming to the store and hence the demand for the other products.

Consumer Model Assumptions

We assume that consumers choose a primary store for each shopping period and may also choose a secondary store. We assume that for each consumer store choice is based on a basket price, as well as on other variables such as distance to the store and size of the store. We also model the consumers demand for milk and for other goods conditional on the choice of store. We assume that the effect of a change in the milk price on the consumer's utility is proportional to its weight in the consumer's basket.

Data on Consumers and Stores

Consumer Data (Source TNS)

We randomly select a subsample of 3977 households from TNS Worldpanel survey. This is a self-scanning survey of households that tracks purchases and store choices over the three years Oct 2002-Oct 2005. The survey includes household information including the number of adults and children, car ownership, and location. Information obtained for each household each period includes store chosen, quantities, and prices for all items bought.
We also obtained a dataset of stores. This comprises all (9617) stores in GB operated by the main 15 supermarket firms. For each store we know the location of store by postcode, the size of the store, and the firm operating the store. We match the consumer and store datasets to identify the 30 stores in a consumer’s area by distance from that consumer.

**Model of Consumer Choice**

All consumers are assumed to visit at least one store per shopping period for their primary shopping. Primary shopping is the main shopping trip in any shopping period. We define a shopping period as a two-week period.

We assume that in any shopping period the consumer's primary shopping decision can be broken down into two stages as follows:

1. **Stage 1**: the consumer makes a choice of store from the stores in his locality and decides how much of his budget to allocate to grocery shopping. The consumer makes this store choice decision based on the price of a basket of products at each alternative store. Once the store has been chosen the consumer decides how much budget to allocate to grocery expenditure: this depends on the price of a basket of groceries.

2. **Stage 2**: the consumer visits the store he selected at stage 1 and allocates the budget between milk and other shopping, depending on milk prices.

The consumer is allowed also to make secondary shopping trips and follows a similar two-stage decision process for these trips.

**Econometric Model**

The consumer model is estimated using TNS consumer choice data. The data is informative about consumers’ preferences because it is possible to relate variation in prices to variation in consumer responses. Consumers in each unique location face a unique choice set of stores. To estimate the consumer model we compare the choices of consumers across locations and find the demand model that best explains the data.

The econometric model is estimated in two stages as is conventional practice in demand analysis. We start with the second stage demand model which conditions on store choice and budget allocation. Then we estimate the first stage demand model.

**Consumer's Stage Two (Allocation of Budget to Milk)**

We aggregate all products other than milk into the catch-all category *other*. In stage two the consumer divides budget $g$ between milk and other goods (i.e. *other*). The details of the model are given in paper 2, including the estimated parameters. The estimated model allows us to compute the elasticity of demand for milk conditional on store choice. This is given below.
Data:

1. $w_m$ and $g$: household-level budget share data from TNS
2. $p_m$: quantity-weighted milk price index (at chosen store)
3. $p_n$: Tornqvist sales-weighted non-milk price index (a sales weighted index is used here as we cannot use quantity weights to aggregate diverse products).

<table>
<thead>
<tr>
<th>Primary Shopping</th>
<th>Secondary Shopping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations=156340</td>
<td>Observations=40735</td>
</tr>
<tr>
<td>$w_m=0.054$</td>
<td>$w_m=0.054$</td>
</tr>
</tbody>
</table>

Table 10: Summary Statistics for Consumer Stage Two Model

<table>
<thead>
<tr>
<th></th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>-0.60</td>
<td>-0.55</td>
</tr>
<tr>
<td>Other</td>
<td>-0.99</td>
<td>-0.98</td>
</tr>
</tbody>
</table>

Table 11: Elasticities Conditional on Store Choice and Grocery Budget

Table 10 presents summary statistics for the budget share of milk and we see that it occupies a budget share of about 5% of a typical basket.

Table 11 presents the elasticities from the model of the consumer’s second choice stage. We see that the own-price elasticity of milk is -0.6. This is interpreted as meaning that a 1% increase in the price of milk results in a 0.6% fall in the demand for milk. This level of elasticity is similar to other studies of the elasticity of demand for milk, showing that the demand for milk is inelastic. The demand for other goods is relatively more elastic, with an elasticity of about 1.

As with conventional studies of milk demand this elasticity is conditional on the consumer’s choice of store and budget; i.e. it gives the change in demand for milk if we hold constant the consumer’s grocery budget and choice of store.

If we are interested in the pricing incentives of the supermarkets, however, we need to know the elasticity of demand for products at the firm level; e.g. the effect on demand for supermarket X of a change in the price of milk at supermarket X. To compute firm level elasticities we need estimates from stage one of the consumer’s demand.

Consumer's Stage One (Choice of Store and Budget)

In stage one the consumer makes a choice of store and chooses the amount of his income to allocate to the grocery budget. These decisions are based on a number of variables such as the closeness of the store, its size, and the price of a basket of goods at that store. Note that we make the natural assumption that the effect of the milk price on the consumer’s choice of store is proportional to its expenditure share in the consumers basket. The estimated parameters are presented in Paper 2. Here we present the
implications of the parameters in terms of firm level elasticities and implied milk mark-ups.

**Firm-Level Elasticities and Non-cooperative Margins**

We now compute the elasticity of demand for milk (and other groceries) at the level of the supermarket firm. That is, what is the percentage change in the demand for milk at a given *firm* that results from a 1% change in the price of milk. Note that this is the *overall* elasticity, allowing for the following effects of a price change: a change in budget spent on groceries and a change in the choice of store.

Table 12 presents the overall elasticities at firm level. Note that Table 12 reports price elasticities averaged across supermarkets.

There are four elasticities of interest:

- the own price elasticity of milk
- the own price elasticity of other products
- the cross elasticity of demand for milk with respect to the price of other products
- the cross elasticity of demand for other products with respect to the price of milk

*The table should be read as follows: the numbers are the elasticities of demand for the product in the column with respect to the price of the product in the row.*

We break down the results into several components. There are four 2-by-2 matrices.

The first two columns present results considering primary shoppers alone. The next two columns present results for all shoppers including secondary shoppers. As firms cannot set prices separately for primary and secondary shoppers, it is the elasticities in the last two columns that are relevant for pricing. The figures do not change greatly when secondary shopping is included showing that it is essentially primary shoppers that determine the pricing incentives of firms.

The first two rows present results holding store choice constant while the second two rows allow consumers to switch. It can be seen that the figures change considerably when consumers are allowed to switch stores, suggesting that the pricing incentives of stores are strongly influenced by the effect of price on store choice.

<table>
<thead>
<tr>
<th>Hold store choice constant</th>
<th>Primary</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other</td>
<td>Milk</td>
</tr>
<tr>
<td>Other</td>
<td>-0.779</td>
<td>-0.068</td>
</tr>
<tr>
<td>Milk</td>
<td>-0.004</td>
<td>-0.675</td>
</tr>
<tr>
<td>Let store choice change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>-2.822</td>
<td>-2.068</td>
</tr>
<tr>
<td>Milk</td>
<td>-0.095</td>
<td>-0.789</td>
</tr>
</tbody>
</table>

*Table 12: Elasticities of Column Quantity with respect to Row Price*

*These are firm-level elasticities averaged across firms*
Thus the bottom right 2-by-2 matrix in Table 12 presents the overall elasticities of demand implied by the estimated choice model (putting consumer stages one and two together). The table shows that the overall own-price elasticity of demand for milk is given by -0.754, i.e. a 1% increase in milk has a -0.754% reduction in demand for milk. A 1% increase in milk price also causes a reduction of quantity demanded for other groceries of 0.087%.

Turning to the elasticity of demand for other goods we see an own-price elasticity of other products of about -2.76%. This is interpreted as a 1% increase in the price index of non-milk products leads to a 2.76% drop in the quantity demanded of non-milk goods. Note that this also leads to a 2% drop in the demand for milk (i.e. the cross elasticity of demand for milk with respect to the price of other goods is 2%).

We now compute the profit maximizing profit margins that firms set in response to these price elasticities. We assume that the firms do not cooperate when setting prices. We compute prices that are a non-cooperative Nash equilibrium, i.e. the set of prices that ensure that for each firm prices maximize profit conditional on the prices set by the other firms.

For single product firms it is well known that Nash equilibrium mark-ups generally have a negative relationship to the absolute size of the price elasticity of demand: i.e. the greater the price elasticity of demand the lower the optimal mark-ups the firm should set. Moreover, if the elasticity of demand is smaller than 1 then a single-product firm can always make more profit by increasing the price. That is, inelastic demands (demand elasticities less than 1) are incompatible with profit maximization.

For multi-product firms however, such as supermarkets, inelastic demands are possible. This is why milk can have an inelastic demand. When setting the price of milk the supermarket internalizes the effect of the milk price on the demand for other products. The negative effect of an increase in the milk price on the demand for other products reduces the profit gain from an increase in the milk price.

<table>
<thead>
<tr>
<th></th>
<th>Primary Shoppers</th>
<th>All Shoppers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common</td>
<td>Milk</td>
</tr>
<tr>
<td>All</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>Tesco</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>ASDA</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>Morr</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>Sain</td>
<td>42</td>
<td>38</td>
</tr>
</tbody>
</table>

Table 13: Implied Non-Cooperative Profit Margins (%)  
*These margins are supported without coordination*

Table 13 presents the non-cooperative profit margins implied by the demand elasticities in Table 12. The profit margin is defined with respect to marginal costs rather than the wholesale input cost secured from the supplier.

The first three columns compute profit margins assuming that the firm only faced primary shoppers. The second three columns report the profit margins considering all shoppers. The margins are similar in each case suggesting that primary shoppers have the main influence on prices.

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The first column (in each set of three) computes the profit maximizing profit margin if
the firm had a policy of uniform margins across all products (i.e. sets the same margin
for milk as for other products). We see that the model predicts a margin of about 33%
on average with a modest amount of variation across firms.

The remaining two columns present the implied markups that obtain when the firm
allows margins to vary by product. The margins predicted for milk are slightly higher
than the margins on other products. The supermarket is predicted to set non-cooperative
margins of about 36% on milk.

Comparison with Observed Retail Margins

The non-cooperative milk retail margin figure of 36% is similar to the retail price
margins of about 31% that we currently actually observe on milk as presented in Table
1. It may be concluded that the actual milk prices that are observed are not far off (and
slightly below) the margins and prices that we predict using the estimated elasticities
and a non-cooperative model of price setting. Thus if the estimated demand model is
correct the firms appear to be setting prices consistent with non-cooperative pricing.
The supermarkets are able to enjoy non-cooperative margins at this level because
consumers are not in general more sensitive to price differences between supermarkets.

Conclusions to Chapter 2

In this paper we estimate a demand system for milk using TNS data. Unlike previous
demand studies we specified the demand model at the level of the firm, which allows us
to understand the pricing incentives faced by firms. We use the demand model to
compute the own-price demand elasticities at the level of the supermarket firm. We
divide the consumers' purchases into two categories: milk and everything else ("other").
The price elasticity estimates imply equilibrium margins on milk of about 36% without
coordination between retailers. This is similar to the price margins over marginal cost
that are currently observed. Thus if the estimated demand model is correct the firms
appear to be setting prices consistent with non-cooperative pricing.
Chapter 3: Upstream Competition and Downstream Buyer Power

In the work of paper 1 (“Estimating bargaining power in the supply chain”) we developed a methodology for analysing the bargaining between supermarkets and their competing suppliers. This subsequent piece of theoretical research explores the implication of the bargaining interface between buyers and their competing suppliers on buyer power, waterbed effects and investment incentives. Buyer power is the contention that larger buyers (either in absolute or relative size) should receive lower prices. Waterbed effects arise if the growth of one buyer results in a worsening (or improvement) in the input prices other buyers are able to secure. These issues have all, for example, come under some intense scrutiny by the UK competition commission in the analysis of the UK grocery market.²

This analysis applies to much more than the liquid milk supply chain. It is a model of the bargaining interface between competing suppliers of a homogeneous good to downstream buyers. The specific bargaining form chosen is best suited to the study of own-label procurement. However it would also apply to, for example, the purchase of salt by trade buyers and other homogeneous inputs in which prices can be determined in advance and the technology and cost functions are well understood.

We build on the work of chapter 1 by allowing for upstream economies of scale. The paper analyses what the effect of any such economies (or diseconomies) would be on buyer power, waterbed effects and innovation. It has been noted in the operations research literature that delivery and logistics naturally gives rise to economies of scale as more customers often means denser customers; and with greater customer density more efficient routing algorithms are possible.³

A Recap of Industry Interviews

We develop the bargaining model in the supply chain by relying on the evidence collected through the interviewing of key executives in the UK liquid milk supply chain. We reported on the insights these interviews generated in the introduction to the first chapter above. Here we build, in particular, on the evidence provided by supermarket buyers and their suppliers. These interviews highlighted the following features:

- Supermarkets unilaterally start a new procurement round at unpredictable points in time. Thus the length of contracts that a supplier (or its rivals) holds is uncertain.
  - Further, we were told, contracts could be cancelled with 3 months notice. Thus any and all supermarkets could be reconsidering their suppliers every 3 months.

³ Burns et al (1985); “Distribution Strategies that Minimize Transportation and Inventory Costs”, Operations Research.
The effect of competition was that suppliers face uncertainty in which tenders will be successful: Thus suppliers priced strategically aiming to be competitive and cover expected costs.

- The costs are only expected (not certain) because of the interaction between economies of scale and uncertain volumes won.

These twin findings of supermarket led procurement and supplier volume uncertainty tally with other published research. For example:

"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, § 5.97)

"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." (KPMG §178-179)

As further evidence that volumes won by suppliers are uncertain, consider the following volumes sold to the largest 4 UK supermarkets by the main competing UK milk processors:

<table>
<thead>
<tr>
<th>Date</th>
<th>Processor 1 mlp</th>
<th>Processor 2 mlp</th>
<th>Processor 3 mlp</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/03</td>
<td>585</td>
<td>690</td>
<td>870</td>
<td>2145</td>
</tr>
<tr>
<td>11/04</td>
<td>575</td>
<td>555</td>
<td>1020</td>
<td>2150</td>
</tr>
<tr>
<td>1/05</td>
<td>350</td>
<td>835</td>
<td>940</td>
<td>2125</td>
</tr>
<tr>
<td>10/05</td>
<td>430</td>
<td>760</td>
<td>920</td>
<td>2110</td>
</tr>
</tbody>
</table>

Data from industry sources

These show considerable volume variation for all processors. It is further the case that in the two months between November 2004 and January 2005 the 3 largest supermarkets (accounting for around half of all UK grocery sales) all changed their suppliers essentially simultaneously.

We will shortly use these findings to extend our model of competing suppliers bargaining with downstream buyers. However before doing so it is reasonable to ask whether buyer power insights are available from a simpler model of upstream

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4 “Arla Foods amba and Express Dairies plc: A report on the proposed merger”.
5 “Prices and Profitability in the British Dairy Chain”

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monopoly, or certainty in upstream volumes. We would argue that such models do not yield the buyer power insights generated by upstream competition.

**Why Not A Simpler Monopoly Supplier/Volume Certainty Model?**

Much of the academic literature has considered buyer power in the context of an upstream monopolist. This is arguably a good model for a primary branded good supplier. However for the suppliers of own-label, or of secondary branded products, then this assumption of monopoly status is less appealing. In addition an assumption of upstream monopoly, or of upstream volume certainty, leads to the prediction that if upstream technology exhibits economies of scale, then large buyers should be weak. That is they should get a higher price than smaller buyers.

The intuition as to why is offered in the diagram below.\(^6\)

![Diagram showing buyer power dynamics](image)

If a supplier knows the volumes that they will supply then they will always bargain with a buyer for volume supplied at the margin. That is every negotiation is conducted as if all the other negotiations go according to plan. Perusal of the diagram above then confirms that the average cost per unit for small buyers is less than that for large buyers. Hence small buyers get a better price. We will see that this seemingly paradoxical insight will not hold when one allows for upstream competition and the resultant upstream volume uncertainty.

**The Model**

The paper develops the model in detail. Here we solely outline its main assumptions. We seek to capture what we consider to be the salient features of the bargaining process illuminated by our industry interviews through the following key assumptions:

- We consider upstream firms with access to the same production technology seeking to supply a homogeneous good to the downstream buyers. These suppliers may have economies (or diseconomies) of scale.

---

The downstream buyers in this theory paper are assumed to have known constant demand which depend only upon the buyer’s identity. Thus we are assuming that the buyers’ demands are inelastic. This is arguably a good model for the supply chain of an input which is one part of a larger whole ultimately sold to consumers. An example is milk that fits into an overall shopping basket with other items.

Each downstream buyer seeks only one supplier. In the case of milk the largest supermarkets subdivide their purchases into two geographic regions (broadly North and South), but currently in each region one supplier is sought.

The buyer and supplier bargain bilaterally. If negotiations should break down then a buyer can commence bargaining with another supplier. Ultimately, if the buyer fails to agree terms with all the suppliers then the input can be sourced from some other market at higher cost.

To preserve the uncertainty as to how other negotiations might be going, we assume that all bargaining with buyers happens simultaneously with no information transfer between them. This is plausibly the case as frequently as every 3 months in the UK milk supply chain when buyers are able to consider changing suppliers/renegotiating price (all 3 main supermarkets did change their suppliers of milk at the end of 2004 for example).

This modelling interpretation of the bargaining between buyers and suppliers preserves the uncertainty in realised volumes that the suppliers experience. In combination with the returns to scale in production we will show that securing a large supplier has a different effect on the expected average incremental cost versus securing a small supplier. In short, securing a large contract is suggestive that realised volumes will be high and so marginal costs will be low with economies of scale.

This bargaining game can be solved inductively by working backwards from the worst case scenario for a buyer of having failed to agree terms with all suppliers. The resultant input price is a weighted average between the expected costs per unit of serving the buyer and the ultimate outside option of sourcing from a different geographic market. The expected cost depends upon the distribution of volumes there are to be won. The split between these two bounds depends on the bargaining skill of the parties (assumed equal here) and the number of competing suppliers.

**How Large Buyers Wield Buyer Power**

Our first result is that if there are upstream economies of scale, and if there is sufficient upstream competition, then large buyers wield buyer power. Note that this stands in contrast to the case with a monopolist upstream. Thus we have an immediate implication of carefully considering the upstream competition.

The result is generated by considering what the expected cost of serving a large versus small contract is in the context of volume uncertainty. So for any realization of supplier

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7 We do not allow the buyers to coordinate their purchases on one supplier in the case of economies of scale. This would not be optimal in a repeated setting as the victorious supplier would then wield monopoly power. Further any differentiation between suppliers over unobserved characteristics would preserve uncertainty in volumes and so the model as described would apply. We note that such coordination on one supplier does not happen in any case in the UK milk supply chain.

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volumes from all but 2 possible buyers, consider the expected costs underlying the bargaining between the supplier and these 2 buyers; one large and one small.

If negotiating with the large buyer

\[ \text{Gradient} = \frac{\text{Average Incremental Cost}}{\text{Volume won}} \]

If negotiating with the small buyer

\[ \text{Pr} \frac{U-1}{U}; \text{other contract won} \]

\[ \text{Pr} \frac{U}{U-1}; \text{other contract lost} \]

We suppose that the number of suppliers, \( U \) is larger than 2. In this case each supplier is more likely to lose rather than win any other given contract. Thus more weight is put on the steeper of the two gradients. The gradients of the chords drawn equal the average incremental cost of delivering the required volumes. So large buyers get a better deal than small buyers. In short securing a large buyer is better news as to final volumes and so is most likely to help steer the supplier into profit. Therefore the supplier is willing to negotiate a lower price to such a buyer.

The analysis next goes on to consider waterbed effects arising from changes in concentration, down and upstream.

**Downstream Organic Growth and Waterbeds**

Our analysis goes on to confirm that if a downstream buyer were to increase their volumes by organic growth without affecting the volumes demanded by other buyers then:

1. With concave total costs upstream (increasing returns to scale), all other buyers receive a lower transfer price.
2. The opposite is true with decreasing returns to scale upstream.

This result follows as the expected volumes served by any supplier grow and so the economies of scale upstream generate the link across input prices.

**Downstream Growth By Acquisition**

The research reported in this section indicates how downstream consolidation results in waterbed effects which alter the input prices for other buyers. To explain the result, suppose that two buyers become more asymmetric while holding their combined purchase volumes constant. Suppose also that all other purchase volumes are unaffected. Then:
1. If average incremental costs are convex then the increase in downstream asymmetry raises the transfer prices for all other downstream firms (a **standard** waterbed effect).

2. If average incremental costs are concave then the increase in downstream asymmetry lowers the transfer prices for all other downstream firms (an **inverse** waterbed effect).

The average incremental cost is the incremental cost per unit of serving a given client plotted as a function of the volumes already being supplied to others. With economies of scale this incremental cost per unit will be declining in volumes already won. If these incremental costs decline at a declining rate (and so costs per unit decline slowly to some lower bound at full efficiency) then we are in case 1 above.

The result is perhaps most neatly explained by the following diagram:

The diagram considers the partial merger of downstream firms 1 and 2 so that they move from being an equal size to firm 1 being the larger, and plots the average incremental cost of serving some other buyer (numbered 3). In this case the volumes upstream suppliers can hope to win have undergone a mean-preserving spread. That is they are more risky as now winning buyer 2 yields little volume. Standard results from risk theory then guarantee that in this case the expected cost per unit of serving buyer 3 has risen. Thus buyer 3 receives a worse input price.

Hence our research identifies a mechanism by which downstream mergers or partial acquisitions can have adverse consequences for the input terms of other buyers. Further we argue that the case of convex average incremental costs is the most relevant. Thus one would typically expect a standard waterbed effect to exist.

In the current investigation into the UK Grocery Market the Competition Commission considered whether waterbed effects might operate in the UK. The model they considered assumed an upstream monopolist and they noted that it was unclear how
relaxing this assumption to upstream competition could generate waterbed effects. Our model here highlights one mechanism implied by the salient features of bargaining in the UK liquid milk supply chain we have identified.

**Welfare Effect of Increases in Downstream Concentration**

Changes in downstream concentration have the effect of altering the risk profile of volumes won by the suppliers. This alters the expected industry costs and so has a welfare effect. Our analysis highlights the direction of this welfare effect. The results here should be caveated however by the fact that this model assumes downstream volumes are fixed. Thus any changes in retail prices generated by alterations in downstream concentration are not included in the analysis.

Our model shows us that if two downstream buyers become, by partial acquisition, more asymmetric, and if there are increasing returns to scale upstream, then welfare is raised as expected industry costs fall.

**Effect of a Change in Upstream Concentration**

The paper presented in Chapter 3 then goes on to consider the relative gain of large versus small buyers as the number of suppliers increases. Here we find a link to the shape of the marginal cost curve. In particular, as the number of suppliers increases; and if there are convex declining marginal costs upstream, then the absolute transfer price differential between large and small buyers grows. That is large buyers become relatively better off and smaller buyers are at a relative disadvantage.

The intuition for this is highlighted in the diagram below. Consider a convex declining marginal cost curve. Thus marginal costs decline slowly to some lower bound. More suppliers means lower volumes are expected to be won. Due to the curvature of the marginal cost curve, incremental costs rise more for small reductions at low volume levels than at high volume levels. Winning a large buyer results in a supplier expecting to finish up with large volume levels. Therefore a rise in supplier numbers helps large buyers more than small ones.

This result concludes our analysis of the waterbed effects which concentration changes create. We next move on to the investment incentives created by the bargaining interface between suppliers and buyers.

**Investment Incentives and Buyer Power**

In this research we seek to understand how the presence of large buyers wielding buyer power alters the incentives suppliers have to invest in their production technology. Thus we seek to endogenise the industry technology and understand whether innovation will act to curb, or promote further buyer power effects.

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In many homogeneous good industries, such as liquid milk supply, any production innovation is unlikely to be covered by patents. For example, if cost reduction is due to better practice or larger plants using well understood technology then this is easily replicable. We therefore make use of the concept of *anticipatory equilibrium*: Does a supplier wish to invest after internalising that her rivals will react by investing also to maintain their competitiveness? In support of our contention that this reciprocal investment is the relevant case note that in the current Competition Commission report into the UK Grocery Industry\(^9\), 60% of suppliers responding to the CC’s survey claim that they conduct innovation to “keep up with the market”

**Deploying a Small Cost Reducing Innovation**

In this first result we consider at what level of production a supplier would choose to deploy a small cost reducing innovation which lowered the cost of producing one unit by some small amount. Thus the thought experiment here is whether incentives to invest are strongest ‘at the margin’ – that is at high levels of production; or perhaps incentives are strongest at low levels of production. This question is of interest as were downstream demand to be slightly elastic, innovations at the margin could be expected to filter down into lower retail prices.

We find that suppliers facing the bargaining interface described would rather lower costs will inside their expected production levels. The reason is two fold:

Firstly when bargaining with buyers the supplier will be at pains to share as little of the cost reduction with the buyer as possible. A buyer can claim a fraction of the cost saving if her volume turns out to be pivotal in getting the supplier to access the lower cost unit. A cost reduction at high levels of production is more likely to be dependent on signing up any given buyer and so the buyers extract more of the rents.

Secondly, after the input prices are agreed, the cost reduction is only triggered if volumes are sufficiently large. Thus a cost reduction at high volume levels is just less likely to be achieved.

Combining therefore, if the cost reduction is deployed for a unit produced when volumes are low then costs are more certainly lowered but transfer prices stay high.

**Analysis of Endogenous Technology Choice**

Our final analysis seeks to endogenise the entire upstream technology rather than focus on incremental cost reductions. The question this section seeks to answer is whether the mere presence of large buyers pushes technology towards one exhibiting economies of scale in which, as we have shown, buyer power is strengthened. We show that indeed this is the case.

To achieve this insight suppose that the suppliers begin with an industry technology exhibiting no returns to scale or decreasing returns to scale. Thus larger buyers either

\(^9\) Op cit, App 8.2, para 34.
wield no buyer power or are actually made weaker. Next suppose that downstream we have many small buyers and one large buyer. This large buyer can be thought of as growing by acquisition through acquiring the smaller buyers. In this case we show that if technology is made endogenous then a large enough buyer creates the incentives for the upstream industry to change to increasing returns to scale.

At first sight this is a surprising result. There are a number of competing suppliers only one of whom can win the large buyer. Thus a move to upstream economies of scale will raise the costs of serving the smaller buyers which the non successful suppliers will be left with. Further economies of scale result in the large buyer wielding buyer power and paying less. Thus given the anticipatory equilibrium – suppliers know if they build in economies of scale their rivals will match – why would the suppliers walk down this road?

The answer lies in the changes to the expected costs. By moving to a technology exhibiting economies of scale the expected costs fall as volumes won have undergone a mean preserving spread. On the other hand the price reduction to the large buyer cannot be too great as the cost of souring abroad remains high and constrains the bargaining agreement. Thus on balance the suppliers are happy to take their chances in competition with economies of scale as the expected cost reductions outweigh the lower input prices secured.

Of course a move to a technology exhibiting economies of scale disadvantages the smaller buyers as we have already established. A manifestation of this move to technology exhibiting economies of scale in the UK liquid milk industry is the continued move to ever larger dairies (superdairies) at which substantial economies of scale can be realised.10

Conclusions to Chapter 3

This final chapter develops a framework applicable to supply chains where consumers see goods as homogeneous. Examples include own-label procurement generally and milk in particular. We have shown that if the upstream technology exhibits economies of scale then large buyers wield buyer power. This power is generated by the uncertainty upstream competition creates. The analysis also highlights one mechanism by which downstream mergers can harm the supply deals of downstream rivals. That is waterbed effects can exist when suppliers compete. Finally the presence of large buyers pushes the upstream technology towards one with economies of scale in which larger buyers become increasingly advantaged as compared to their smaller downstream rivals.

As in all of the three chapters presented here, we are indebted to our sponsors, MDC and DEFRA, and also to all those who provided time for interviews and discussions. Our work is very much improved by their generosity.

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10 Superdairies are classed as dairies capable of processing over 300 million litres of milk per annum. At the time of writing the three main processors have, between them, over 7 such dairies. (Industry sources).